SPECIAL REPORT

PRESS INTIMIDATION, SCIENCE SUPPRESSION AND THE 5G ROLLOUT

PEER REVIEW

a radiation inspired jeff prager publication • april, twenty-nineteen

A SPECIAL REPORT

The Federal Communications Commission (FCC), Press Intimidation and Science Suppression

THE

ROLLOUT

AND THE 2018-2019 PEER REVIEW

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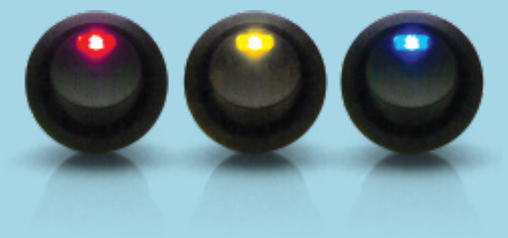


INTENT

The publisher and writer(s) warrant that the information presented in this report is an accurate reflection of information presented on public web sites on the internet. If information is verifiable and appears to have merit, and that information is consistent with other facts in this investigation, the factual information from that site is included as best possible, without any reflection on the merit of that site's objectives or intent. The ambition, objective and desire behind publication of this report is to:

1) provide verifiable documentation for the lethal health effects on all living things on planet earth by the global 5G rollout using current peer reviewed reports to expose the serious and deadly harms to all living things directly resulting from the global use of the 5G radiofrequency network;

2) to focus public attention on circumstances that strongly suggest that there has been wrong doing in the form of international crimes by elected and public officials and corporate organizations involved in rolling out the 5G netwotk and an attempt to downplay the publics constant, lethal exposure to non-ionizing radiation all day, every day. Exposure to adults, children, pregnant women and unborn fetuses, plants, animals, insects and bacteria — exposure to all living things;

3) and to provide a foundation of research for future reference. Information presented in this report documents that the federal institutions responsible for investigating these events are currently involved in efforts to suppress the facts. Hence, this information is being provided here, in this format, in the hope that unknown officials with an appropriate level of authority can institute a proper investigation, or that private investigative resources can continue to substantiate the claims made herein and take divisive action — the 5G rollout is lethal to all life on planet earth, an Indisputable assertion.

ACCORDING TO THE PEER REVIEW 5G WILL CAUSE

Alteration of heart rhythm
Altered gene expression
Altered metabolism
Altered stem cell development
Cancers
Cardiovascular disease
Cognitive impairment
DNA damage
Impacts on general well-being
Increased free radicals
Learning and memory deficits
Impaired sperm function and quality
Miscarriage
Neurological damage
Obesity and diabetes
Oxidative stress
and more ...

Environmental Research • January 2018
No. 164 - Pages 405–416

Wi-Fi Is An Important Threat To Human Health

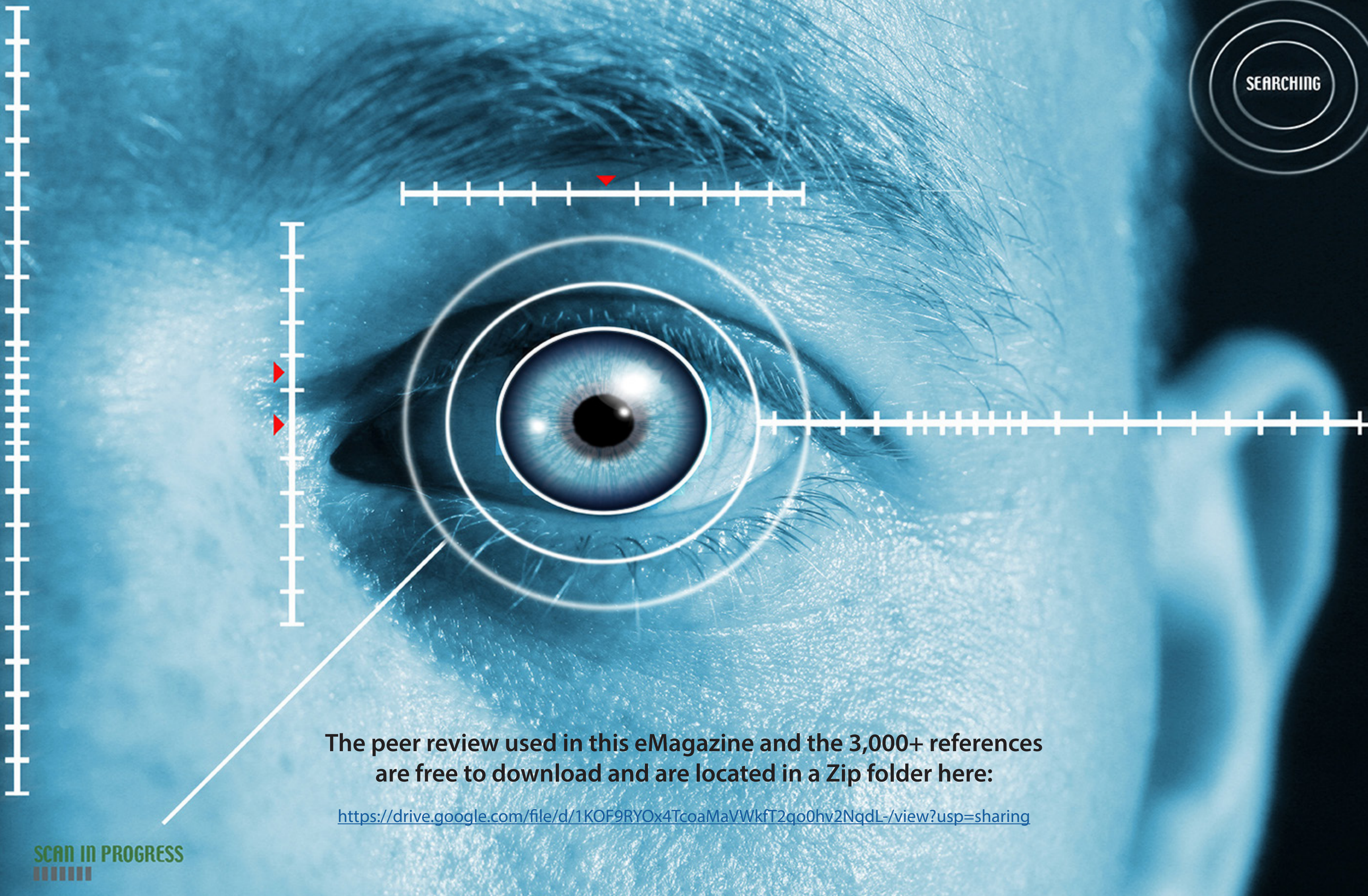
by Martin L. Pall
Washington State University, 638 NE 41st Avenue, Portland, OR 97232-3312, USA

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***.

Each of these effects are also caused by exposures to other microwave frequency EMFs, with each such effect being documented in from 10 to 16 reviews. Therefore, each of these seven EMF effects are established effects of Wi-Fi and of other microwave frequency EMFs. Each of these seven is also produced by downstream effects of the main action of such EMFs, voltage-gated calcium channel (VGCC) activation. While VGCC activation via EMF interaction with the VGCC voltage sensor seems to be the predominant mechanism of action of EMFs, other mechanisms appear to have minor roles.

Minor roles include activation of other voltage-gated ion channels, calcium cyclotron resonance and the geomagnetic magnetoreception mechanism. Five properties of non-thermal EMF effects are discussed. These are that pulsed EMFs are, in most cases, more active than are non-pulsed EMFs; artificial EMFs are polarized and such polarized EMFs are much more active than non-polarized EMFs; dose-response curves are non-linear and non-monotone; ***EMF effects are often cumulative; and EMFs may impact young people more than adults***.

These general findings and data presented earlier on Wi-Fi effects were used to assess the Foster and Moulder (F&M) review of Wi-Fi. The F&M study claimed that there were seven important studies of Wi-Fi that each showed no effect. However, none of these were Wi-Fi studies, with each differing from genuine Wi-Fi in three distinct ways. F&M could, at most conclude that there was no statistically significant evidence of an effect. The tiny numbers studied in each of these seven F&M-linked studies show that each of them lack power to make any substantive conclusions. In conclusion, there are seven repeatedly found Wi-Fi effects which have also been shown to be caused by other similar EMF exposures. Each of the seven should be considered, therefore, as established effects of Wi-Fi.



The peer review used in this eMagazine and the 3,000+ references are free to download and are located in a Zip folder here:

https://drive.google.com/file/d/1KOF9RYOx4TcoaMaVWkfT2qo0hv2NqdL-/view?usp=sharing

5G

PREFACE:

WHY 5G?
AMERICA'S COMING 'SOCIAL CREDIT' SYSTEM

by Jeff Prager

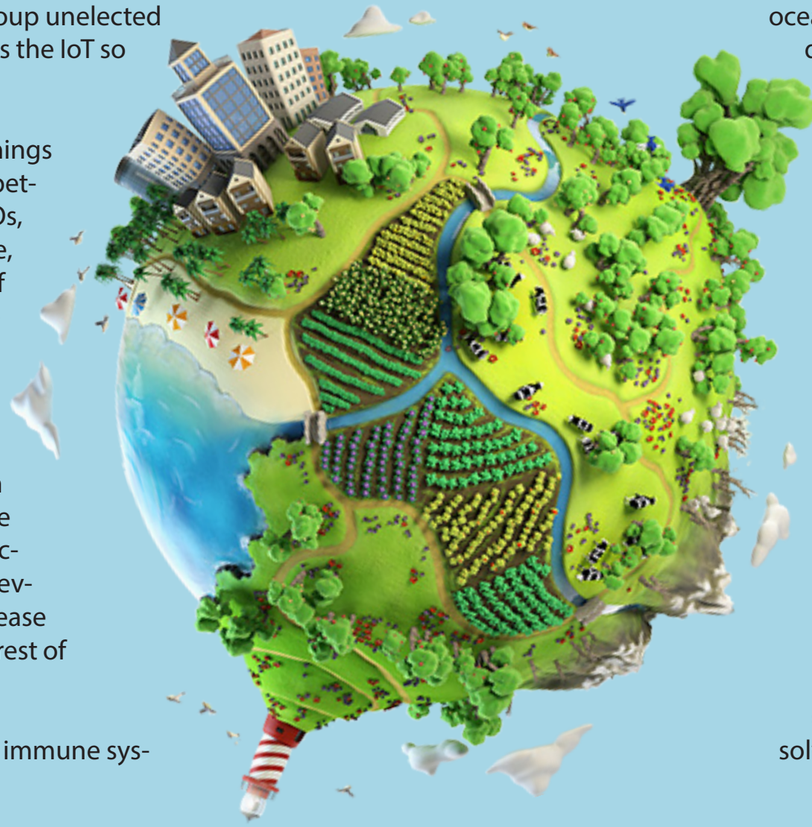
WHY 5G? WHO'S IT FOR? WHAT'S THE PURPOSE?

The purpose is multi-fold, as always. 5G is being rolled out globally by major multinational players at great expense and it's being touted as the next best thing to sliced bread and it's free! Globalists and Oligarchs and Multinational Corporate Executives, supported by the World Health Organization and a slew of international alphabet soup unelected bodies and funded by the world's bankers, are preparing to give us the IoT so we can live supremely! The Internet Of 'Things' !

If those aren't glaring red flags, I don't know what would be. Nothings free. And the majority of global products that are promoted as better than sliced bread are costly, deadly, and often both. Like GMOs, Smart Meters, Coca Cola, Oxycontin, Vaccines, Agent Orange, NAFTA, TPP, NDA, the Patriot Act, the War On Terror, on and on. If it's free and the globalists are, ostensibly and on the surface anyway, promoting it and paying for it, you can be sure you'll pay twice as much for it in the end and the final outcome won't be healthy nor favorable for you.

5G appears to be designed to extract money from a population already extracted to the max. A population with little left to take since the cost of living, the cost of actually staying alive and functional for 60, 70, 80 years or more has been slowly increased for several decades while wages have not. 5G is designed to cause disease and disorder at the age of 40-50 years old so that you'll spend the rest of your life, as short as it will be, paying to stay alive a little longer.

That is, if you're lucky enough to experience only heart problems, immune system disorders, various cancers, cataracts and infertility.



For the unlucky, psychiatric disorders on the Autism spectrum, some not on the spectrum, ADHD and other learning disabilities are in store. It's all in the American Crockpot.

Functionally and factually, most of us alive today, middle-aged or older, in what's left of the American Middle Class won't be living in smart homes anytime soon and more than likely never, until death we do part. Turning up the heat, closing the blinds, firing up the fireplace, flipping on the microwave and turning on the crockpot as we begin our one hour daily commute with our Smart Phone connected to both our car and home alike isn't something we'll be doing. Ever.

But there's even more to 5G. Every item you buy, from pantyhose to feminine hygiene products and from condoms to peanuts, coca cola, candy and cracker jacks, even your Big Mac, your shoes, socks, underwear and slacks, your bra too if you wear one and the firewire cord you bought from Walmart will all be chipped. Everything purchasable from barrels of oil and ocean-going shipments of steel will be chipped for the 5G rollout. Even money, dollars and cents alike, will be chipped. A primary purpose of the 5G rollout is to increase, dramatically, the ability of governments to curtail crime, black market purchases and sales, gain knowledge of your buying habits, increase awareness of your every move through GPS tracking, monitor your habits and eventually know and record everything you do. IoT.

YOU ARE NOW CONNECTED TO THE INTERNET OF 'THINGS'

Did you overuse your electrical allotment this year? Maybe you'll have to settle for slightly warmer summers and even cooler winters by using less electricity to repay your social debt. In America's new 5G surveillance state, everyone will be watched, reviewed and rated in a "Social Credit" system and a high-tech, all-seeing government will keep every citizen in line.

Your contributions to the social system will be weighed against what you consume. Over-consume, commit a petty crime, litter, eat unhealthy food, dress poorly, fail to shave, use deodorant and fix your hair properly? Perhaps you'll lose housing, food or credit benefits. Maybe you'll have to move to a lower income neighborhood. Are your children doing poorly in school? Docking your weekly paycheck by 30% should solve that problem. But it gets worse.

DISEASE AND DISORDER ARE THE DISORDER OF THE DAY

5G kills us early. Some of us will be born with Autism, ADHD and learning disabilities, others will have heart trouble, metabolic syndrome — which is the precursor for every disease — infertility, psychiatric issues, early onset dementia and cancers. You'll read here about Toddler Dementia caused by WiFi toys. All sorts of cancers like skin cancer, glioma's and other various brain, head and neck cancers. It won't stop there. Pancreatic cancer, testicular cancer and a wide variety of additional cancers will, well 4G already has increased the rate of cancer globally, as you'll read in the peer review. 5G is deadly, inescapable and designed to destroy our health at an early age. It will destroy all life on earth. Get involved.

5G

WE'RE FACING A PLANETARY EMERGENCY

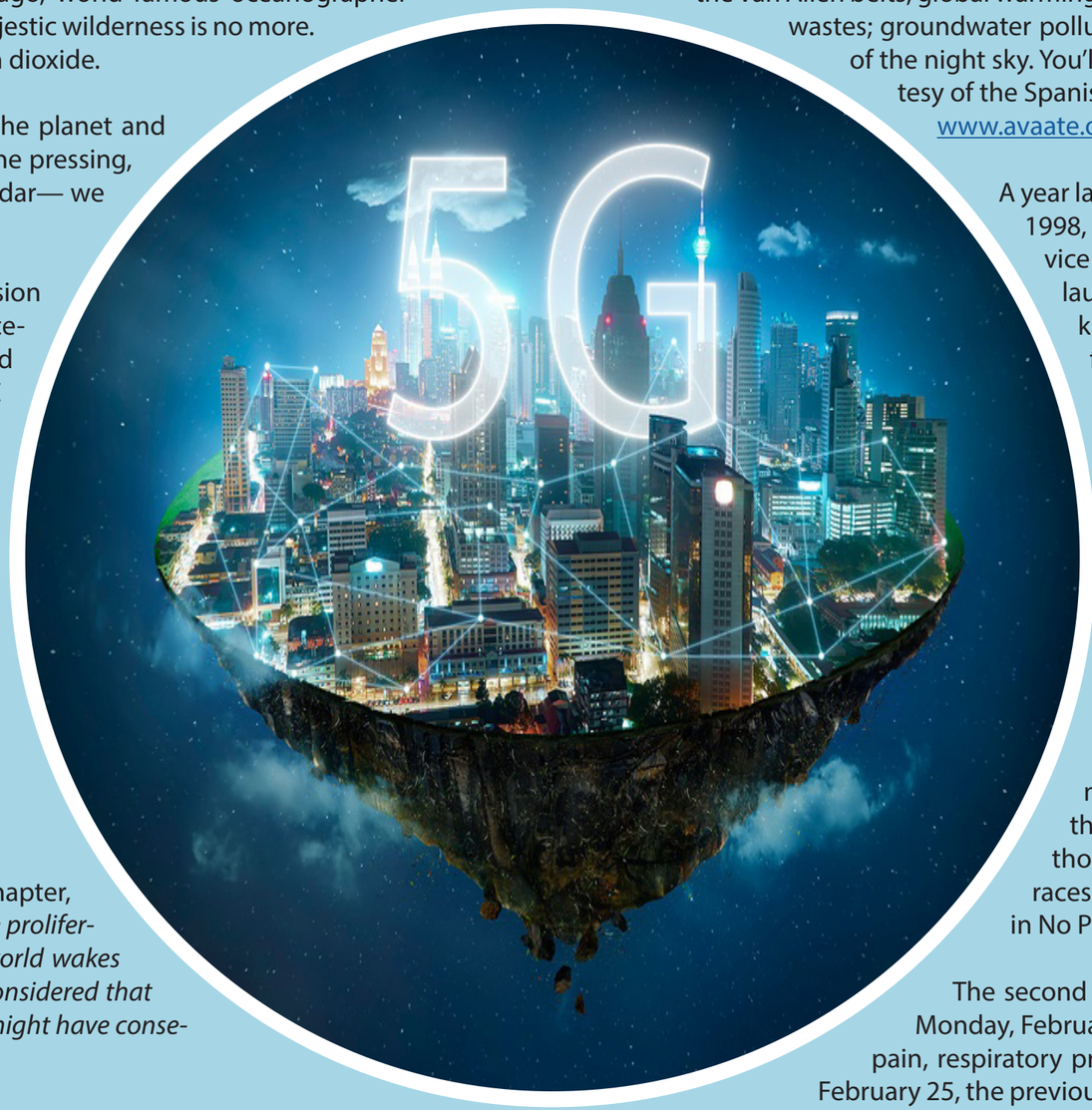
THE EARTH NEEDS YOUR HELP. NOW.

Many are the assaults on our planet. Almost 50 years ago, world famous oceanographer Jacques Cousteau said it — "the oceans are dying". The majestic wilderness is no more. The very oxygen we breathe is being converted to carbon dioxide.

Others are wrestling with a myriad of problems facing the planet and they are not going to be solved overnight. But there is one pressing, imminent disaster that must be averted and it's off the radar— we must leave space alone.

On March 29, 2018, the Federal Communications Commission gave its approval to SpaceX's plan to launch an unprecedented 4,425 satellites into low orbit around the Earth. And that's only the beginning. SpaceX has applied to the FCC to increase the number of satellites to 12,000 in order to provide "*ultrafast, lag-free Internet*" to every square inch of the earth. 5G from space. SpaceX's CEO, Elon Musk, has announced his intention to begin launches in 2019, to begin operating as soon as he has about 100 satellites in orbit, and to have at least 800 satellites up and running by 2020. The name of SpaceX's project is "Starlink."

The global electrical circuit, the only one we have and which sustains all life, is about to be seriously disturbed unless we all act collectively. All of us.



Recent History

In the 1997 book, Microwaving Our Planet, in the last chapter, titled "The Danger from Satellites," the author writes: "*The proliferation of satellites we are about to witness — unless this world wakes up soon — is mind boggling, and nobody seems to have considered that popping thousands of them up there like so much confetti might have consequences for our atmosphere and our climate.*"

The author, Arthur Firstenberg, wrote about the expected ozone loss; the destruction of the Van Allen belts; global warming from the addition of water vapor to the stratosphere; toxic wastes; groundwater pollution; space junk; microwave radiation; and the vandalism of the night sky. You'll find that 1997 book posted here for free download, courtesy of the Spanish website AVAATE, one of the best websites on this issue: www.avaate.org/IMG/doc/Microwaving_Our_Planet_firstenberg.doc

A year later the radiation problem asserted itself. On September 23, 1998, the world's first satellite phones became operational. Service was provided by 66 satellites in low orbit around the Earth, launched by the Iridium Corporation. They unleashed a new kind of rain that turned the sky red and emptied it of birds for a couple of weeks.

A six-nation telephone survey was done of electrically sensitive people, support groups, and nurses and physicians serving this population. The results: 86% of electrically sensitive people and a majority of patients and support group members became ill on Wednesday, September 23 exactly, with typical symptoms of electrical illness including headaches, dizziness, nausea, insomnia, nosebleeds, heart palpitations, asthma attacks, ringing in the ears, etc. Follow-ups revealed that some of these people were acutely ill for up to three weeks. Some were so sick they weren't sure they would live. In the United States the national death rate rose by 4% to 5% for two weeks. During those two weeks, very few birds were seen in the sky and thousands of homing pigeons failed to return home in pigeon races throughout much of the country. This was all documented in No Place to Hide, Vol. 2, No. 1, Feb. 1999, pp. 3-4.

The second satellite service, Globalstar, began commercial service on Monday, February 28, 2000. Widespread reports of nausea, headaches, leg pain, respiratory problems, depression, and lack of energy began on Friday, February 25, the previous business day, and came from people both with and with-

out electrical sensitivity. See No Place To Hide, Vol. 2, No. 3, March 2000, p. 18.

Iridium, which had gone bankrupt in the summer of 1999, was resurrected by a contract with the United States Armed Forces. On March 30, 2001, commercial service resumed. Again the sky turned red. Again came reports of nausea, flu-like illness and feelings of oppression. But the events that made the news were catastrophic losses of race horse foals that were reported throughout the United States and as far away as Peru. On June 5, 2001, Iridium added data and Internet to its satellite phone service. Again came widespread reports of nausea, flu-like illness and oppression, and this time also hoarseness. See No Place To Hide, Vol 3, No. 2, Nov. 2001, p. 15.

Additional details are provided in chapter 17 of The Invisible Rainbow: A History of Electricity and Life (AGB Press, 2017). Between 2001 and now, our skies have not essentially changed. Iridium and Globalstar, operating 66 and 40 satellites respectively, are still the only providers of satellite phones. The amount of data raining on us all from space is still dominated by those two fleets. The predicted fleets of thousands of satellites have not materialized. But they are about to now, unless we stop them. Everything we know and love is at stake — not just hawks and geese, pigeons and race horses, not just the human race, but life itself. This is a mortal threat not just to our children and grandchildren, but to all of us, immediately, within just a few years.

The Details

The biggest threats are from Boeing, OneWeb, and SpaceX, all of which have similar applications before the FCC. SpaceX's 12,000 satellites will operate in two constellations, at 700 miles and 210 miles in altitude. They will operate at millimeter wave frequencies and they will be phased arrays. Each satellite will have thousands of antenna elements that will aim focused, steerable beams at any desired point on the surface of the earth. Each beam from the 4,425 satellites already approved at the 700-mile height would have a maximum effective radiated power of up to 8,800 watts. The revised application for 12,000 satellites is requesting an increase to 5,000,000 watts per beam (for the upper constellation of 4,425 satellites) and 500,000 watts per beam (for the lower constellation of 7,518 satellites). The satellites will communicate both with individual users and with gateway earth stations, of which there will be several hundred just in the United States.

OneWeb's founder and Executive Chairman is Greg Wyler. So far, OneWeb has applied to the FCC for only 4,540 satellites, but it is partnering with Airbus, which will build the satellites; Blue Origin, a subsidiary of Amazon, which will provide the rockets; and Virgin Galactic, which will launch them. Its investors include Qualcomm, Hughes Network Systems, Intelsat of Luxembourg, Marker LLC of Israel, Grupo Salinas of Mexico, SoftBank of Japan, Bharti Enterprises of India, and Coca-Cola. It received a license from the FCC for 720 low-orbit satellites in June 2017, but has already sold most of their capacity to Honeywell and other companies. Honeywell plans to use satellite transmissions to supply fast Internet to business, commercial, and military aircraft worldwide. On January 4, 2018 OneWeb filed an application for an additional fleet of 2,560 medium-orbit satellites, and on March 19, 2018 it filed an application for 1,260 additional low-orbit satellites. It is now touting its enterprise as an essential element of the worldwide rollout of 5G technology. Like SpaceX, OneWeb's satellites will have antennas in phased arrays and use the millimeter wave spectrum. Their maximum effective power will be 6,000 watts. OneWeb intends to launch 36 satellites every 21 days beginning in the last quarter of 2018, and to begin service with the first few hundred satellites in 2019.

Boeing, which has its own plans for a fleet of 2,956 low-orbit satellites, and already has FCC approval for them, may now be backing OneWeb. In December, Boeing asked permission from the FCC to transfer its license for the 2,956 satellites to a company named SOM1101 LLC. Greg Wyler, the founder of OneWeb, is the sole owner of SOM1101.

A fourth company, Telesat Canada, was granted an FCC license on November 3, 2017. It plans to have a minimum of 117 satellites up and running by 2021. It intends to add satellites "as needed" to increase capacity. These satellites will also be phased arrays and they will also be for global internet to "*unserved and under-served*" communities, businesses, governments and individuals. They will have a maximum effective power of 8,000 watts.

Iridium, in an effort to compete with all these new companies, is presently in process of replacing its original fleet with a new fleet of 66 satellites called Iridium Next that will offer additional services.

These five companies together have approved and pending applications before the FCC for almost 20,000 low and medium orbit satellites to provide Internet to the world from space.

"THE GLOBAL ELECTRICAL CIRCUIT, WHICH SUSTAINS ALL LIFE ON EARTH, IS ABOUT TO BE SERIOUSLY DISTURBED BY 5G RADIATION, UNLESS WE ACT."

If 66 satellites providing only voice communication caused widespread illness and mortality among birds, horses, and people, what will a 20,000-satellite Internet-in-the-Sky do to us all?

The Way To Understanding

The original Iridium satellites were (and are still) at 1,000 watts of effective power and 483 miles in altitude. They are spread out around the Earth so that only one satellite is above any given point on the earth at any time. If a 1,000-watt tower were to be placed on a mountaintop that was 483 miles from the nearest person, no one would be alarmed. Why, then, worry about satellites in space? Five million watts is a lot scarier, but even a 5-million-watt beam from 700 miles away will produce a power level of only 13 picowatts (trillionths of a watt) per square centimeter on the ground, a level that is far below the levels most of us are exposed to already from WiFi, cell phones, and cell towers.

The answer has to do with what atmospheric physicists call the global electrical circuit, and with what Chinese medicine calls qi. Electricity is not only something "out there" that powers our lights and machinery, it is the force that orchestrates growth and healing and keeps us alive. The global electrical circuit flows through the earth, up to the sky in thunderstorms, through the ionosphere, and back down to earth through the atmosphere and through our bodies. The current enters our bodies through the top of our head, circulates through our acupuncture meridians, and reenters the earth through our feet. In addition to direct current, it contains 8 Hz, 14 Hz, 20 Hz, 26 Hz, and 33 Hz components. These ELF frequencies are the Schumann resonances, and are identical to the brain wave frequencies of every animal. It also contains VLF frequencies. These are generated by lightning, vary seasonally, and regulate our annual biorhythms. We pollute this circuit at our peril. Let me say again, more succinctly, that we ARE polluting this circuit and it IS at our own peril. The corporate/government/banking motivation, as always, is profit at our expense.

From The Invisible Rainbow:
A History Of Electricity And Life
Chapter 9, "Earth's Electric Envelope"

The strength of the atmospheric electrical current is between 1 and 10 picoamperes (trillionths of an ampere) per square meter. Dr. Robert Becker found that 1 picoampere is all the current that is necessary to stimulate healing in frogs. It is these tiny currents that keep us alive and healthy. (See: R.O. Becker and G. Selden, The Body Electric, New York: Morrow 1985, p. 142; R.O. Becker and A.A. Marino, Electromagnetism and Life, Albany: State University of New York Press 1982, pp. 49-51).

The experiences of astronauts are a clue to the importance of the global electrical circuit to terrestrial life. The International Space Station is not completely outside of it; the Schumann resonances are clearly detectable even at that altitude, but they are greatly diminished. In the Space Station, astronauts' circadian rhythms are disrupted. (See: John R. Ball and Charles H. Evans, Jr., editors, Safe Passage: Astronaut Care for Exploration Missions, National Academies Press 2001). Russian authors have noted that "*a decrease in all physiological processes*" occurs during space missions and that these changes are "*identical to those that occur during the process of aging on Earth*." (See: Irina M. Lirina et al., "*Protein expression changes caused by spaceflight as measured for 18 Russian cosmonauts,*" Nature, Scientific Reports 7:8142 (2017)). It is doubtful that human beings could long survive if completely removed electrically from Earth, for example in a colony on Mars such as Elon Musk is also contemplating. We require electricity, an electrical current.

Power Line Harmonic Radiation

Another piece of the puzzle is provided by research that has been done at Stanford University and elsewhere on the properties of the ionosphere and magnetosphere — the regions of space hundreds to thousands of miles above our heads that contain mostly electrons, protons, and other electrically charged ions.

It was discovered more than forty years ago that ELF and VLF radiation from all of the power lines on earth is reaching the ionosphere, and the magnetosphere above it, where it is being amplified up to one hundred thousand-fold by interaction with electrons. As a result, the earth's electromagnetic environment has been changed. The behavior of the magnetosphere, the structure of the Van Allen belts, the values of the Schumann resonances, and even the weather here on earth, have been altered. This phenomenon is called "*power line harmonic radiation*" and is a well known, firmly established scientific phenomenon.

It was further discovered that the radiation from VLF radio stations is also amplified tremendously in the magnetosphere — so much so that a radio signal of 0.5 watts sent from an antenna in Antarctica can be detected by a receiver in northern Quebec, 1000s of miles away.

Dirty Electricity On The Global Circuit

What does this have to do with SpaceX and OneWeb? Or, to rephrase the question, if a single half-watt radio station broadcasting from the earth has a measurable effect on the magnetosphere, what effect will 20,000 satellites, some located directly in the ionosphere and some directly in the magnetosphere, each blasting out up to five million watts — what effect will that have on life below?

The answer has to do with the fact that the satellite signals — like all wireless signals today — will be pulsed at ELF and VLF frequencies. That is how the data will be sent. Like an AM radio, the ionosphere and magnetosphere will demodulate, or extract, the ELF and VLF components, and then amplify them tremendously. Until now nobody has looked for these effects from satellites. But a Stanford physicist explained why this could happen and showed how to estimate the minimum power level that would be necessary:

"*Iridium had enough power, and the new satellites will have more than enough power: as a rough estimate, the five-million-watt SpaceX beams will contain enough energy up to a distance of 135 miles from each satellite for their ELF/VLF components to be demodulated by the ionospheric plasma and then amplified in the magnetosphere.*" The result is similar to how dirty electricity gets onto house wiring. All of the electronic equipment — dimmer switches, fluorescent lamps, computers, cell phone chargers, etc. — that are plugged into our walls, produce electronic noise that travels on the wiring, radiates into our homes, and has the potential to makes us sick. The potential to make us sick without knowing why.

Except that now the dirty electricity will get onto our bodies' wiring. The noise from 20,000 satellites that are plugged into the ionosphere will pollute the global electrical circuit that we are all plugged into. It will kill us, albeit slowly from numerous different diseases and disorders, and it must be stopped.

It isn't only the number of satellites but the number of customers they will serve that is the problem. A cell tower is more harmful than a radio station because instead of emitting just one signal it emits hundreds. Iridium is so impactful not only because it has 66 satellites but because it serves more than a million customers. Because of Iridium and Globalstar, standing barefoot on the earth is no longer as healthful and invigorating as it once was, anywhere on the planet. Grounding yourself increases the flow of qi through your body, but the qi now has electronic noise on it. SpaceX's initial goal is to sign up 40 million subscribers. If OneWeb signs up another 40 million, and one-tenth of the subscribers are online at any given time, electronic noise from an additional 8,000,000 signals, to start with, will pollute the global circuit. There are other equally serious environmental impacts from the intensive use of space.

PRESS INTIMIDATION AND SCIENCE SUPPRESSION IS REAL

STOP THE 5G ROLLOUT

For example, the rockets of both SpaceX and OneWeb will burn kerosene. Burning kerosene in space produces prodigious amounts of black soot, which accumulates in the stratosphere. Black carbon absorbs so much solar energy that its contribution to global warming is two million times greater per unit mass than carbon dioxide.

Just 35 launches of SpaceX's Falcon Heavy rocket per year would produce an amount of warming roughly equal to the amount of warming produced in a year by the world's one billion cars. This is an extrapolation from the estimates of Martin Ross of the Aerospace Corporation, which were made in 2012 when there were 25 launches per year of much smaller kerosene-burning rockets. (See: M. N. Ross and P. M. Sheaffer, "Radiative forcing caused by rocket engine emissions," Earth's Future 2: 177-196 (2014)).

As Ross points out, the problem of black soot could be solved, or at least reduced, by using a different type of fuel. The radiation problem, however, by definition cannot be solved, because the radiation is the product. The decision-makers and investors in these companies understand that they are playing with fire, and that what they are planning to do within the next two years will have fatal consequences, but short-term profit has always trumped sanity in our societies. Global capitalism on steroids is the motivating factor for short-term gain.

The Key Players For SpaceX:

Elon Musk, CEO & Chief Officer
Residence: Bel Air, CA
Gwynne Shotwell, President and COO
Residence: Rolling Hills Estates, CA
Bret Johnson, CFO

Board of Directors: David S. Kidder, CEO of Bionic Solutions, Rye, NY; Luke Nosek, founder and partner of Gigafund, San Francisco, CA; Antonio Gracias, founder, Valor Equity Partners, Chicago, IL; Donald Harrison, Google's president of Mountain View, CA global partnerships and corporate development; Kimbal Musk (Elon's younger brother), Boulder, CO; Barry Schuler, advisor, Napa, CA.

"The noise from 20,000 satellites that are plugged into the ionosphere will pollute the global electrical circuit that we are all plugged into. It will kill us, albeit slowly from numerous different diseases and disorders, and it must be stopped."

Lead Investors: Fidelity Investments, Abigail Johnson, CEO, Boston, MA; Google ($900 million); Nihal Mehta, founding partner of Eniac Ventures, New York, NY; Bracket Capital, Yalda Aoukar, CEO, London; For OneWeb Board of Directors, Greg Wyler, Founder and Chairman, Stuart, FL; Eric Béranger, CEO, Paris, France; Thomas Enders, CEO of Airbus, Toulouse, France; Paul E. Jacobs (also on board of Dropbox), Sacramento area; Alex Clavel, Head of Corporate Finance, SoftBank, Palo Alto, CA; Ohad Finkelstein, Co-Founder, Marker LLC., Israel; Ricardo Salinas, Founder of Grupo Salinas, Mexico City.

Large Investors

Stephen Spengler, CEO of Intelsat
Luxembourg

Jeff Bezos, CEO of Amazon, Medina, WA

Richard Branson, CEO Virgin Galactic
Brit Virgin Islands

Sunil Mittal, CEO of Bharti Enterprises
New Delhi, India

Dean Manson, Executive VP, Echo Star
Englewood, CO

Largest Customer

Darius Adamczyk, Honeywell CEO
Morris Plains, NJ

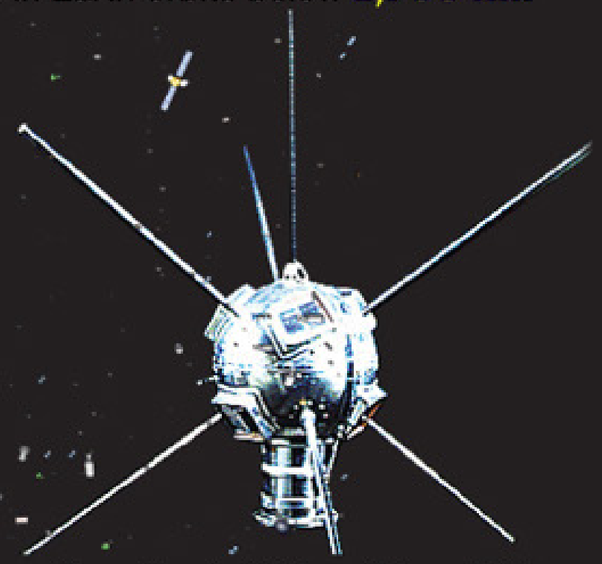
Dennis Muilenburg
Owner of Satellite License,
Boeing, CEO, Collinsville, IL.

All of these people have families and children and have a stake in the future of the Earth. Some — for example, **Kimbal Musk** and his wife, **Christiana** — are long-time advocates for the environment and investors in environmental causes. What is needed is a team of dedicated people who can raise funds, mobilize scientists, petition governments, and call and meet with environmental organizations. We need an opening into that community of billionaires to begin a dialogue that will save this planet. So I'm asking for your help — email me: jprager@rocketmail.com and put "5G" in the subject line. Tell me what you're willing to do to stop the 5G rollout. You can also contact:

Global Union Against
Radiation Deployment from Space
(GUARDS)
(505) 471-0129

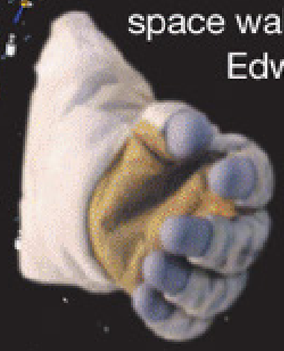
Space junk facts

In 2005 at least **13** nuclear reactor fuel cores, **eight** thermoelectric generators, and **32** nuclear reactors were known to be in Earth orbits below **1,700 km**



The oldest debris still in orbit is **Vanguard I**, America's second satellite, launched in **1958**

In **1965,** during the first American space walk, **Gemini 4** astronaut Edward White, lost a glove. For a month, the glove stayed in orbit with a speed of **28,000kph**, becoming the most dangerous garment in history



More than **200 objects**, most of which were bags of rubbish, were released by the Mir space station during its first **ten years** of operation

At any one time, as many as **ten million** pieces of human-made debris are estimated to be in orbit

A crash between a defunct Russian satellite and an Iridium Communications satellite in 2009 left around **1,500** pieces of junk whizzing around Earth at **7.8km** per second

INTRODUCTION

"The deployment of 5G constitutes
an experiment on humanity and the environment that is
defined as a crime under international law."

AN INTERNATIONAL APPEAL
STOP 5G ON EARTH AND IN SPACE

To the UN, WHO, EU, Council of Europe and governments of all nations:

We the undersigned scientists, doctors, environmental organizations and citizens from ten countries, urgently call for a halt to the deployment of the 5G (fifth generation) wireless network, including 5G from space satellites. 5G will massively increase exposure to radio frequency (RF) radiation on top of the 2G, 3G and 4G networks for telecommunications already in place. RF radiation has been proven harmful for humans and the environment. The deployment of 5G constitutes an experiment on humanity and the environment that is defined as a crime under international law (statement follows):

EMF effects are often cumulative

and EMFs impact young people more than adults

Telecommunications companies worldwide, with the support of governments, are poised within the next two years to roll out the fifth-generation wireless network or 5G. This is set to deliver what is acknowledged to be unprecedented societal change on a global scale. We will have "smart" homes, "smart" businesses, "smart" highways, "smart" cities and self-driving cars. Virtually everything we own and buy, from refrigerators and washing machines to milk cartons, hairbrushes and infants' diapers, will contain antennas and microchips and will be connected wirelessly to the Internet. Every person on Earth will have instant access to super-high-speed, low-latency wireless communications from any point on the planet, even in rain forests, mid-ocean and the Antarctic.

What is not widely acknowledged is that this will also result in unprecedented environmental change on a global scale. The planned density of radio frequency transmitters is impossible to envisage. In addition to millions of new 5G base stations on Earth and 20,000 new satellites in space, 200 billion transmitting objects, according to estimates, will be part of the Internet of Things by 2020, and one trillion objects a few years later. Commercial 5G at lower frequencies and slower speeds was deployed in Qatar, Finland and Estonia in mid-2018. The rollout of 5G at extremely high (millimeter wave) frequencies is planned to begin at the end of 2018.

Despite widespread denial, the evidence that radio frequency (RF) radiation is harmful to life is already overwhelming. The accumulated clinical evidence of sick and injured human beings, experimental evidence of damage to DNA, cells and organ systems in a wide variety of plants and animals, and epidemiological evidence that the major diseases of modern civilization — cancer, heart disease and diabetes — are in large part caused by electromagnetic pollution, forms a literature base of well over 10,000 peer-reviewed studies. Many are included here both in print and as references.

If the telecommunications industry's plans for 5G come to fruition, no person, no animal, no bird, no insect and no plant on Earth will be able to avoid exposure, 24 hours a day, 365 days a year, to levels of RF radiation that are tens to hundreds of times greater than what exists today, without any possibility of escape anywhere on the planet. These 5G plans threaten to provoke serious, irreversible effects on humans and permanent damage to all of the Earth's ecosystems — all living things.

Immediate measures must be taken to protect humanity and the environment, in accordance with ethical imperatives and international agreements.

5G will result in a massive increase in inescapable, involuntary exposure to wireless radiation.

Ground-Based 5G

In order to transmit the enormous amounts of data required for the Internet of Things (IoT), 5G technology, when fully deployed, will use millimeter waves, which are poorly transmitted through solid material. This will require every carrier to install base stations every 100 meters [1] (300 feet) in every urban area in the world. Unlike previous generations of wireless technology, in which a single antenna broadcasts over a wide area, 5G base stations and 5G devices will have multiple antennas arranged in "*phased arrays*" [2,3] that work together to emit focused, steerable, laser-like beams that track each other.

Each 5G phone will contain dozens of tiny antennas, all working together to track and aim a narrowly focused beam at the nearest cell tower. The US Federal Communications Commission (FCC) has adopted rules [4] permitting the effective power of those beams to be as much as 20 watts, ten times more powerful than the levels permitted for current phones. Each 5G base station will contain hundreds or thousands of antennas aiming multiple laser-like beams simultaneously at all cell phones and user devices in its service area. This technology is called "*multiple input multiple output*" or MIMO. FCC rules permit the effective radiated power of a 5G base station's beams to be as much as 30,000 watts per 100 MHz of spectrum, [2] or equivalently 300,000 watts per GHz of spectrum, tens to hundreds of times more powerful than the levels permitted for current base stations.

Space-Based 5G

At least five companies [5] are proposing to provide 5G from space from a combined 20,000 satellites in low- and medium-Earth orbit that will blanket the Earth with powerful, focused, steerable beams. Each satellite will emit millimeter waves with an effective radiated power of up to 5 million watts [6] from thousands of antennas arranged in a phased array. Although the energy reaching the ground from satellites will be less than that from ground-based antennas, it will irradiate areas of the Earth not reached by other transmitters and will be additional to ground-based 5G transmissions from billions of IoT objects. Even more importantly, the satellites will be located in the Earth's magnetosphere, which exerts a significant influence over the electrical properties of the atmosphere. The alteration of the Earth's electromagnetic environment may be an even greater threat to life than the radiation from ground-based antennas.

Even before 5G was proposed, dozens of petitions and appeals [7] by international scientists, including the Freiburger Appeal signed by over 3,000 physicians, called for a halt to the expansion of wireless technology and a moratorium on new base stations [8].

In 2015, 215 scientists from 41 countries communicated their alarm to the United Nations (UN) and World Health Organization (WHO) [9]. They stated that "*numerous recent scientific publications have shown that EMF [electromagnetic fields] affects living organisms at levels well below most international and national guidelines*". More than 10,000 peer-reviewed scientific studies demonstrate harm to human health from RF radiation [10,11] Effects include, but are not limited to:

- Alteration of heart rhythm [12]
- Altered gene expression [13]
- Altered metabolism [14]
- Altered stem cell development [15]
- Cancers [16]
- Cardiovascular disease [17]
- Cognitive impairment [18]
- DNA damage [19]
- Impacts on general well-being [20]
- Increased free radicals [21]
- Learning and memory deficits [22]
- Impaired sperm function and quality [23]
- Miscarriage [24]
- Neurological damage [25]
- Obesity and diabetes [26]
- Oxidative stress [27]

Effects in children include autism, [28] attention deficit hyperactivity disorder (ADHD) [29,30] and asthma [31]. Damage goes well beyond the human race, as there is abundant evidence of harm to diverse plant-life and wildlife [32,33] and laboratory animals, including, but not limited to:

- Ants [34]
- Birds [35,36]
- Forests [37]
- Frogs [38]
- Fruit flies [39]
- Honey bees [40]
- Insects [41]
- Mammals [42]
- Mice [43,44]
- Plants [45]
- Rats [46]
- Trees [47]

Negative microbiological effects [48] have also been recorded.

The WHO's International Agency for Research on Cancer (IARC) concluded in 2011 that RF radiation of frequencies 30 kHz - 300 GHz are possibly carcinogenic to humans (Group 2B) [49]. However, recent evidence, including the latest studies on cell phone use and brain cancer risks, indicate that RF radiation is proven carcinogenic to humans [50] and should now be classified as a "Group 1 carcinogen" along with tobacco smoke and asbestos.

Most contemporary wireless signals are pulse-modulated. Harm is caused by both the high-frequency carrier wave and the low-frequency pulsations [51].

The Deployment Of 5G Satellites Must Be Prohibited

The Earth, the ionosphere and the lower atmosphere form the global electric circuit [52] in which we live. It is well established that biological rhythms — of humans, [53,54] birds, [55] hamsters, [56] and spiders [57,58] — are controlled by the Earth's natural electromagnetic environment and that the well-being of all organisms depends on the stability of this environment, including the electrical properties of the atmosphere. [59 , 60 , 61 , 62]. Cherry, in a groundbreaking paper, [63] explained the importance of the Schumann resonances [64] and why ionospheric disturbances can alter blood pressure and melatonin and cause "*cancer, reproductive, cardiac and neurological disease and death*".

These elements of our electromagnetic environment have already been altered by radiation from power lines. Power line harmonic radiation [65] reaches the Earth's ionosphere and magnetosphere, where it is amplified by wave-particle interactions [66,67]. In 1985, Dr. Robert O. Becker warned that power line harmonic radiation had already changed the structure of the magnetosphere, and that the continued expansion of this effect "*threatens the viability of all life on Earth*" [68]. The placement of tens of thousands of satellites directly in both the ionosphere and magnetosphere, emitting modulated signals at millions of watts and millions of frequencies, is likely to alter our electromagnetic environment beyond our ability to adapt [69].

Informal monitoring has already provided evidence indicating serious effects on humans and animals from the approximately 100 satellites that have provided 2G and 3G phone service from low orbit since 1998. Such effects cannot be understood only from consideration of the low levels of radiation on the ground. Knowledge from other relevant scientific disciplines must be taken into account, including the fields of atmospheric physics and acupuncture (70,71,72,73). Adding 20,000 5G satellites will further pollute the global electric circuit (74,75) and could alter the Schumann resonances, (76) with which all life on Earth has evolved. The effects will be universal and may be profoundly damaging.

5G Is Qualitatively And Quantitatively Different From 4G

The idea that we will tolerate tens to hundreds of times more radiation at millimeter wavelengths is based on faulty modeling of the human body as a shell filled with a homogeneous liquid [77,78]. The assumption that millimeter waves do not penetrate beyond the skin completely ignores nerves, [79] blood vessels [80,81] and other electrically conducting structures that can carry radiation-induced currents deep into the body [82,83,84]. Another, potentially more serious error is that phased arrays are not ordinary antennas. When an ordinary electromagnetic field enters the body, it causes charges to move and currents to flow. But when extremely short electromagnetic pulses enter the body, something else happens: the moving charges themselves become little antennas that re-radiate the electromagnetic field and send it deeper into the body. These re-radiated waves are called Brillouin precursors [85]. They become significant when either the power or the phase of the waves changes rapidly enough [86]. 5G will probably satisfy both criteria.

In addition, shallow penetration in itself poses a unique danger to eyes and to the largest organ of the body, the skin, as well as to very small creatures. Peer-reviewed studies have recently been published, predicting thermal skin burns [87] in humans from 5G radiation and resonant absorption by insects, [88] which absorb up to 100 times as much radiation at millimeter wavelengths as they do at wavelengths presently in use. Since populations of flying insects have declined by 75-80 per cent since 1989 even in protected nature areas, [89] 5G radiation could have catastrophic effects on insect populations worldwide. A 1986 study by Om Gandhi warned that millimeter waves are strongly absorbed by the cornea of the eye, and that ordinary clothing, being of millimeter-size thickness, increases the absorption of energy by the skin by a resonance-type effect [90]. Russell (2018) reviews the known effects of millimeter waves on skin, eyes (including cataracts), heart rate, immune system and DNA [91].

Regulators Have Deliberately Excluded The Scientific Evidence Of Harm

Stakeholders thus far in the development of 5G have been industry and governments, while renowned international EMF scientists who have documented biological effects on humans, animals, insects and plants, and alarming effects on health and the environment in thousands of peer-reviewed studies have been excluded. The reason for the current inadequate safety guidelines is that conflicts of interest of standard-setting bodies "*due to their relationships with telecommunications or electric companies undermine the impartiality that should govern the regulation of Public Exposure Standards for non-ionizing radiation*" [92]. Professor Emeritus Martin L. Pall lays out the conflicts of interest in detail, and the lists of important studies that have been excluded, in his literature review [93].

The Thermal Hypothesis Is Obsolete – New Safety Standards Are Needed

Current safety guidelines are based on the obsolete hypothesis that heating is the only harmful effect

of EMFs. As Markov and Grigoriev have stated, "***Today standards do not consider the real pollution of the environment with non-ionizing radiation***" [94]. Hundreds of scientists, including many signatories to this appeal, have proven that many different kinds of acute and chronic illnesses and injuries are caused without heating ("non-thermal effect") from radiation levels far below international guidelines [95]. Biological effects occur even at near-zero power levels. Effects that have been found at 0.02 picowatts (trillionths of a watt) per square centimeter or less include altered genetic structure in E. coli [95] and in rats, [96] altered EEG in humans, [97] growth stimulation in bean plants, [98] and stimulation of ovulation in chickens [99].

To protect against non-thermal effects, duration of exposure must be considered. 5G will expose everyone to many more transmissions simultaneously and continuously, day and night without cessation. **New safety standards are needed and should be based on cumulative exposure and not only on power levels but also on frequency, bandwidth, modulation, waveform, pulse width and other properties that are biologically important.** Antennas must be confined to specific, publicly identified locations. To protect humans, antennas must be located far from where people live and work, and excluded from the public rights-of-way where people walk. To protect wildlife, they must be excluded from wilderness sanctuaries and strictly minimized in remote areas of the Earth. To protect all life, commercial communications satellites must be limited in number and prohibited in low- and medium-Earth orbits. Phased arrays must be prohibited on Earth and in space.

RF Radiation Has Both Acute And Chronic Effects

RF radiation has both immediate and long-term effects. Cancer and heart disease are examples of long-term effects. Alteration of heart rhythm [100] and changes in brain function (EEG) [101] are examples of immediate effects. A syndrome that was called radiowave sickness [102] in the former Soviet Union and is called electromagnetic hypersensitivity (EHS) around the world today [103] can be either acute or chronic. Professor Dr. Karl Hecht has published a detailed history of these syndromes, compiled from a review of more than 1,500 Russian scientific papers and the clinical histories of more than 1,000 of his own patients in Germany. Objective findings include sleep disorders, abnormal blood pressure and heart rate, digestive disorders, hair loss, tinnitus and skin rash. Subjective symptoms include dizziness, nausea, headache, memory loss, inability to concentrate, fatigue, flu-like symptoms and cardiac pain [104].

"5G will expose everyone to many more transmissions simultaneously and continuously, day and night without cessation."

The EUROPAEM EMF Guideline 2016 states that EHS develops when people are "*continuously exposed in their daily life*" to increasing levels of EMFs, and that "*reduction and prevention of EMF exposure*" is necessary to restore these patients to health [105]. EHS should no longer be considered a disease, but an injury by a toxic environment that affects an increasingly large portion of the population, estimated already at 100 million people worldwide, [106,107] and that will soon affect everyone on earth [108] if the worldwide rollout of 5G is permitted.

The International Scientific Declaration on EHS and multiple chemical sensitivity (MCS), Brussels, declared in 2015 that "***[i]naction is a cost to society and is not an option any more ... [W]e unanimously acknowledge this serious hazard to public health ... [urgently requiring] that major primary prevention measures are adopted and prioritized, to face this worldwide pan-epidemic in perspective***" (emphasis added) [109].

World Governments Are Failing In Their Duty Of Care To The Populations They Govern

In their haste to implement 5G and to encourage the unconstrained use of outer space, the European Union, United States and national governments worldwide are taking steps to ensure a "*barrier-free*" regulatory environment [110]. They are prohibiting local authorities from enforcing environmental laws, [111] and "*in the interest of speedy and cost-effective deployment*", removing "*unnecessary burdens ... such as local planning procedures [and] the variety of specific limits on electromagnetic field (EMF) emissions and of the methods required to aggregate them*" [112].

Governments are also enacting laws to make wireless facilities a permitted use in all public rights-of-way [113]. To date, most wireless facilities have been located on private property at some distance from homes and businesses. In order for them to be spaced less than 100 meters (300 feet) apart as required by 5G, however, they will now be located on the sidewalk directly in front of homes and businesses and close above the heads of pedestrians, including mothers with babies.

Public notice requirements and public hearings are being eliminated. Even if there were a hearing and 100 scientific experts were to testify against 5G, laws have been passed making it illegal for local authorities to take their testimony into consideration. US law, for example, prohibits local governments from regulating wireless technology "*on the basis of the environmental effects of radio frequency radiation*", [114] and courts have reversed regulatory decisions about cell tower placement simply because most of the public testimony was about health [115]. Insurers will not provide coverage against EMF risks, [116] and there is zero clarity as to what entity will bear legal responsibility for damage to life, limb and property arising from exposure to 5G, whether ground- or space-based [117].

In the absence of an agreed comprehensive legal regime governing activities in outer space, legal liability for those activities is non-existent, despite the prospect of whole continents, the atmosphere and the oceans being put at risk by them.

International Agreements Are Being Violated
~ Children And Duty Of Care ~

The United Nations Convention on the Rights of the Child: States shall "*undertake to ensure the child such protection and care as is necessary for his or her well-being*" (art. 3), "*ensure ... the survival and development of the child*" (art. 6) and "*take appropriate measures to combat disease ... taking into consideration the dangers and risks of environmental pollution*" (art. 24(c)).

The Nuremberg Code (1949) applies to all experiments on humans, thus including the deployment of 5G with new, higher RF radiation exposure that has not been pre-market tested for safety. "*The voluntary consent of the human subject is absolutely essential*" (art. 1). Exposure to 5G will be involuntary. "*No experiment should be conducted, where there is an a priori reason to believe that death or disabling injury will occur*" (art. 5). The findings of over 10,000 scientific studies and the voices of hundreds of international

organizations representing hundreds of thousands of members who have suffered disabling injury and been displaced from their homes by already-existing wireless telecommunications facilities, are "*a priori reasons to believe that death or disabling injury will occur*".

Duty To Inform And EMFs

The World Telecommunication Standardization Assembly (2012) of the International Telecommunication Union (ITU) stated that "*[t]here is a need to inform the public of the potential effects of exposure to electromagnetic fields (EMFs)*" and invited Member States "*to adopt suitable measures in order to ensure compliance with relevant international recommendations to protect health against the adverse effect of EMF*".

The Mid-term review of the European Environment and Health Action Plan 2004-2010 (2008): "***The European Parliament ... [n]otes that the limits on exposure to electromagnetic fields which have been set for the general public are obsolete, ... obviously take no account of developments in information and communication technologies, of the recommendations issued by the European Environment Agency or of the stricter emission standards adopted, for example, by Belgium, Italy and Austria, and do not address the issue of vulnerable groups, such as pregnant women, newborn babies and children.***"

Resolution 1815 (Council of Europe, 2011): "***Take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people.***"

Environment

The Declaration of the United Nations Conference on the Human Environment (1972): "***The discharge of toxic substances ... in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems***" (principle 6).

Objective findings include sleep disorders, abnormal blood pressure and heart rate, digestive disorders, hair loss, tinnitus and skin rash. Subjective symptoms include dizziness, nausea, headache, memory loss, inability to concentrate, fatigue, flu-like symptoms and cardiac pain.

The World Charter for Nature (1982): "***Activities which are likely to cause irreversible damage to nature shall be avoided ... [W]here potential adverse effects are not fully understood, the activities should not proceed***" (art. 11). The Rio Declaration on Environment and Development (1992): "***States have ... the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction***" (principle 2). The United Nations World Summit on Sustainable Development (2002): "***There is an urgent need to ... create more effective national and regional policy responses to environmental threats to human health***" (para. 54(k)).

The African Convention on the Conservation of Nature and Natural Resources (2017): "***The Parties shall ... take all appropriate measures to prevent, mitigate and eliminate to the maximum extent possible, detrimental effects on the environment, in particular from radioactive, toxic, and other hazardous substances and wastes***" (art. 13).

Health And Human Rights

The Universal Declaration of Human Rights: "***Everyone has the right to life, liberty and security of person***" (art. 3).

The United Nations Global Strategy for Women's, Children's and Adolescents' Health (2016-2030) has as objectives and targets to "*transform*", by expanding enabling environments; to "*survive*", by reducing maternal and newborn mortality; and to "*thrive*" by ensuring health and well-being and reducing pollution-related deaths and illnesses.

Space

The Outer Space Treaty (1967) requires that the use of outer space be conducted "***so as to avoid [its] harmful contamination and also adverse changes in the environment of the Earth***" (art. IX).

The United Nations Guidelines for The Long-Term Sustainability of Outer Space Activities (2018): "***States and international intergovernmental organizations should address ... risks to people, property, public health and the environment associated with the launch, in-orbit operation and re-entry of space objects***" (guideline 2.2(c)).

World Governments Are Playing Dice With Life On Earth

Albert Einstein famously asserted that "*God does not play dice*" [118]. Yet by pursuing the broadcast on Earth and from space of 5G, an unprecedented technology of millimeter waves previously used as an energy weapon in military operations and crowd control, [119] world governments are recklessly playing dice with the future of life on Earth.

To refuse to accept and apply relevant and valid scientific knowledge is ethically unacceptable. Existing research shows that 5G — and especially space-based 5G — contravenes principles enshrined in a host of international agreements.

We Call Upon The UN, WHO, EU, Council Of Europe And Governments Of All Nations:

(a) To take immediate measures to halt the deployment of 5G on Earth and in space in order to protect all humankind, especially the unborn, infants, children, adolescents and pregnant women, as well as the environment;

(b) To follow the United Nations Convention on the Rights of the Child and Council of Europe Resolution 1815 by informing citizens, including teachers and physicians, about the health risks (to adults and children) from RF radiation, and why they should and how they can avoid wireless communication and base stations, particularly in or near day-care centers, schools, hospitals, homes and workplaces;

(c) To favor and implement wired telecommunications instead of wireless;

(d) To prohibit the wireless/telecommunications industry through its lobbying organizations from persuading officials to make decisions permitting further expansion of RF radiation, including ground- and space-based 5G;

(e) To appoint immediately — without industry influence — international groups of independent, truly impartial EMF and health scientists with no conflicts of interest,[120] for the purpose of establishing new international safety standards for RF radiation that are not based only on power levels, that consider cumulative exposure, and that protect against all health and environmental effects, not just thermal effects and not just effects on humans;

(f) To appoint immediately — without industry influence — international groups of scientists with expertise in EMFs, health, biology and atmospheric physics, for the purpose of developing a comprehensive regulatory framework that will ensure that the uses of outer space are safe for humans and the environment, taking into account RF radiation, rocket exhaust gases, black soot, and space debris and their impacts on ozone, [121] global warming, [122] the atmosphere and the preservation of life on Earth. Not only ground-based but also space-based technology must be sustainable [123] for adults and children, animals and plants.

Please respond to the Appeal Administrator listed below detailing the measures you intend to take to protect the global population against RF radiation exposure, especially 5G radiation. This appeal and your response will be publicly available on www.5gSpaceAppeal.org. Respectfully submitted,Arthur Firstenberg, Appeal Administrator, info@5gSpaceAppeal.org

Initial Signatories

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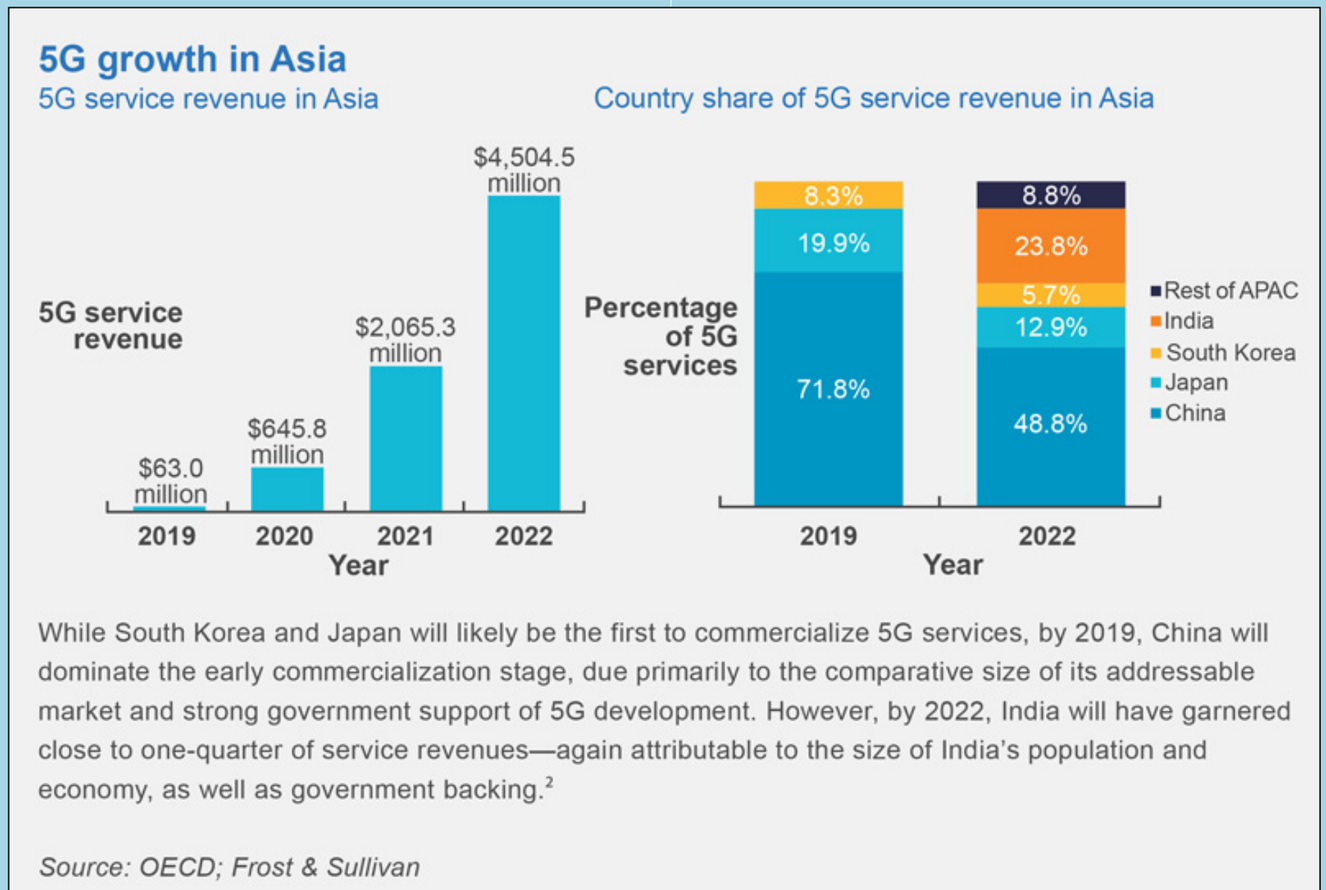

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120. Conflicts of interest have frequently arisen in the past. For example, the EU Commission (2008/721/EC) appointed industry-supportive members for SCENIHR who submitted to the EU a misleading SCENIHR report on health risks, which gave the telecommunications industry carte blanche to irradiate EU citizens. The report is now quoted by radiation safety agencies in the EU. Another example is the US National Toxicology Program contracting with the IT'IS Foundation, which is funded by the entire telecommuni- cations industry, to design, build and monitor the exposure facility for a two-year, 25-million-US-dollar study of cell phones. It subsequently produced a misleading report that is now quoted by industry officials in the US.
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THE SPACE ECONOMY: A MODERN DAY GOLD RUSH

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- 1,500 — EASIER TO REACH THAN MOON
- 8,800 — DISCOVERED TO DATE
- 1000+ — NEARLY 1K+ FOUND EVERY YEAR

PLATINUM-RICH ASTEROID

Could contain more Platinum Group Metals than **what's been mined on Earth in all of history**

NEAR-INFINITE SUPPLY OF PRECIOUS RESOURCES

WATER-RICH ASTEROID

One water-rich asteroid could produce **enough fuel for every rocket launched in history.**

USES OF WATER IN SPACE

- ROCKET **FUEL**
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ELECTRIFY TRANSPORTATION

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Asteroid mining will open a trillion-dollar industry and provide a **near-infinite supply** of Platinum Group Metals and water to **support our growth** both on this planet and off.

PLANETARY RESOURCES

5G EFFECTS

Impaired sperm function and quality
Altered stem cell development
Impacts on general well-being
Learning and memory deficits
Altered gene expression
Cardiovascular disease
Increased free radicals
Cognitive impairment
Neurological damage
Obesity and diabetes
Altered metabolism
Oxidative stress
DNA damage
Miscarriage
Cancers

5G

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5G Wireless Telecommunications Expansion: Public Health And Environmental Implications

by Cindy L. Russell

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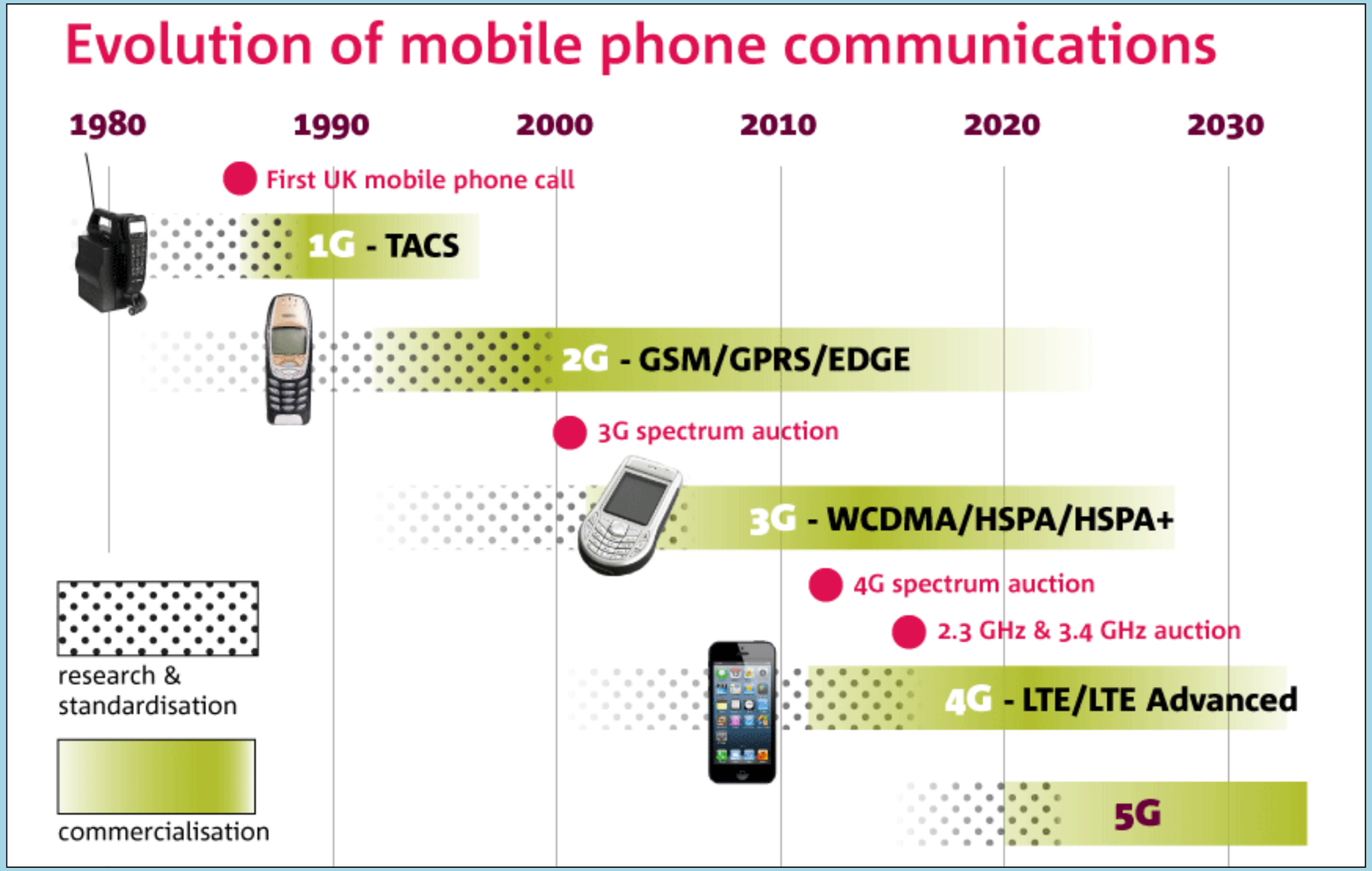


Results

3.1. Controversy persists as evidence of harm increases

The controversy over health effects of radiofrequency electromagnetic radiation (RF EMR) from commonly used wireless devices such as cell phones, cordless phones, WiFi routers and cell tower infrastructure remains problematic. RF research in the U.S. is poorly funded and even when a study is robust it never seems to answer the question of long term safety or provide appropriate precautionary limits. (Wyde, 2016).

In 2011 the International Agency on Research on Cancer (IARC) listed non-ionizing radiofrequency radiation from cell phones and other wireless devices in Group 2B: Possibly carcinogenic to humans, based on a thorough analysis of current scientific evidence (IARC, 2011; IARC, 2017).

Some researchers feel this listing should be changed to a Group 2A: Probably carcinogenic to humans or to Group 1: Carcinogenic to humans classification (Morgan et al., 2015; Sage and Carpenter, 2012). This is based on the recent National Toxicology Program Carcinogenicity Studies of Cell Phone Radiofrequency Radiation that report a significant increase in heart and brain tumors with RF-EMR exposure (Wyde, 2016).

This is in addition to the abundance of basic scientific studies that show a clear health risk associated with exposure to radiofrequencies, especially with long term exposure (Hardell et al., 2013a, 2013b; Adams et al.al., 2014; Bortkiewicz et al., 2017; Carlberg and Hardell, 2017; Hassanshahi et al., 2017; Liu et al., 2014; Levitt and Lai, 2010).

Many of these studies demonstrate effects well below the heat threshold of current safety standards (Wyde, 2016; IARC, 2011; Sage and Carpenter, 2012; EPA, 1992; Esmekaya et al., 2011; Grigoriev et al., 2010; Belyaev, 2005; Yu and Yao, 2010).

Radiofrequencies are absorbed by and pass through living systems that contain water. Pregnant women and children are more vulnerable to developmental harm from microwave radiation due to immature organ sys-

tems (Birks et al., 2017; Othman et al., 2017a, 2017b). Research also shows children absorb more microwave radiation per body weight than an adult, however, standards were developed for adult bodies (Morgan et al., 2014).

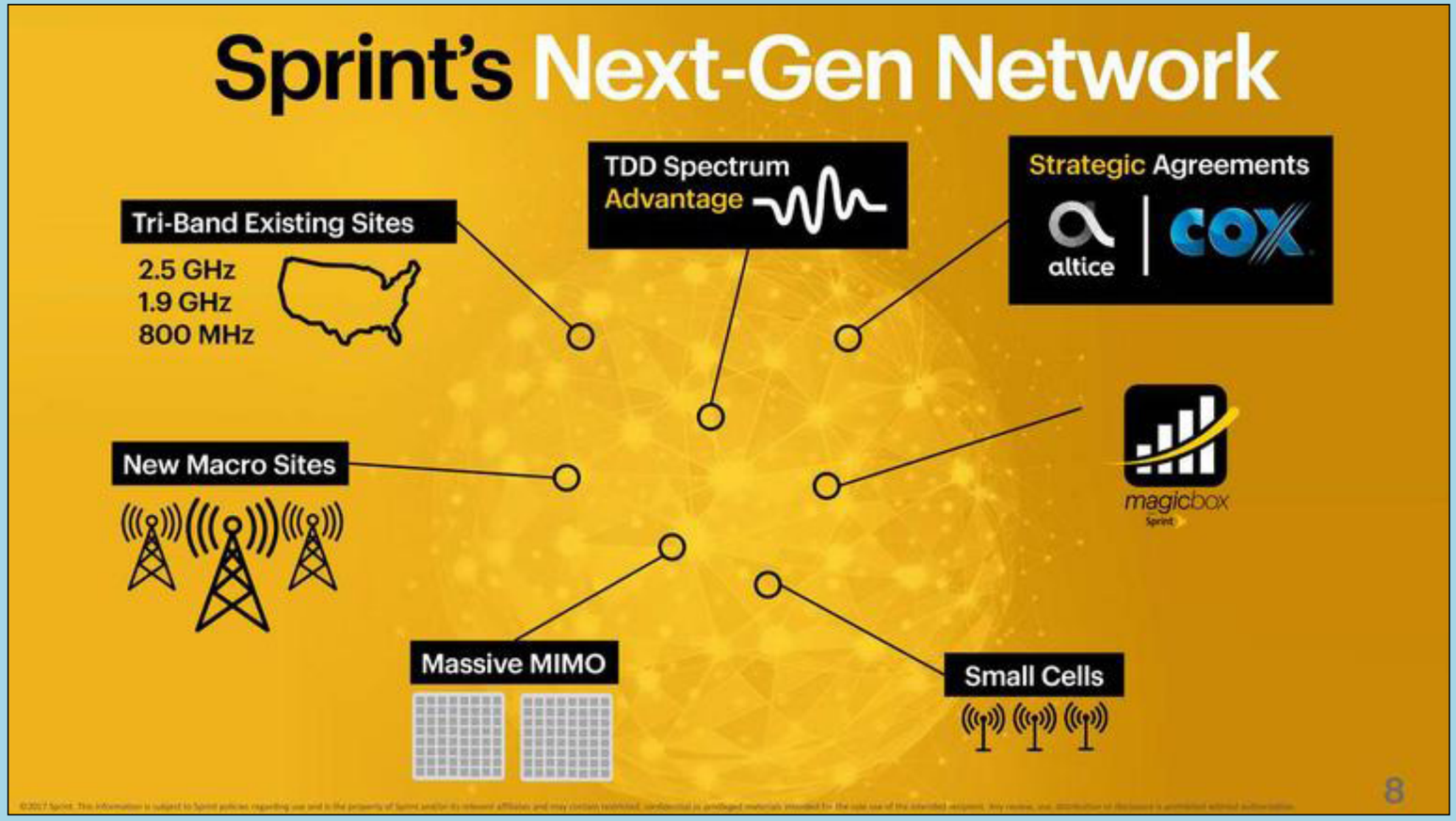
3.1.1. Industry bias and scientific results

Industry continues to state that the weight of evidence regarding harm from RF-EMR is inconclusive. Studies that review the sources of funding and scientific bias regarding cell phones and brain cancer indicate otherwise. Huss et al. (2007) performed a systematic review regarding the association of cell phone use and brain tumors in relation to funding. He found that industry studies showed a positive association 33% of the time, whereas non-industry studies showed an 82% association. In addition, they discovered that none of the 31 peer reviewed journals listed conflicts of interest for the authors.

Myung et al. (2009) performed a meta-analysis and found that there was a small but significant elevation in brain tumors with long term cell phone use when high quality studies were examined. He noted Hardell's research to be more robust, as "*all of the studies by Hardell et al. used blinding to the status of patient cases or controls at the interview and were categorized as having a high methodologic quality when assessed based on the NOS, whereas most of the INTERPHONE-related studies and studies by other groups did not use blinding and were thus categorized as having low methodologic quality*".

Prasad et al. (2017) investigated the results of 22 case-controlled studies which showed an increased risk of brain tumor with long-term exposure to mobile phone radiation while industry-funded research tended to underestimate the risk.

An analysis of the Interphone study by Morgan (2009) noted eleven design flaws, including1) selection bias, 2) insufficient latency time, 3) definition of 'regular' cellphone user, 4) exclusion of young adults and children, 5) no cosideration for cell phone exposure in rural areas where they would be radiating at higher power levels, 6) exposure to other transmitting sources are excluded, 7) exclusion of brain tumor types, 8) recall accuracy of cellphone use, and 9) funding bias.



In the first court case to award damages to a plaintiff for a brain tumor caused by cell phones, an Italian court excluded cancer-based studies related to cellphones that had been financed by telecommunications companies., according to a news articles (Williams, 2017).

3.2. Current Federal Communications Commission (FCC) radiofrequency guidelines

Physicists and engineers point out that non-ionizing radiofrequency radiation, which we use in

modern telecommunications today, has too low an energy unit per photon to move electrons in an atom, causing ionization, as seen with radiation from X-rays and radioactive materials (WHO, 1981). They argue that heat is the only measure of harm which is meaningful with regards to health and safety of RF EMR. ***Scientists, however, have elucidated other mechanisms whereby cellular functioning can be disrupted by non-thermal exposures to radiofrequency radiation.***

Current FCC Guidelines for non-ionizing radiation exposure ***were developed over two decades ago*** and are based on heating of tissues over short exposure periods (6 minutes for occupational/controlled and 30 minutes for public/uncontrolled exposure) (FCC, 1997, 2015; FCC, 2013). There are no long term exposure guidelines, nor are there guidelines for low level, non-thermal or biological effects considered in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards which are the basis for standards used worldwide (ICNIRP, 2009; Hardell, 2017).

With the passage of the federal Telecommunication Act of 1996 responsibility for safety of non-ionizing radiation was passed from the EPA to the FCC (1996). At the time, the EPA was preparing recommendations for long term exposure which were not included in the FCC guidelines (EPA, 1981; EPA, 1992). In a 1993 scientific conference sponsored by the US EPA Office of Air and Radiation and the Office of Research and Development, the EPA discussed its concerns about public RF exposure and the need for additional research. The report noted health issues that remained unsolved including "***potential effects of long term, low level exposure; and biophysical mechanisms.***" (EPA, 1993).

A World Health Organization summary of Environmental Health Criteria from a Warsaw conference in 1973 stated "*More data on the relationship between biological and health effects and the frequency and mode of generation of the radiation, particularly in complex modulations, are needed*." They further state, "*Prevention of potential hazards is a more efficient and economical way of achieving control than belated efforts to reduce existing levels.*" (WHO, 1981).

Sage and Carpenter, among others, note that for adequate public health protection a biological safety standard is needed that considers current research indicating cellular harm, long term effects of constant exposure and effects on vulnerable populations (Sage and Carpenter, 2012; Blank et al., 2015).

FCC recommendations have not been updated to include current literature on cellular affects at levels below FCC guidelines or effects of long term exposure (EPA Letter, 2002). It is notable that Section 704 of the 1996 Telecommunications Act specifies the following: "*Section 704(a) of the 1996 Act expressly preempts state and local government regulation of the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the FCC's regulations concerning such emissions (FCC, 1996).*" This policy directly contradicts current evidence of harm.

3.3. The science of biological harm from non-ionizing radiation

A growing body of scientific literature documents evidence of non-thermal cellular damage from non-ionizing wireless radiation used in telecommunications. This RF EMR has been shown to cause an array of adverse effects on DNA integrity, cellular membranes, gene expression, protein synthesis, neuronal function, the blood brain barrier, melatonin production, sperm damage and immune dysfunction (Dasdag et al., 2015a; Dasdag et al., 2015a, 2015b; La Vignera et al.al., 2012; Levine et al.al., 2017). Human health effects associated with wireless radiation include infertility, neurodegenerative changes and brain cancer (Wyde, 2016; IARC, 2011) (; Sage and Carpenter, 2012; Kim et al., 2017; Kesari et al., 2011; Kesari et al., 2012a, 2012b; Zhang et al., 2016; Agarwal et al., 2011, 2008; Al-Quzwini et al., 2016; Banik, 2003; Consales, 2012; D'Andrea and Chalfin, 2000; Desai et al., 2009: Prasad et al., 2017).

In addition, electrosensitivity to wireless and electrical devices is being increasingly recognized by scientists and physicians (Hojo et al., 2016; Singh and Kapoor, 2014; Belpomme et al., 2015). A biologically based standard has been recommended with a scientific benchmark to a "*lowest observable effect level*" for RF EMR at 0.003 uW/cm2 (Sage and Carpenter, 2012). There is also growing evidence of harm to trees, wildlife and other biosystems (Sivani and Sudarsanam, 2013).

3.3.1. Oxidation mechanism of cellular harm

A well-studied potential mechanism of harm from radiofrequency radiation is one of cellular oxidation. Healthy biological systems require a balance of oxidation and antioxidation to fight infection and prevent disease (44, 45, 46). A review of the literature by Yakymenko et al. (2016) confirmed that in 93 of 100 studies, non-ionizing radio-frequency radiation caused a cellular stress response with excessive reactive oxygen species. He concluded, "*oxidative stress induced by RFR exposure should be recognized as one of the primary mechanisms of the biological activity of this kind of radiation*."

Reactive oxygen species (ROS) are a normal part of cellular processes and cell signaling. Overproduction of ROS that is not balanced with either endogenous antioxidants (superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), glutathione (GSH), melatonin), or exogenous antioxidants (Vitamin C, Vitamin E, carotenoids, polyphenols) allows the formation of free radicals that oxidize and damage DNA, proteins, membrane lipids and mitochondria. Mitochondrial DNA is more susceptible to DNA damage than nuclear DNA as it lacks histones, has a reduced ability to repair DNA, and is not protected from mitochondrial reactive oxygen species (Görlach et al., 2015). Excess ROS have been associated with exposure to toxic chemicals, pesticides and metals (Abdollahi et al., 2004; Sharma et al., 2014: Drechsel and Patel, 2008). Oxidative damage from ROS has been increasing linked to the development and/or exacerbation of a number of chronic diseases and cancer (Thannickal and Fanburg, 2000; Valko et al., 2006; Bouayed and BohnBohn, 2010; Görlach et al., 2015; Alfadda and Sallam, 2012).

3.3.2. Electrosensitivity

An increasing number of people are reporting a variety of symptoms with exposure to wireless devices and infrastructure, including headaches, insomnia, dizziness, nausea, lack of concentration, heart palpitations and depression. These are now recognized as signs of electrosensitivity or electromagnetic hypersensitivity. A personal communication and case history was recently described by Dr. Scott Eberle, a hospice physician who, after an inciting event, became electrosensitive, and discovered his continuing physical symptoms were due to wireless radiation from his computer and cell phone. (Eberle, 2014; Eberle, 2014, 2017). Reports of electrosensitivity with these non-specific but sometimes debilitating symptoms have incidences from 1.5% of the population in Sweden to 13.3% of the population in Taiwan (Hedendahl et al., 2015).

The United States Access Board recognizes "*that multiple chemical sensitivities and electromagnetic sensitivities may be considered disabilities under the ADA if they so severely impair the neurological, respiratory or other functions of an individual that it substantially limits one or more of the individual's major life activities.*" (ADA, 2014).

It is notable that these same symptoms were described in military personnel working near radar communications systems. A 1981 NASA report, "*Electromagnetic Field Interactions: Observed Effects and Theories*", described microwave sickness with a host of symptoms recorded, including headaches, eyestrain, fatigue, dizziness, disturbed sleep at night, sleepiness in daytime, moodiness, irritability, unsociability, hypochondriac reactions, feelings of fear, nervous tension, mental depression, memory impairment, pulling sensation in the scalp and brow, loss of hair, pain in muscles and heart region, breathing difficulties, and increased perspiration of extremities (NASA, 1981).

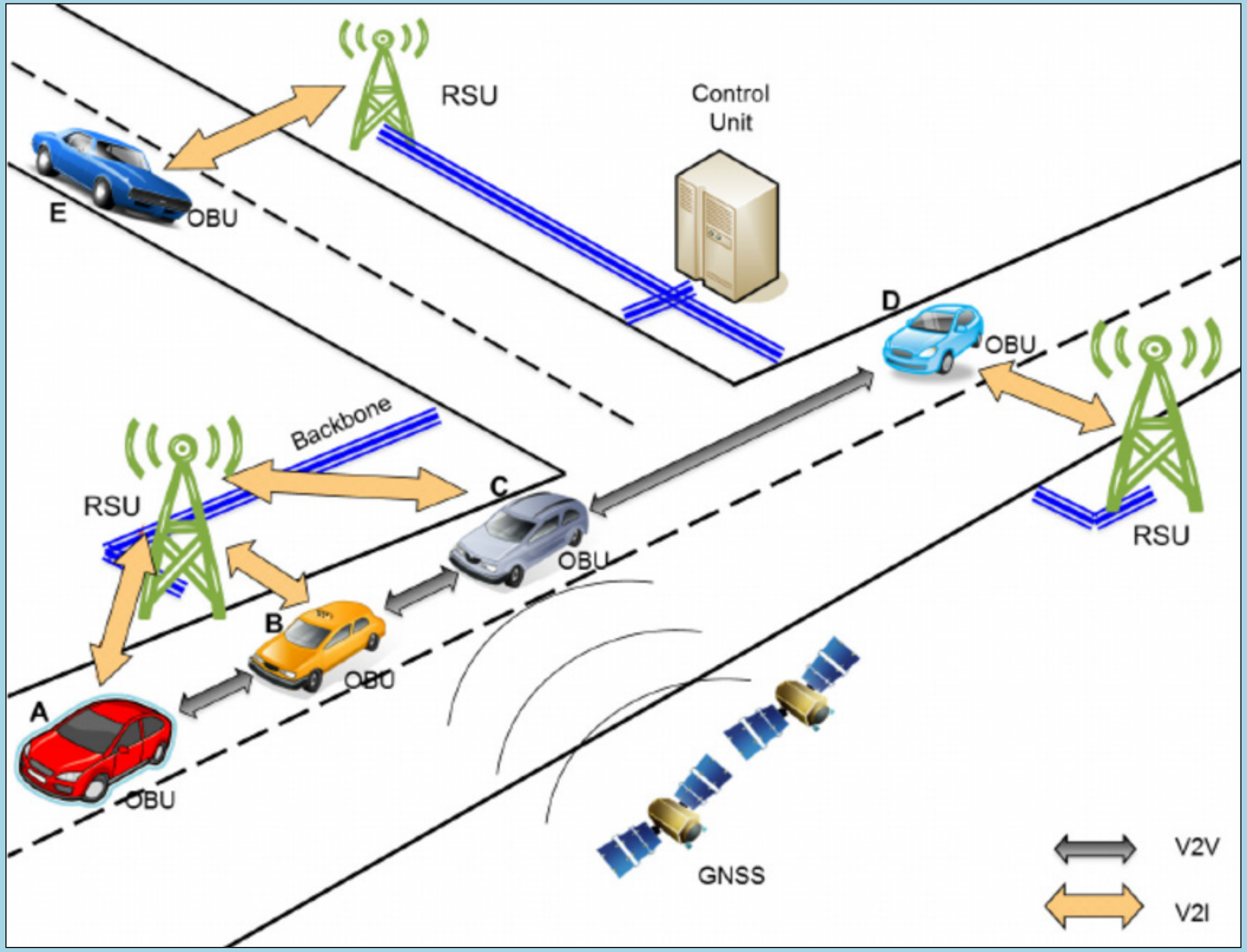
3.4. 5G technology would be a mix of microwave frequencies

The vision of the next generation of communications technology, 5G, is to have instantaneous delivery of large volumes of multimedia content over a seamless wireless connection anywhere at any time (Chávez-Santiago et al., 2015; Greenemeier, 2015). To do this, new high frequency, faster delivery bands and a wider spectral bandwidth would need to be allocated in the 6–100 GHz range. Because the shorter frequencies transmit across short distances (hundreds of meters), a dense network of cellular antennas would need to be deployed throughout cities and neighborhoods, including extensive battery backup systems.

This system proposes to be additive with a blended architecture. Plans are in the works to adopt underused licensed frequencies throughout the spectrum. It will be a network of networks, with multiple layers of frequencies, multiple devices, and multiple user interactions (Jacobfeuerborn, 2015). Small cell deployments can be used as high capacity Wi-Fi hotspots forming an outdoor mesh network with an intergenerational mix of communications networks with 5G added later. It is not a completely new technology which will be deployed, according to Chavez-Santiago et al. (2015), but a "*spectrum-usage combination*."

3.4.1. 5G deployment by 2020

The start of commercial deployment of 5G systems is expected in 2020 with rapid expansion thereafter "*to support more than one thousand times today's mobile traffic volume*" (Chávez-Santiago et al., 2015). The development of this technology has been underway for several years with research and development funding from many sources. Public, private and academic partnerships have been developed to advance this initiative. There is a race for R&D with significant resources invested with expected much higher return on investment. In 2012, the University of Surrey in the United Kingdom secured £35 million



in funding for the 5G Innovation Centre, 5GIC, which offers testing facilities to mobile operators developing spectrum technologies. This year they announced their first 5G digital gaming initiative (University of Surrey, 2017). 5G Americas are planning to boost development of broadband technologies in Latin America as well (FCC Letter, 2016; 5G Americas, 2017).

3.4.2. Are there downsides to 5G telecommunications technology?

Industry papers discussing 5G, talk about markets, business models, and start-ups. New white papers have focused on needs for public safety, emergency response and earthquake preparedness. How much benefit will there really be for adding all this hyper-connecting technology compared to public health and environmental consequences? A more thorough investigation is needed with all the downsides included in the analysis, including E-Waste, global climate change, toxics emissions, occupational safety, privacy, security, public safety from wide-spread battery backup systems, and most critically, direct human health and environmental risks. We already have the 911 call system and satellite communications for emergencies. If this technology is adopted we will lose our critical copper landline wires that are safer, more secure, and require no battery backups. Regulations regarding cost, access and usage of this widespread internet system have yet to be determined. Health and psychosocial effects are largely absent from business discussions.

3.4.3. More antennas and more frequencies are needed for a seamless connection

5G millimeter waves (MMW) are extremely high-frequency (30–300GHz) electromagnetic radiation. In general, the longer the wavelength the longer it travels and the farther apart broadcast stations are placed. The 5G short, higher frequency, millimeter wavelengths travel shorter distances (a few hundred meters) thus to achieve a seamless integrated wireless system the "*small cell*" antenna are proposed to be placed about every 250 meters. The exact frequencies of MMW desired for the next-generation of high-speed wireless technologies are not yet configured but industry letters to the FCC seek to open all the frequencies up to 100 GHz, with some suggesting even higher frequencies (FCC Letter 5G Americas). These MMW frequencies will be mixed with current longer microwave frequencies to achieve integration of systems. At higher power densities, cell tower studies show that symptoms of electrosensitivity occur within about 300 meters of a cell tower (Santini et al., 2002; Zothansiama et al., 2017). The added frequencies and close proximity of small cell antenna in this dense network are a valid concern for residents. MMW are absorbed by anything with water such as foliage thus causing attenuation of the signals and making connections with the system line of sight only (Rappaport and Deng, 2015). Millimeter waves also do not penetrate walls. This has been a problem for designers, who are still trying to figure out a solution.

3.4.4. FCC exposure limits for 5G millimeter waves

SAR levels are used for cell phones, tablets and other handheld wireless devices to determine regulatory compliance. For millimeter wavelength devices and infrastructure power density above 6GHz (FCC) and above 10 GHz (ICNIRP) needs to be measured with power density (FCC, 1997; Wu et al., 2015a). This is due to the higher energy absorption in a shallow area that causes heating more rapidly resulting in much higher SAR levels. The FCC maximum permissible exposure (MPE) in terms of power density for frequencies between 1.5 and 100 GHz is 10 mW/cm2 over a 30 minute period (FCC, 1997; Romanenko et al., 2014). Heat generated is a concern in handheld devices for 5G but is still considered the only valid measure of harm, no biological cellular alterations are considered (Wu et al., 2015a).

3.4.5. Studies on millimeter wavelenghts

Millimeter waves (MMW) are absorbed by water in living plants, bacteria, insects and human skin with variable effects. Because of shallow penetration of MMW, the eyes and skin are of primary concern. Bacterial effects have also been examined with evidence of antibiotic resistance caused by MMW. In humans, the penetration depth of more than 90% of the transmitted power is absorbed in the epidermal and dermal layers (Wu et al., 2015a). Because the depth is so superficial, higher heating occurs more quickly with less dissipation. Many biological responses to MMW irradiation can be initiated within the skin (Isaac et al., 2012; Ziskin, 2013; Gandhi and Riazi, 1986). Systemic signaling in the skin can result in physiological effects on the nervous system, heart, and immune system mediated through neuroendocrine mechanisms (Pakhomov et al., 1998). Currently MMW is used for some high speed wireless networks (Sundeep et al., 2012) and radar sensors for car navigation (Menzel, and Moebius, 2012). Considering planned ubiquitous and continuous MMW exposure there is a need to understand any potentially negative health effects of these frequencies (National Research Council US, 1983; Liu et al., 2014; Drean et al., 2013; Mahamoud et al., 2016; Nelson et al., 2000).

3.4.5.1. Skin effects

Numerous experimental studies have shown that surface effects of low intensity MMW can be quite substantial, inducing a number of biological changes, even at non thermal levels, including cell membrane effects (Feldman et al., 2009; Ramundo-Orlando et al., 2009; Feldman et al., 2008; Millenbaugh et al., 2006; Enin et al., 1992; Ramundo-Orlando, 2012; Ziskin, 2013; Hayut et al., 2014; Ney and Abdulhalim, 2011; Chernyakov et al., 1989).

There are MMW studies showing both beneficial and adverse effects, depending on frequency, modulation, power density, polarization, and exposure time (Belyaev et al., 2000). MMW has been used for many years as a non-invasive therapeutic modality in complementary medicine in many Eastern European countries for pain therapy (Taras et al., 2006) with some evidence that short term application of certain frequencies stimulate release of endogenous opioids in the skin (Ziskin, 2013).

For a contrary purpose, the military are using 95GHz MMW for non-lethal active denial systems (Gross, 2010). It appears that the 95 GHz MMW range affects the cutaneous nociceptors and act as a threatening stimulus without heating or thermal damage (LeVine, 2009). The mechanism has not been fully elucidated but researchers have proposed the sweat glands as a target. Feldman et al. (2008; 2009) demonstrated that the sweat ducts in human skin are helically shaped tubes, filled with a conductive aqueous solution. Their research indicates that sweat ducts in the skin could behave as antennas and thus respond to millimeter waves.

3.4.5.2. Ocular effects

There is particular concern for 5G applications as the eyes would also receive significant radiation especially for near field exposures. Cataracts remain the leading cause of blindness in the world, and are a societal burden due to the high incidence, cost and consequences to quality of life (CDC, 2015). NIH statistics from 2010 show there is a 17.11% overall prevalence of cataracts over age 40 (NIH NEH, 2010) and a steady rise in cataract surgeries (Gollogly et al., 2013). An eight-year study showed the total Medicare costs for cataract surgery alone was approximately 3.6 billion, which is 60% of all eye care costs (Ellwein and Urato, 2002). Well established risk factors in the development of cataracts are age, smoking, diabetes, and UVB exposure. Research is pointing towards oxidative damage as a general mechanism for age related cataracts (Spector, 1995; Ye et al., 2001; Abraham et al., 2006). Microwave radiation is also a known cause of cataracts with heat being an undisputed mechanism. The eyes lack sufficient blood flow to dissipate heat effectively. There is some evidence that repeated low level exposures to microwave radiation could cause cataracts but researchers agree that more studies are needed (Vignal et al., 2009; Carpenter and Van Ummeren, 1968; Moss et al., 1977; Foster et al., 1986; Van Umersen and Cogan, 1976; Riva et al., 2005; Ryzhov et al., 1991; Drean et al., 2013; Morgan et al., 2015).

Frey (1985) elucidates the reasons why the earlier Appleton and McCrossan study found no cataractogenesis from microwave exposure after reviewing their data. He found 3 major flaws in the study design and interpretation. These were 1) the exposed group likely included people with little or no exposure 2) control group consisted of people working with equipment known to cause eye damage 3) they never performed a statistical analysis on their data. Nevertheless, their study was held up as proof there were no harmful effects from radiofrequency radiation. Frey notes the need to critically review negative studies as this contributes to the distortion and distrust of science.

Lipman et al. (1988) noted that microwaves most commonly cause anterior and/or posterior subcapsular lenticular opacities both in experimental animals, epidemiologic studies and case reports. They indicate that cataract formation is related to the power of the microwave radiation and duration of exposure. Lipman concludes that until further definitive research is conducted on the mechanisms of injury and protective measures identified, mechanical shielding is recommended to minimize the possibility of development of radiation-induced cataracts.

Cutz (1989) in his publication "*Effects of microwave radiation on the eye: The occupational health perspective*", looked at occupational exposure to RF EMR noting that eye effects from microwave radiation can be thermal or non-thermal and that lens opacities can be generated experimentally in animals with relatively high intensity RF EMR (power density above 100mW/cm2). He states that for lower intensities cumulative exposures may cause damage. He also reported that microwaves caused degeneration of retinal nerve endings. Long term effects were not determined, pointing to the need for additional research.

Kues and Monhan (1992) at John Hopkins University, researched the effects of low-level microwave radiation on the primate eye using 1.25 and 2.45 GHz wavelengths for 4 hours daily for 3 consecutive days. They identified damaging ocular effects including corneal lesions, increased vascular permeability and degeneration of photoreceptors in the retina. They found that pulsed microwave exposure produced abnormalities at lower power densities than continuous wave exposure. These were relatively short exposure periods.

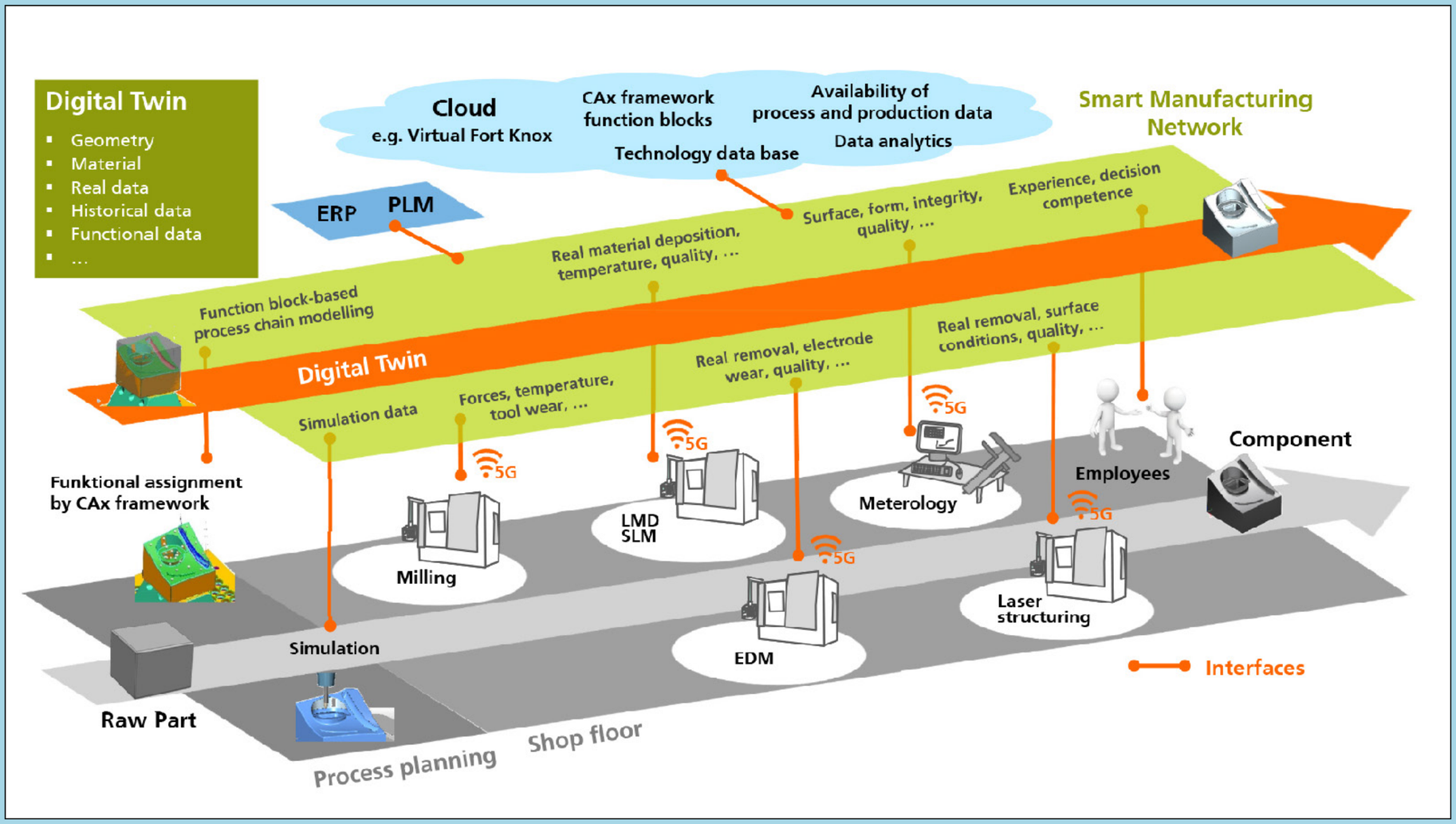
Prost et al. (1994) was one of the first to study the effects of millimeter microwave radiation on the eye. He noted that microwaves of different wavelengths have been implicated in the development of cataracts. His research found that low power millimeter waves produced lens opacity in rats over a 58-day period (10mW/cm2), indicating MMW is a predisposing factor for cataracts. Bormusov et al. (2008) examined the non-thermal effects of high frequency radiation from cell phones and other wireless devices on lens epithelium. They found both reversible and irreversible ocular changes and notes that the effects they saw with short term exposure at low levels could translate to similar effects with cataracts over a 10–20 year period of cumulative exposure. They state "*It is recommended to use cell phones from a distance to minimize exposure, thus reducing any potential harmful effects of cell phone use on the lens.*"

Yu and Yao (2010) reviewed literature on microwave radiation and induction of cataracts. Reports of non-thermal biologic effects of microwave radiation include alteration of cell proliferation and apoptosis, inhibition of gap junctional intercellular communication, stress response and genetic instability. They concluded that further in vivo studies are needed.

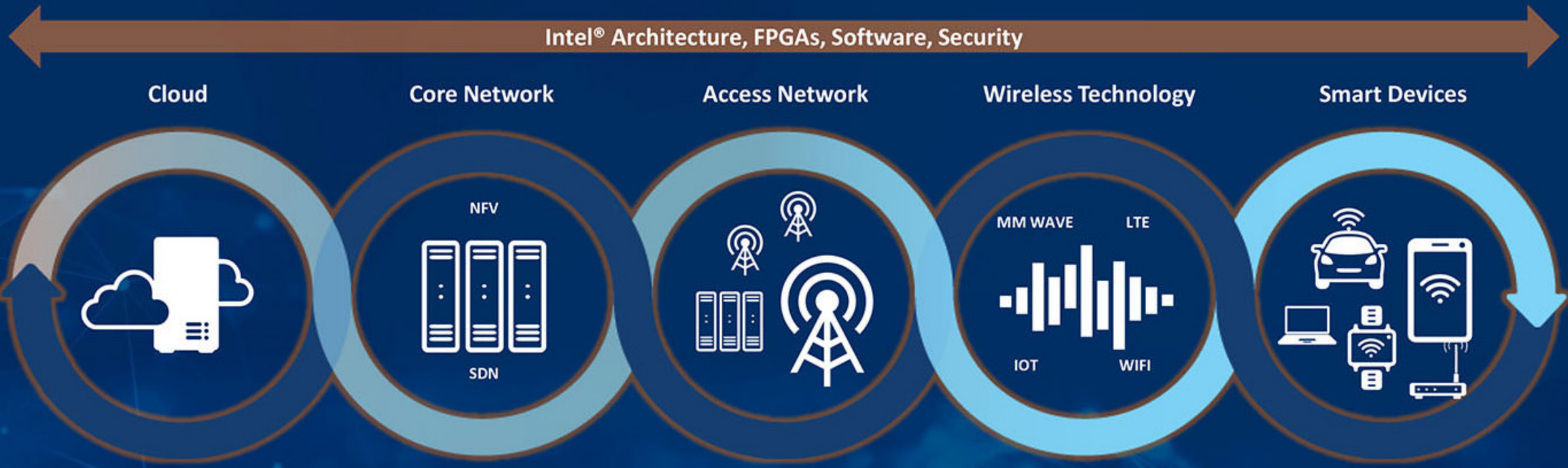
Shawaf (2015) reported on an acute bilateral cataract development in a healthy young radar worker due to accidental high power microwave exposure. He notes "*there are also non-thermal effects of microwave energy on the eye including pressure waves and physical stretching, deformation, and tearing of the membranes of the lens cells.*"

In a 2014 publication in the Institute of Electrical and Electronics Engineers journal, IEEE Transactions on Microwave Theory and Techniques, Sasaki et al. (2014) reported their in vivo rabbit experiments for operating frequencies ranging from 24.5 to 95 GHz, measuring temperature elevation. Their studies suggest that corneal damage occurred at an incident power density of 300 mW/cm2. They conclude that ocular heating should be the basis for safety guidelines for near field exposure. It is mentioned however that only a few experimental studies in the miilimeter wavelengths were used to determine the current exposure guideline limits. In another IEEE publication looking at MMW health effects, Wu et al. (2015b) support current standards of safety based on heat but point out that the MMW research on biological effects is sparse relative to that of longer microwave frequencies. They advise that additional studies may be needed to examine the potential biological effects of MMW radiation in order to develop appropriate consumer guidelines, especially where antennas are located close to the body.

From the available literature it appears that microwave frequencies including MMW proposed for 5G can have non-thermal biological ef- fects on the lens of the eye. 5G deployment will add shorter wave- lengths to longer wavelengths which have not been adequately tested for long term exposure. With the expected rise of wear-



5G • LETHAL TO ALL LIVING THINGS



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able ocular digital technology devices such as virtual reality for gaming, entertainment, the social sciences and healthcare, there will be significantly more exposure to microwave radiation very close to the orbit. Current safety guidelines are based on heat measurements. The paucity of current literature on ocular effects of millimeter wavelengths highlights the need for much more independent research and precaution moving forward to prevent an epidemic of ocular pathology.

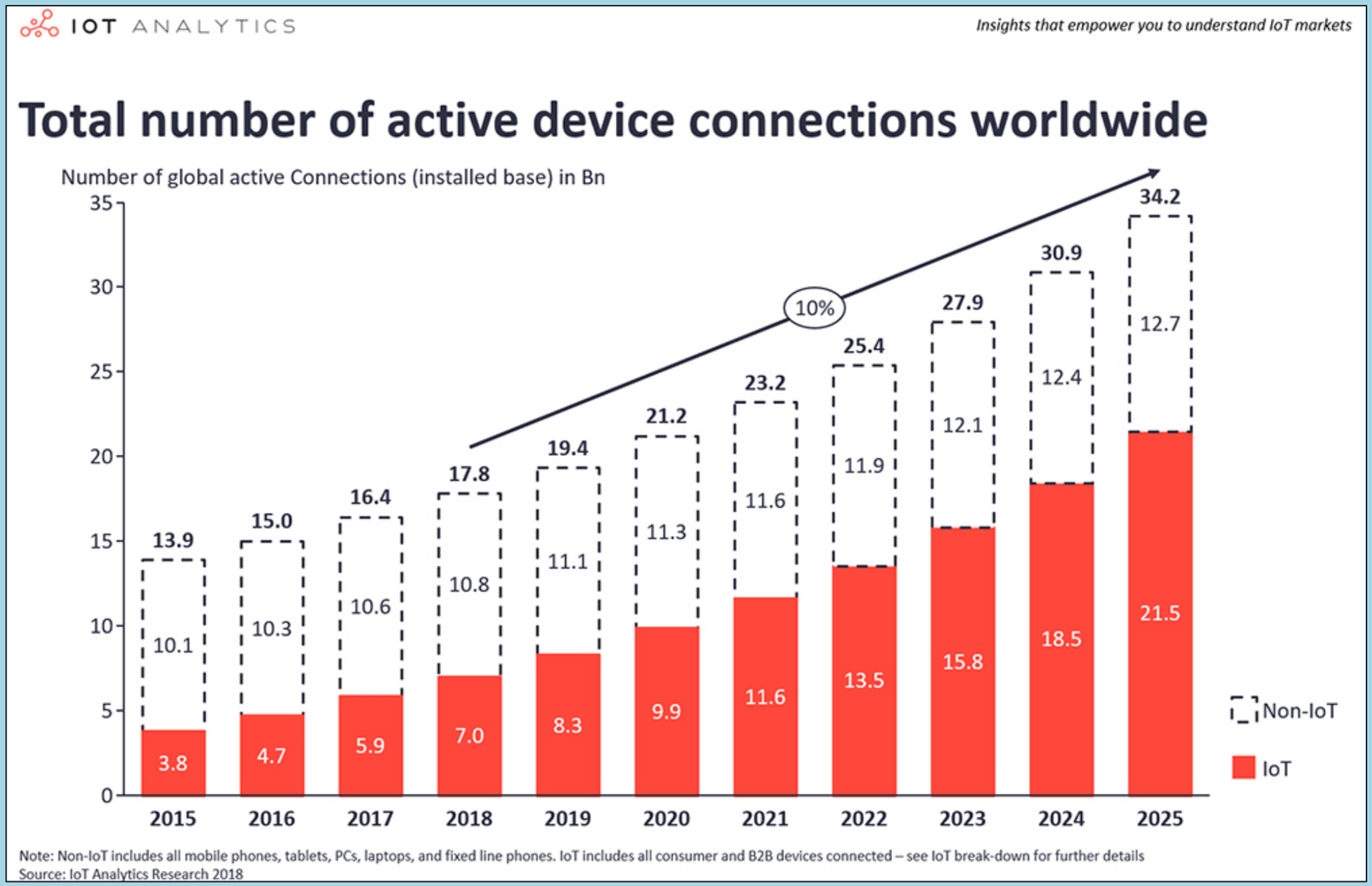
3.4.5.3. Review of effects

In a very thorough review article, Pakhomov et al. (1998) looked at the biological effects of MMW. He examined dozens of studies and cites research demonstrating profound effects of MMW on all biological systems including cells, bacteria, yeast, animals and humans. Some effects were clearly thermal, however, many of the studies showed non-thermal biological effects at low intensities. Both negative and positive responses were seen depending on frequency, power, resonance and exposure time. Researchers found at times even small difference in frequencies could have very different biological effects.

Pakhomov summarized the studies and included effects on heart rate variability, teratogenicity, and bacterial growth alterations with antibiotic resistance. Chernyakov et al. (1989) induced heart rate changes in anesthetized frogs by microwave irradiation of remote skin areas. Complete denervation of the heart did not prevent the reaction. This suggested a reflex mechanism of the MMW action involving certain peripheral receptors. Potekhina et al. (1992) found certain frequencies from 53 to 78 GHz band continuous wave changed the natural heart rate variability in anesthetized rats. He showed that some frequencies had no effect (61 or 75 GH) while other frequencies (55 and 73 GHz) caused pronounced arrhythmia. There was no change in skin or whole body temperature.

One study of MMW teratogenic effects was performed in Drosophila flies by Belyaev et al. (1990). Embryos were exposed to 3 different GHz frequencies for 4–4.5 h at 0.1 mW/cm2. He found that irradiation at 46.35 GHz, but not at 46.42 or 46.50 GHz, caused marked effects including an increase in morphological abnormalities and decreased survival. It was felt the MMW disturbed DNA-protein interactions at that particular frequency. Bulgakova et al. (1996) in studies with 14 different antibiotics showed how MMW exposure of the bacterium S. aureus affects its sensitivity to antibiotics with different mechanisms of action. The MMW increased or decreased antibiotic sensitivity depending on the antibiotic concentration.

Pakhomov warned that there was a possibility of significant bio-effects of millimeter wave technology at current safety standards and more study was needed. He called for replication of studies especially long term effects of MMW. Pakhomov concluded that the effects were not necessarily linear as different individuals may react differently, there were unknown and uncontrolled factors affecting sensitivities, and electrosensitivity to millimeters may be real with 30 to 80% of test subjects able to feel low intensity millimeter wave radiation.



3.4.5.4. Immune system

Kolomytseva et al. (2002), looked at the function of peripheral blood neutrophils under whole-body exposure of healthy mice to low-intensity extremely high-frequency electromagnetic radiation (EHF EMR, 42.0 GHz, 0.15 mW/cm2, 20min daily). ***The study showed 50% suppression of phagocytic activity of neutrophils after a single exposure to MMW radiation with the authors noting a profound effect on nonspecific immunity.***

Lushnikov et al. (2003) investigated cell-mediated immunity and nonspecific inflammatory response in mice exposed to low-intensity extremely high-frequency electromagnetic radiation (EHF EMR, 42.0 GHz, 0.1 mW/cm2, 20 min daily). ***They found that MMW radiation reduced both immune and nonspecific inflammatory responses*** (130).

Other research by the same group corroborated an anti-inflammatory effect of MMW that appeared mediated by the immune neuro-endocrine system. This could explain some of the reported beneficial effects. Long term exposure was not mentioned.

Gapeev et al. (2003) showed for the first time that low-intensity extremely high-frequency MMH electromagnetic radiation in vivo causes effects on spatial organization of chromatin in cells of lymphoid organs. Chromatin is a complex of DNA and proteins that forms chromosomes within the nucleus of eukaryotic cells. He exposed mice to a single whole-body exposure for 20 min at 42.0 GHz and 0.15 mW/cm2. He suggests that the effects were due to involvement of the neuroendocrine and central nervous systems.

3.4.5.5. Tumor suppression

Makar et al. (2005) showed that MMW irradiation at 42.2GHz can up-regulate natural killer (NK) cell functions with short exposures. An increase in TNF-alpha was also identified. Logani et al. (2006) investigated inhibition of tumor growth transplants with short 30 minute pretreatment with MMW. They found a reduction in tumor metastasis by MMWs mediated through activation of NK cells. Long term exposure was not investigated.

3.4.5.6. Gene expression

Chen et al. (2008) found upregulation of some genes in human keratinocytes with MMW exposure at low power density (1.0 mW/cm2 millimeter).

Habauzit et al. (2014) looked at gene expression in keratinocytes with 60GHz exposure at the upper limit of current guidelines and concluded, "*In our experimental design, the high number of modified genes (665) shows that the ICNIRP current limit is probably too permissive to prevent biological response.*"

3.4.5.7. Bacterial antibiotic resistance

Bulgakova et al. irradiated staphylococcus cultures with different frequencies of MMW with non-thermal intensities with short exposure periods (minutes). He found changes in bacterial sensitivities developed in 5 of 14 antibiotics used in sublethal concentrations with both suppression and stimulation of growth.

Shcheglov et al. (2002) examined MMW on E. coli cells at various cell densities and frequencies. His work suggests that cell-to-cell communication may be involved in bacterial responses to weak EMF. Isakhanian and Trchunian (2005) irradiated water and buffer solution with low intensity MMW and found that the irradiated water had a bactericidal effect that disappeared after repeated exposure and the buffer solution increased growth of bacteria. They concluded this was due to membranotrophic effects. Repeated irradiation reversed the bactericidal effects indicating that a compensatory mechanism was involved.

Torgomyan and Trchounian (2013) reviewed research on the mechanisms of bactericidal and antibiotic resistance after exposure to low intensity MMW. They suggest that alterations in water structure, cell membrane or the genome leading to changes in metabolic pathways could account for these effects. The importance of this research is emphasized in light of ongoing concerns about bacterial resistance to antibiotics.

Soghomonyan et al. (2016) found that MMW affected growth and antibiotic sensitivity of E. coli and many other bacteria via non-thermal mechanisms. This may lead to antibiotic resistance.

3.5. Data gaps need to be closed before launching 5G millimeter devices

5G technology with its diverse blend of frequencies and densely packed cell antenna network will substantially increase exposure to electromagnetic radiation. Significant data gaps exist for research into both MMW and mixed frequencies for biological effects, long term exposure and vulnerable populations (children, pregnant women, chronically ill). Considering current peer reviewed science, predictable harm to life forms within the mixed frequency mesh networks with negative consequences appears likely over time. For electrosensitive individuals, it will add to their physical symptoms and isolation, with significant reduction in non-exposed safe havens. There is an urgent need for independent studies to guide development of effective public health standards and policies.

3.6. Technology addiction: overuse and over-connection

Overuse of technology and mental health is another related but no less important issue. Physicians, social scientists and educators are concerned with the over-connection to technology, especially in children and adolescents. Psychiatrists have reported an increase in technology addiction, cyberbullying, depression, insomnia, loss of empathy and impaired social-emotional learning in their young patients. Internet game disorder has been found to have psychological and neural effects similar to other types of impulse control disorders and addictions which are both substance and non-substance-related (Chi et al., 2016; Király et al., 2017; Meng et al., 2015; Sanchez-Carbonell et al., 2008; Tamura,Tamura et al., 2017; Feng et al., 2017). Lack of outdoor play and psychological well-being for young children is also of growing concern (Xu et al., 2016). We should begin to question the supposed benefits versus the true risks of a hyper-connected society.

3.7. What is public health?

There are many definitions of public health but one succinct definition is, "*Public health is what we, as a society, do collectively to assure the conditions for people to be healthy." (Upshur, 2015). Public health involves the science and art of preventing and controlling disease, promoting health, monitoring populations for health assessments, identifying causes, identifying effective interventions and assuring equity in populations and communities*." (APHA, 2017; CDCCDC, 2017).

Public health involves an ever widening range of topics. John R. Goldsmith, MD, MPH, a pioneer in public health, wrote a seminal article in 1997 called "*From Sanitation to Cellphones: Participants and Principles Involved in Environmental Health Protection*" (Goldsmith, 1997a, 1997b).

This work details the history of public health over his decades working in this field. He describes four phases of public health issues: sanitation (prior to 1914), industrialization (1915–1950), emissions constraints (1951–1995) and then globalization (1996 on). He notes three common principles of public health which apply through all those phases, 1) The need for regulation by government 2) Need for a market by which protection of environmental health is economically attractive compared to alternatives and 3) Social acceptability, with cultural norms endorsing protective versus risk generating behavior.

3.7.1. Wireless technologies: a question of public health

A growing number of scientists have articulated the need to recognize that the increase in wireless technologies is a serious emerging and neglected public health threat. (Blank et al., 2015; Goldsmith, 1997a, 1997b; Sage and Carpenter, 2012). In a recent poll, public health scientists were asked what they consider to be emerging public health issues (Bernier, 2017). Responses included issues such as racism, bullying, gun violence, gang violence, adult obesity and climate change. They were also asked what defines a public health issue. The open forum identified the following criteria.

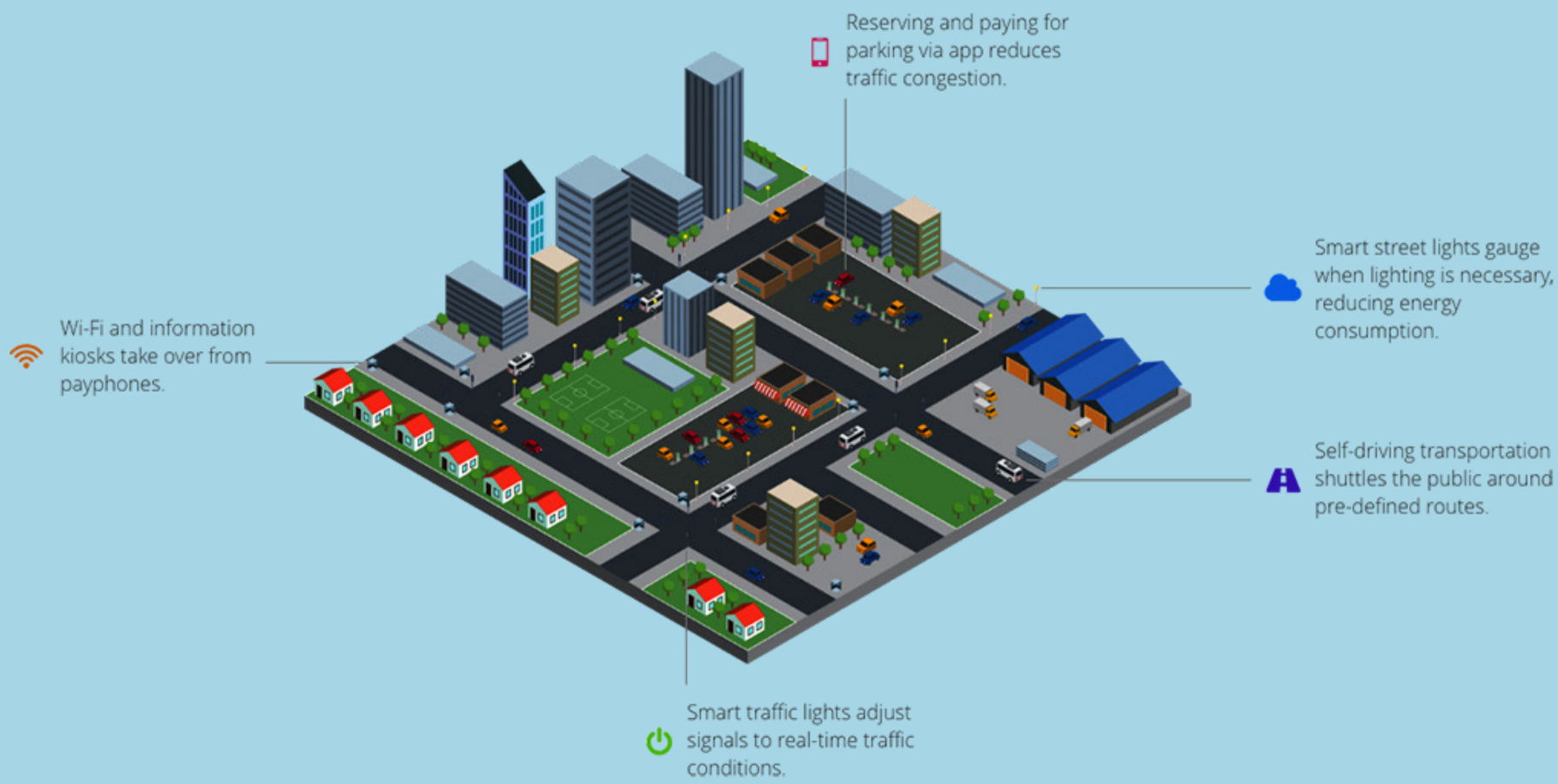
1. The health impacts are preventable and modifiable.
2. There is a high prevalence of a risk factor.
3. There is an increase in incidence and prevalence.
4. There is an economic impact.
5. There is disability, morbidity and mortality.
6. It can affect a large population.
7. A collaborative effort is needed to solve it.
8. The problem can be recognized unencumbered by lack of funding, cultural norms, or politics.

For wireless technology to be considered a public health issue in this regard there would need to be broad recognition and consensus that wireless technology could cause or contribute to diseases such as brain cancer, neurodegeneration, developmental defects, infertility, electro-sensitivity and addiction. The cost and burden could then be calculated. Wireless technology could fulfill the other criteria in that there is an unprecedented high prevalence in the use of wireless devices, it can affect the population as a whole, and will require collaborative action to solve.

The biggest obstacles appear to be of a cultural, economic and political nature along with a noted lack of funding in the U.S. for independent scientific research on health effects of RF EMR that is free of industry influence or bias. As with tobacco, the science was denied and doubt created until overwhelming research and evidence of harm decades later shifted the debate and protective regulations followed. Chemical companies followed tobacco with similar methods to dismiss and manipulate science that was not in their favor (Michaels, 2008).

4. Conclusion

Although 5G technology may have many unimagined uses and benefits, it is also increasingly clear that significant negative consequences to human health and ecosystems could occur if it is widely adopted. Current radiofrequncy 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 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. Considering the current science, lack of relevant



exposure standards based on known biological effects and data gaps in research, we need to reduce our exposure to RF EMR where ever technically feasible. Laws or policies which restrict the full integrity of science and the scientific community with regards to health and environmental effects of wireless technologies or other toxic exposures should be changed to enable unbiased, objective and precautionary science to drive necessary public policies and regulation. Climate change, fracking, toxic emissions and microwave radiation from wireless devices all have something in common with smoking. There is much denial and confusion about health and environmental risks, along with industry insistence for absolute proof before regulatory action occurs (Frentzel-Beyme, 1994; MichaelsMichaels, 2008).

There are many lessons we have not learned with the introduction of novel substances, which later became precarious environmental pollutants by not heeding warning signs from scientists (Gee, 2009).

The threats of these common pollutants continue to weigh heavily on the health and wellbeing of our nation. We now accept them as the price of progress. If we do not take precautions but wait for unquestioned proof of harm will it be too late at that point for some or all of us?

Reproductive Biology and Endocrinology • December 2018

Radiations And Male Fertility

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During recent years, an increasing percentage of male infertility has to be attributed to an array of environmental, health and lifestyle factors. Male infertility is likely to be affected by the intense exposure to heat and extreme exposure to pesticides, radiations, radioactivity and other hazardous substances. We are surrounded by several types of ionizing and non-ionizing radiations and both have recognized causative effects on spermatogenesis. Since it is impossible to cover all types of radiation sources and their biological effects under a single title, this review is focusing on radiation deriving from cell phones, laptops, Wi-Fi and microwave ovens, as these are the most common sources of non-ionizing radiations, which may contribute to the cause of infertility by exploring the effect of exposure to radiofrequency radiations on the male fertility pattern. From currently available studies it is clear that radiofrequency electromagnetic fields (RF-EMF) have deleterious effects on sperm parameters (like sperm count, morphology, motility), affects the role of kinases in cellular metabolism and the endocrine system, and produces genotoxicity, genomic instability and oxidative stress. This is followed with protective measures for these radiations and future recommendations. The study concludes that the RF-EMF may induce oxidative stress with an increased level of reactive oxygen species, which may lead to infertility. This has been concluded based on available evidences from in vitro and in vivo studies suggesting that RF-EMF exposure negatively affects sperm quality.

Conclusion

Studies reveal that the exposure to cell phones, microwave ovens, laptops, or Wi-Fi produces deleterious effects on the testes, which may affect sperm count, morphology, motility, an increased DNA damage, causing micronuclei formation and genomic instability, as well as disruptions in protein kinases, hormones and antioxidative enzymes. Such

"Moreover, very limited research is available on protective measures, which actually worsens the problem as the electro-smog pollution is constantly increasing and one could then expect even more health problems including increased rates of male infertility due to such kind of ra-

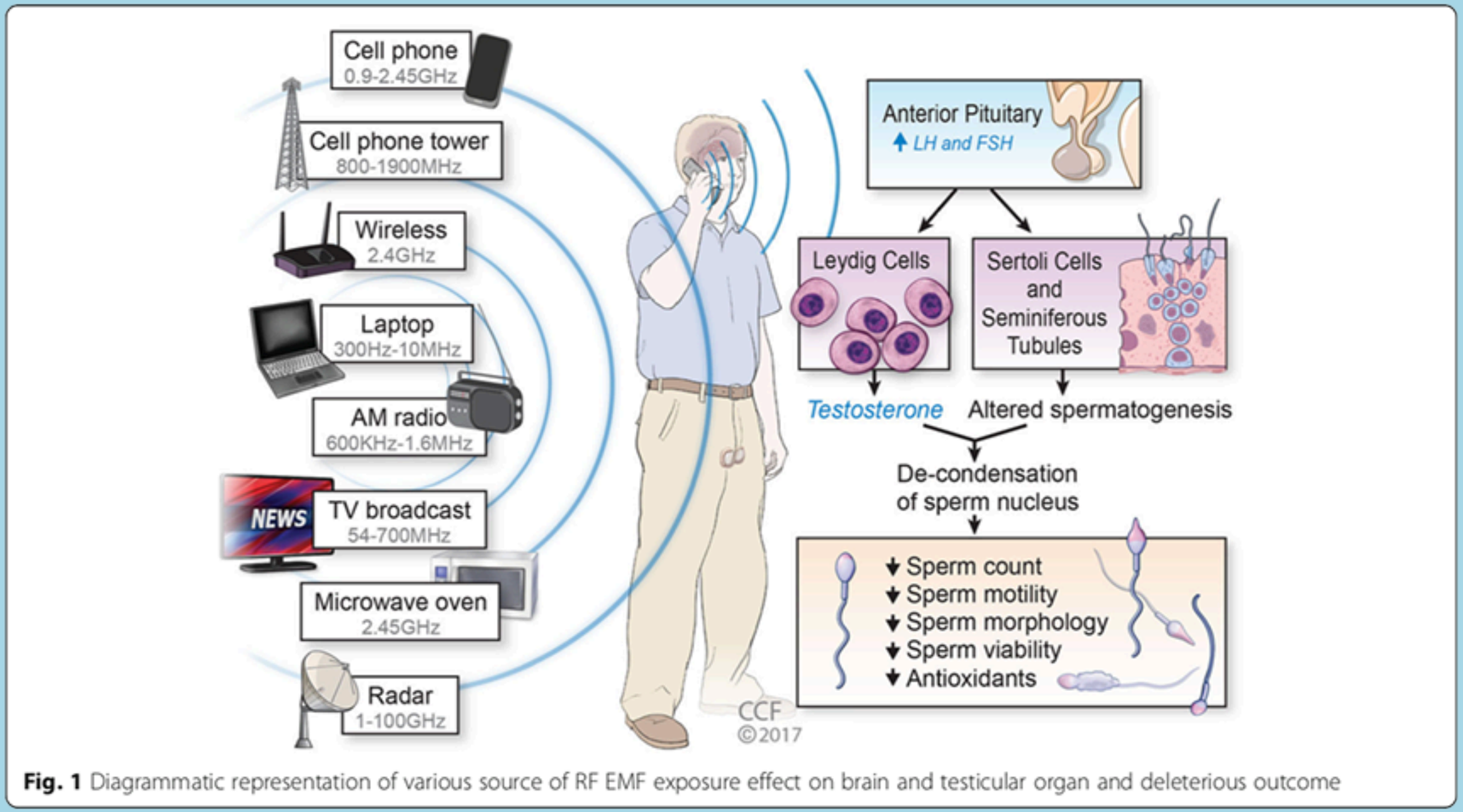

Fig. 1 Diagrammatic representation of various source of RF EMF exposure effect on brain and testicular organ and deleterious outcome

effects were found to be responsible for infertility due to an over-production of ROS in exposed cells. Studies suggest that the abnormal- ities reported due to RF-EMF-exposure depend on physical parameters such as duration of the exposure, distance to the source of radiation, power density, and depth of the penetration. Unfortunately, current studies are unable to suggest a true mechanism of how RF-EMF radiation affects the male reproductive system. Therefore, more studies are necessary to provide better evidence of RF-EMF radiations emitted from cell phones, microwaves, Wi-Fi and Wi-Fi-connected laptops, which can be provided by in vitro and in vivo studies in combination with physical bio-modeling. Moreover, very limited research is available on protective measures, which actually worsens the problem as the electro-smog pollution is constantly increasing and one could then expect even more health problems including increased rates of male infertility due to such kind of radiation. On the other hand, possible protective effects of various antioxidants should be elucidated. Yet, this would only address the problem at symptomatic level.

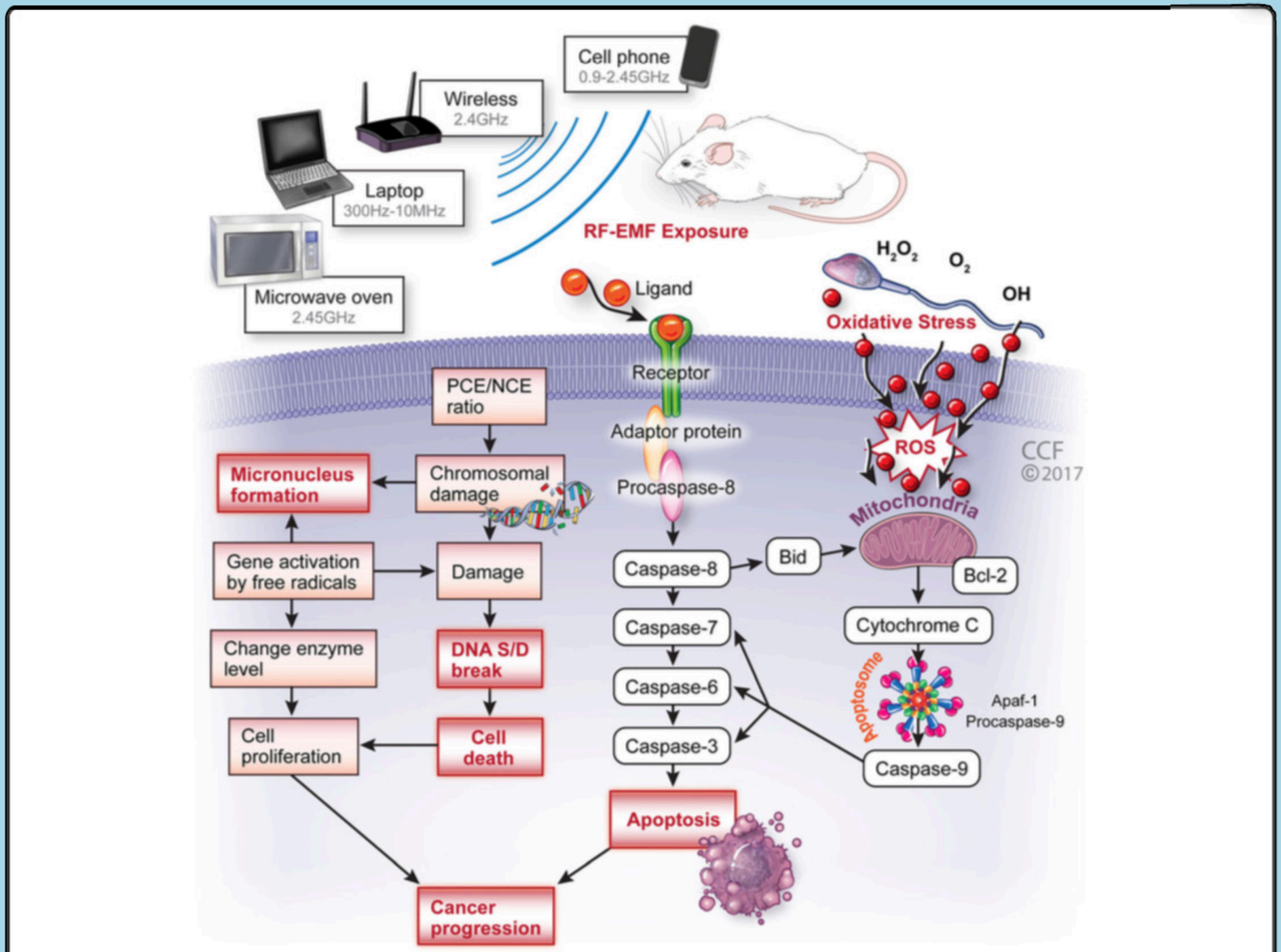

Fig. 2 An overview on the effects of RF EMF exposure, emitting from various sources (cell phone, microwave oven, Wi-Fi, Laptop) on genotoxic parameters. The proposed mechanism suggesting radiation-induced oxidative damage may increase DNA damage, micronudei formation and leading cancer progression. This has been linked to distorted sperm head and mitochondrial sheath in sperm tail which leads to apoptosis and finally cancer progression

Environmental Health Perspectives • July 2018

A Prospective Cohort Study Of Adolescents' Memory Performance And Individual Brain Dose Of Microwave Radiation From Wireless Communication

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BACKGROUND:
The potential impact of microwave radiofrequency electromagnetic fields (RF-EMF) emitted by wireless communication devices on neurocognitive functions of adolescents is controversial. In a previous analysis, we found changes in figural memory scores associated with a higher cumulative RF-EMF brain dose in adolescents.

OBJECTIVE:
We aimed to follow-up our previous results using a new study population, dose estimation, and approach to controlling for confounding from media usage itself.

METHODS:
RF-EMF brain dose for each participant was modeled. Multivariable linear regression models were fitted on verbal and figural memory score changes over 1 year and on estimated cumulative brain dose and RF-EMF related and unrelated media usage (n = 669–676). Because of the hemispheric lateralization of memory, we conducted a laterality analysis for phone call ear preference. To control for the confounding of media use behaviors, a stratified analysis for different media usage groups was also conducted.

RESULTS:
We found decreased figural memory scores in association with an interquartile range (IQR) increase in estimated cumulative RF-EMF brain dose scores: −0:22 (95% CI: −0:47, 0.03; IQR: 953 mJ=kg per day) in the whole sample, −0:39 (95% CI: −0:67, −0:10; IQR: 953 mJ=kg per day) in right-side users (n = 532), and −0:26 (95% CI: −0:42, −0:10; IQR: 341 mJ=kg per day) when recorded network operator data were used for RF-EMF dose estimation (n = 274). Media usage unrelated to RF-EMF did not show significant associations or consistent patterns, with the exception of consistent (nonsignificant) positive associations between data traffic duration and verbal memory.

CONCLUSIONS:
Our findings for a cohort of Swiss adolescents require confirmation in other populations but suggest a potential adverse effect of RF- EMF brain dose on cognitive functions that involve brain regions mostly exposed during mobile phone use.

"Our findings for a cohort of Swiss adolescents require confirmation in other populations but suggest a potential adverse effect of RF-EMF brain dose on cognitive functions that involve brain regions mostly exposed during mobile phone use."

DISCUSSION:
In the present study, an IQR increase in estimated cumulative RF- EMF brain dose was associated with a nonsignificant decrease in figural memory score, but was not associated with verbal memory score. This inverse association of cumulative RF-EMF brain dose was consistently seen in the full sample analysis and the sub-group analysis of the two study waves (2012–2014 vs. 2014– 2016), media usage groups, and the operator sample although the strength of the association differed somewhat. The association was stronger in the second than in the first wave (however, with a wider confidence interval) and statistically significant in the operator sample, but not in the whole sample with self-reported exposure (after calibration using operator data). A significant decrease in figural memory score with cumulative brain dose was further seen in laterality analysis for right-side users of both the full sample and the operator sample only. In left-side users, in contrast, we found a significant decrease in verbal memory score for the operator sample. However, there was no such association for the full sample and estimates for the left-side users were in general imprecise due to the small sample size and also less consistent. The more consistent association of right-side users with a decrease for figural memory and the decrease for verbal memory score seen in left-side users of the operator sample might be related to the lateralization of memory processes (Golby et al. 2001) and requires further study.

Regarding wireless media usage not related to high RF-EMF exposure, a nonsignificant positive association for cumulative duration of mobile phone data traffic and verbal memory score change was observed, whereas the coefficients for text messages and gaming were generally small. It is conceivable that a positive significant association of verbal memory and data traffic could cover a potential negative RF-EMF effect on verbal memory if data traffic and RF-EMF dose are highly correlated. To control for this, we post hoc calculated the Spearman's correlation and fitted a regression model on verbal memory including both variables and adjusted for the same confounding variables as before. Spearman's correlation was weak (q = 0:25), and the linear regression estimates for neither RF-EMF dose nor duration of data traffic changed majorly in the mutually adjusted model (data not shown).

Bratislav Medical Journal • May 2018

The Effect Of Exposure To 1800 MHz Radiofrequency Radiation On Epidermal Growth Factor, Caspase-3, Hsp27 And p38MAPK Gene Expressions In The Rat Eye

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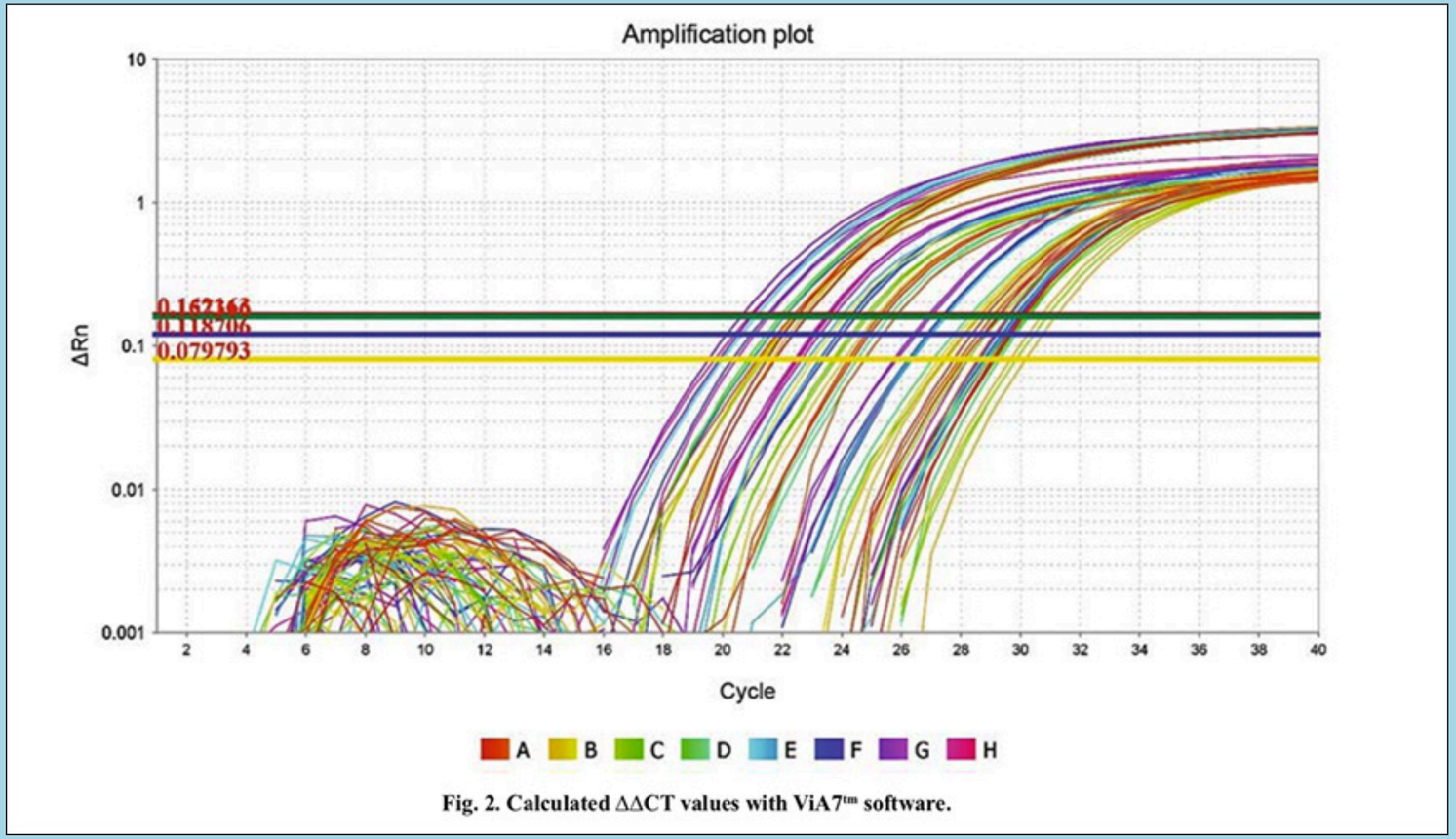

Fig. 2. Calculated ΔΔCT values with ViA7™ software.

"According to our findings, eye cells recognize EMF as a stress factor, and in response, activate caspase-3 and p38MAPK gene expressions. These results confirm that RF-EMF can cause cellular damage in rat ocular cells."

OBJECTIVE: Radiofrequency electromagnetic fields (RF-EMF) may induce DNA damage and oxidative stress in human lens epithelial cells (LECs). We aimed to investigate the expression levels of heat shock protein 27 (Hsp27), p38 mitogen-activated protein kinase (p38MAPK), epidermal growth factor receptor (EGFR) and caspase-3 gene expression levels in rat eye that was exposed to 1800 MHz RF-EMF.

METHODS: Thirty-seven female Wistar albino rats were divided into three groups. The rats in the study group (n = 9) were exposed to 1800 MHz RF-EMF at an electric field 6.8 ± 0.1 V/m and 0.06 W/kg specific absorption rate (SAR) for 2 hours per day for eight weeks. Sham group (n = 9) was kept under similar conditions as the exposed group without exposure to RF-EMF. The rats in all three groups were sacrificed and their eyes were removed. Hsp27, p38MAPK, EGFR, caspase-3 gene expression levels were investigated in detail with real-time polymerase chain reactions (Real-Time PCR).

RESULTS: Caspase-3 and p38MAPK gene expression were significantly upregulated in the ocular tissues following exposure to RF-EMF ($p < 0.05$).

CONCLUSION: According to our findings, eye cells recognize EMF as a stress factor, and in response, activate caspase-3 and p38MAPK gene expressions. These results confirm that RF-EMF can cause cellular damage in rat ocular cells (Tab. 2, Fig. 3, Ref. 37). Text in PDF www.elis.sk.

KEY WORDS:
radiofrequency radiation, rat eye, gene expression, caspase-3, p38MAPK.

Environmental Research • January 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 GSM Base Station Environmental Emission

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R. Montella, S. Panzacchi, D. Sgargi, V. Strollo, A. Vornoli, F. Belpoggi

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The experiments were conducted according to the Italian law regulating, at the time, the protection of animals used for experimental and other scientific purposes (Decreto Legislativo, 1992).

Disclosure Statement

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper. They also declare that their funding sources had no direct role in the study design, data collection, analysis and interpretation of the data, in the writing of the manuscript, or in the decision to publish the work.

Background: In 2011, IARC classified radiofrequency radiation (RFR) as possible human carcinogen (Group 2B). According to IARC, animals studies, as well as epidemiological ones, showed limited evidence of carcinogenicity. In 2016, the NTP published the first results of its long-term bioassays on near field RFR, reporting increased incidence of malignant glial tumors of the brain and heart Schwannoma in rats exposed to GSM – and CDMA – modulated cell phone RFR. The tumors observed in the NTP study are of the type similar to the ones observed in some epidemiological studies of cell phone users.

Objectives: The Ramazzini Institute (RI) performed a life-span carcinogenic study on Sprague-Dawley rats to evaluate the carcinogenic effects of RFR in the situation of far field, reproducing the environmental exposure to RFR generated by 1.8 GHz GSM antenna of the radio base stations of mobile phone. This is the largest long-term study ever performed in rats on the health effects of RFR, including 2,448 animals. In this article, we reported the final results regarding brain and heart tumors.

Methods: Male and female Sprague-Dawley rats were exposed from prenatal life until natural death to a 1.8 GHz GSM far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day.

Results: A statistically significant increase in the incidence of heart Schwannomas was observed in treated male rats at the highest dose (50 V/m). Furthermore, an increase in the incidence of heart Schwann cells hyperplasia was observed in treated male and female rats at the highest dose (50 V/m), although this was not statistically significant. An increase in the incidence of malignant glial tumors was observed in treated female rats at the highest dose (50 V/m), although not statistically significant.

Conclusions: The RI findings on far field exposure to RFR are consistent with and reinforce the results of the NTP study on near field exposure, as both reported an increase in the incidence of tumors of the brain and heart in RFR-exposed Sprague-Dawley rats. These tumors are of the same histotype of those observed in some epidemiological studies on cell phone users. These experimental studies provide sufficient evidence to call for the re-evaluation of IARC conclusions regarding the carcinogenic potential of RFR in humans.

Group	Treatment	Animals	
No.	GSM-RFR 1.8 GHz (V/m)[a]	Sex	No.
I	0	M	412
		F	405
		M+F	817
II	5	M	401
		F	410
		M+F	811
III	25	M	209
		F	202
		M+F	411
IV	50	M	207
		F	202
		M+F	409
Total			2448

[a] Treatment with GSM-RFR 1.8 GHz for 19 h/day started on the 12th day of pregnancy and lasted until natural death for groups I, II, III, IV.

Table 1: Long-term bioassay on 1.8GHz base station RFR, administered at different doses to Sprague-Dawley rats, from prenatal life to spontaneous death: plan of the experiment (Experiment BT 1CEMRF).

Fig. 1. RI study on 1.8 GHz base station RFR: exposure system. The rat cages were located in wooden circular-shaped devices, as in a sort of condominium. Each single exposure device served at least 400 rats (A). The exposure rooms were totally shielded in order to minimize the effect of field non-uniformity due to reflection and consequent interference caused by the walls (B). Detail of the RFR feedback probe used to measure the field (TESY2001 field sensor) and of the animal cage with methacrylate markers, cover and mangers (C).

Oncology Letters • May 2018

Radiofrequency Radiation From Nearby Base Stations Gives High Levels In An Apartment In Stockholm, Sweden: A Case Report

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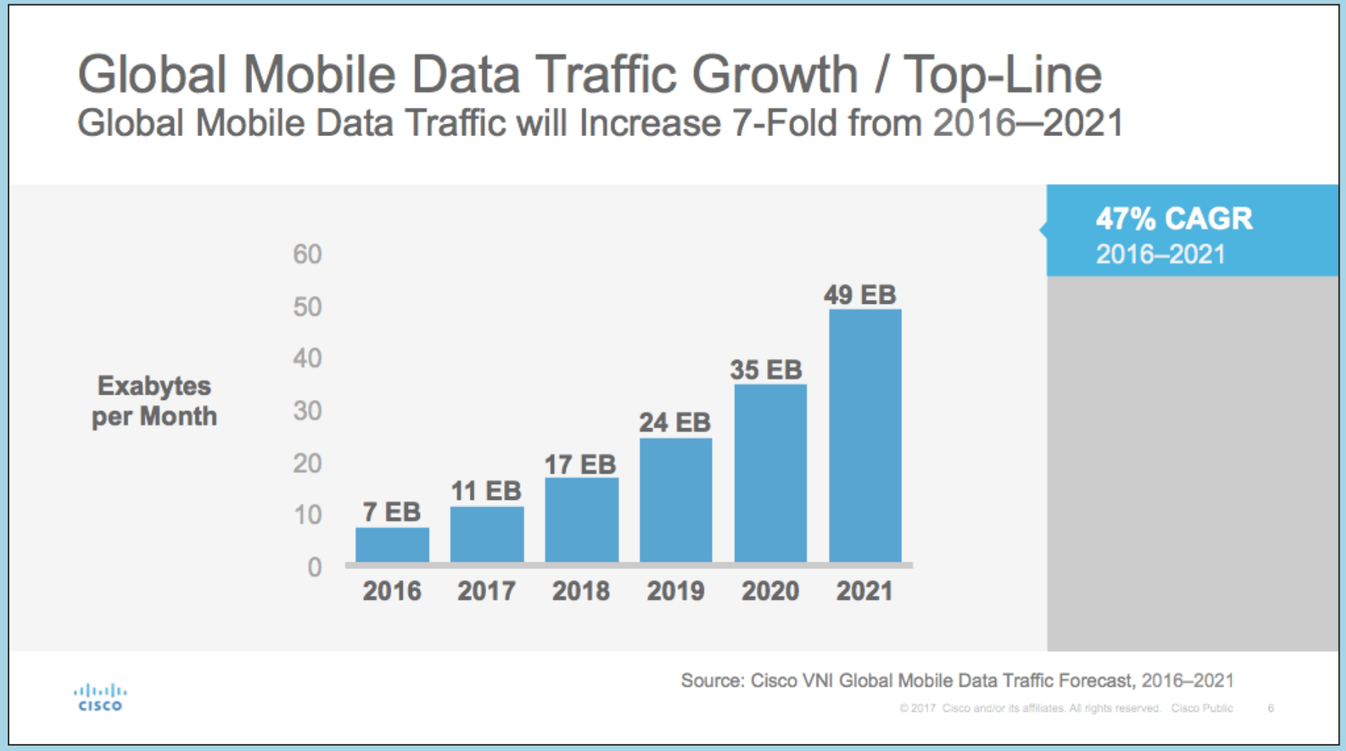
Exposure to radiofrequency (RF) radiation was classified in 2011 as a possible human carcinogen, Group 2B, by the International Agency for Research on Cancer of the World Health Organisation. Evidence of the risk of cancer risk has since strengthened. Exposure is changing due to the rapid development of technology resulting in increased ambient (background) radiation. RF radiation of sufficient intensity heats tissues, but the energy is insufficient to cause ionization, hence it is called non-ionizing radiation. These non-thermal exposure levels have resulted in biological effects in humans, animals and cells, including an increased cancer risk. In the present study, the levels of RF radiation were measured in an apartment close to two groups of mobile phone base stations on the roof. A total of 74,531 measurements were made corresponding to ~83 h of recording. The total mean RF radiation level was 3,811 µW/m2 (range 15.2-112,318 µW/m2) for the measurement of the whole apartment, including balconies. Particularly high levels were measured on three balconies and 3 of 4 bedrooms. The total mean RF radiation level decreased by 98% when the measured down-links from the base stations for 2, 3 and 4G were disregarded. The results are discussed in relation to the detrimental health effects of non-thermal RF radiation. Due to the current high RF radiation, the apartment is not suitable for long-term living, particularly for children who may be more sensitive than adults. For a definitive conclusion regarding the effect of RF radiation from nearby base stations, one option would be to turn them off and repeat the measurements. However, the simplest and safest solution would be to turn them off and dismantle them.



Journal of Biomedical Physics and Engineering • January 2018

Can Light Emitted From Smartphone Screens And Taking Selfies Cause Premature Aging And Wrinkles?

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Since the early days of human life on the Earth, our skin has been exposed to different levels of light. Recently, due to inevitable consequences of modern life, humans are not exposed to adequate levels of natural light during the day but they are overexposed to relatively high levels of artificial light at night. Skin is a major target of oxidative stress and the link between aging and oxidative stress is well documented. Especially, extrinsic skin aging can be caused by oxidative stress. The widespread use of light emitting diodes (LEDs) and the rapidly increasing use of smartphones, tablets, laptops and desktop computers have led to a significant rise in the exposure of human eyes to short-wavelength visible light. Recent studies show that exposure of human skin cells to light emitted from electronic devices, even for exposures as short as 1 hour, may cause reactive oxygen species (ROS) generation, apoptosis, and necrosis. The biological effects of exposure to short-wavelength visible light in blue region in humans and other living organisms were among our research priorities at the Ionizing and Non-ionizing Radiation Protection Research Center (INIRPRC). Today, there is a growing concern over the safety of the light sources such as LEDs with peak emissions in the blue light range (400-490 nm). Recent studies aimed at investigating the effect of exposure to light emitted from electronic device on human skin cells, shows that even short exposures can increase the generation of reactive oxygen species. However, the biological effects of either long-term or repeated exposures are not fully known, yet. Furthermore, there are reports indicating that frequent exposure to visible light spectrum of the selfie flashes may cause skin damage and accelerated skin ageing. In this paper we have addressed the different aspects of potential effects of exposure to the light emitted from smartphones' digital screens as well as smartphones' photoflashes on premature aging of the human skin. Specifically, the effects of blue light on eyes and skin are discussed. Based on current knowledge, it can be suggested that changing the spectral output of LED-based smartphones' flashes can be introduced as an effective method to reduce the adverse health effects associated with exposure to blue light.

Heart Rate Variability Affected By Radiofrequency Electromagnetic Field In Adolescent Students

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This study examines the possible effect of radiofrequency (RF) electromagnetic fields (EMF) on the autonomic nervous system (ANS). The effect of RF EMF on ANS activity was studied by measuring heart rate variability (HRV) during ortho-clinostatic test (i.e., transition from lying to standing and back) in 46 healthy grammar school students. A 1788 MHz pulsed wave with intensity of 54 1.6 V/m was applied intermittently for 18min in each trial. Maximum specific absorption rate (SAR10) value was determined to 0.405W/kg. We also measured the respiration rate and estimated a subjective perception of EMF exposure. RF exposure decreased heart rate of subjects in a lying position, while no such change was seen in standing students. After exposure while lying, a rise in high frequency band of HRV and root Mean Square of the Successive Differences was observed, which indicated an increase in parasympathetic nerve activity. Tympanic temperature and skin temperature were measured showing no heating under RF exposure. No RF effect on respiration rate was observed. None of the tested subjects were able to distinguish real exposure from sham exposure when queried at the end of the trial. In conclusion, short-term RF EMF exposure of students in a lying position during the ortho-clinostatic test affected ANS with significant increase in parasympathetic nerve activity compared to sham exposed group.

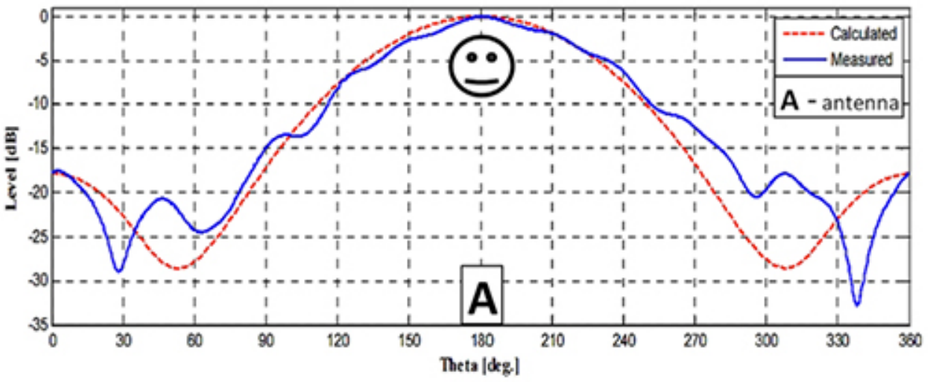

Fig. 3. Radiation pattern from plane circular waveguide feed. E was both measured (solid) and calculated (dashed) [Galuscak and Hazdra, 2008]. Head was located in main radiation lobe. *Theta* determines measurement angle while Level shows strength of electric field in dB.

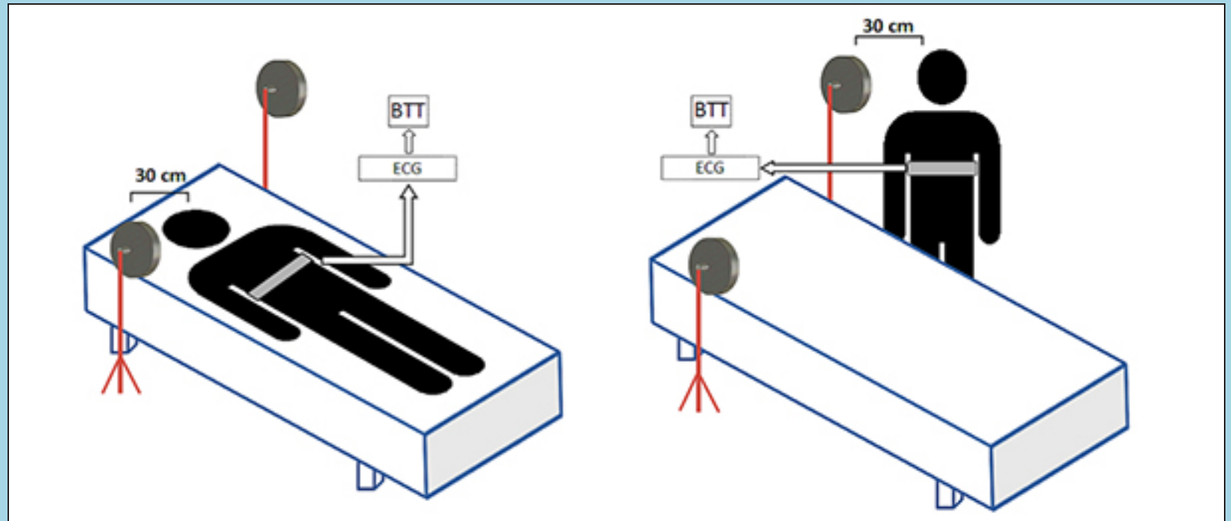

Fig. 2. Each student was exposed to RF with antenna fixed by a tripod stand at 30 cm distance from student's right face while lying (left side) and standing (right side). ECG belt was attached on student's chest and wired to Bluetooth transducer.

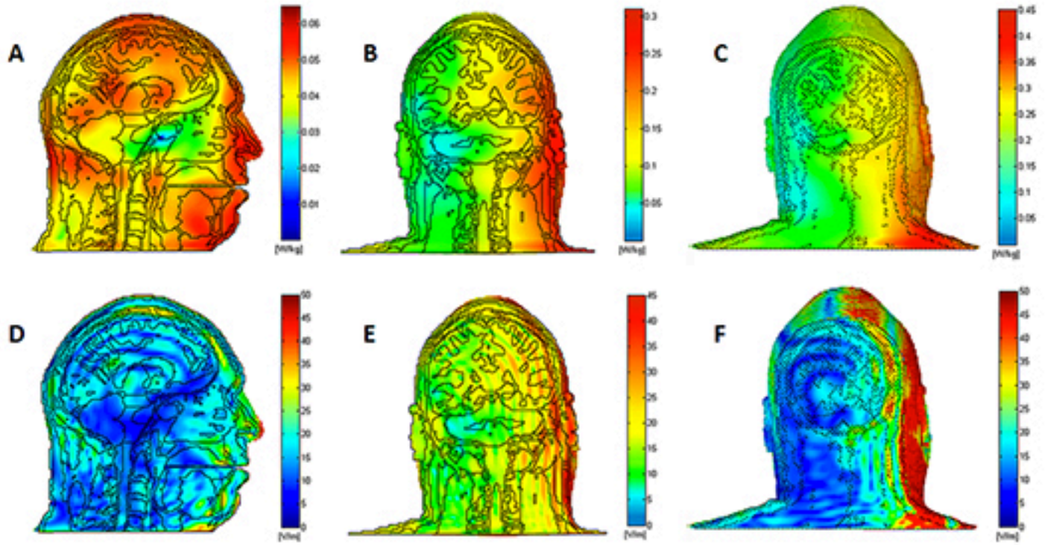

Fig. 4. Numerical simulation showing SAR_{10} spatial distribution in sagittal (A) and coronal (B, C) plane and E- field distribution in sagittal (D) and coronal (E, F) plane of human head phantom with the same signal and experimental setup as used for measurements.

CONCLUSION

Our results showed that RF EMF has a noticeable effect on HRV parameters, which can be revealed with an ortho-clinostatic test. Short-term intermittent RF EMF exposure affected ANS, leading to a significant increase in HRV indicators such as HF band spectral power and rMSSD, and a decrease in HR (measured by the RR interval). The obtained data indicate that short-term exposure to RF EMF under given conditions increases parasympathetic nerve activity. Closer attention should be dedicated to long- term chronic exposure from widespread use of cell phones.

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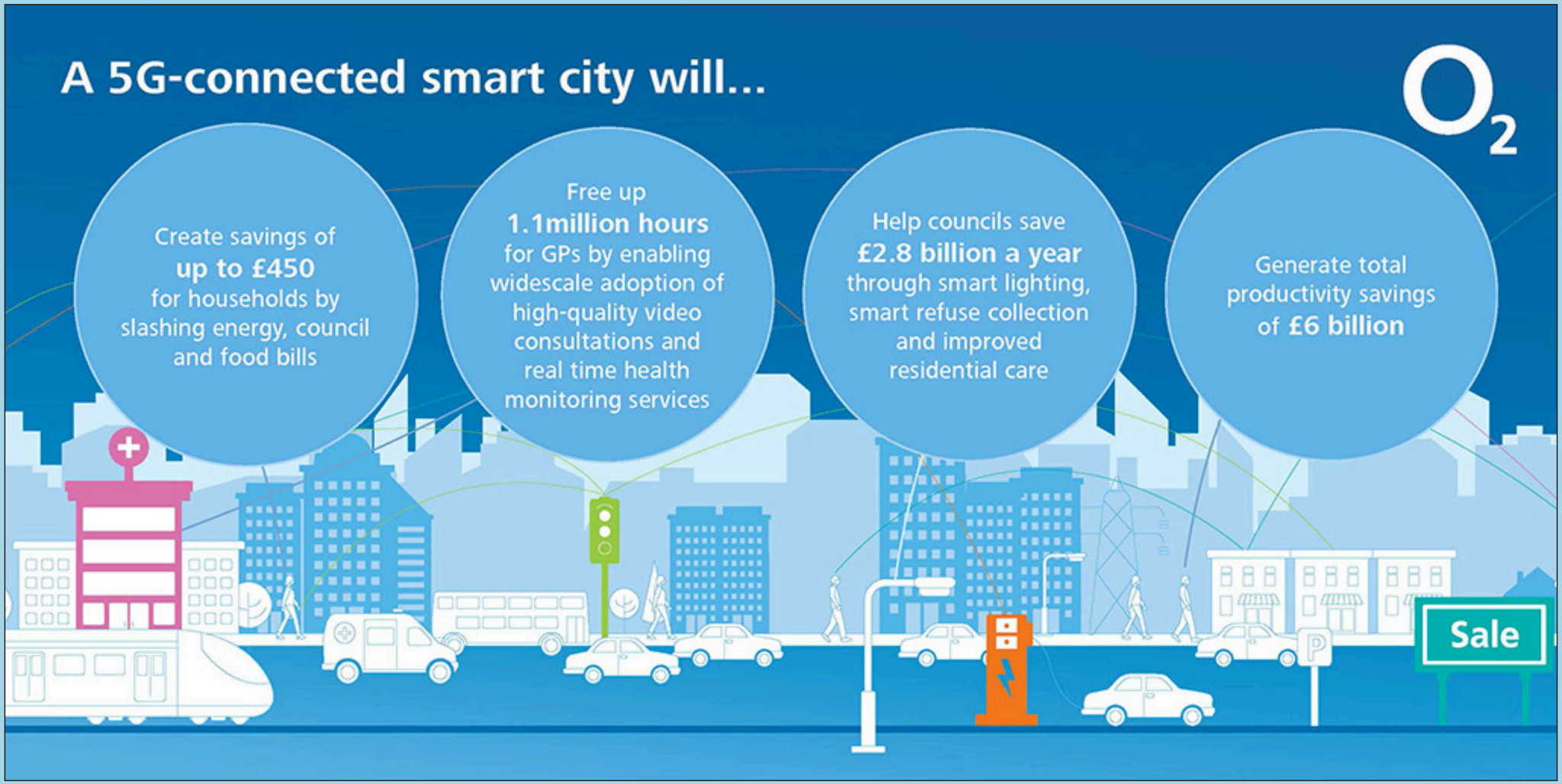

May 17, 2018

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

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We know that there is a massive literature, providing a high level of scientific certainty, for each of eight pathophysiological effects caused by non-thermal microwave frequency EMF exposures. This is shown in from 12 to 35 reviews on each specific effect, with each review listed in Chapter 1, providing a substantial body of evidence on the existence of each effect. Such EMFs:

1. Attack our nervous systems including our brains leading to widespread neurological/neuropsychiatric effects and possibly many other effects. This nervous system attack is of great concern.

2. Attack our endocrine (that is hormonal) systems. In this context, the main things that make us functionally different from single celled creatures are our nervous system and our endocrine systems – even a simple planaria worm needs both of these. Thus the consequences of the disruption of these two regulatory systems is immense, such that it is a travesty to ignore these findings.

3. Produce oxidative stress and free radical damage, which have central roles in essentially all chronic diseases.

4. Attack the DNA of our cells, producing single strand and double strand breaks in cellular DNA and oxidized bases in our cellular DNA. These in turn produce cancer and also mutations in germ line cells which produce mutations in future generations.

5. Produce elevated levels of apoptosis (programmed cell death), events especially important in causing both neurodegenerative diseases and infertility.

6. Lower male and female fertility, lower sex hormones, lower libido and increased levels of spontaneous abortion and, as already stated, attack the DNA in sperm cells.

7. Produce excessive intracellular calcium [Ca2+]i and excessive calcium signaling.

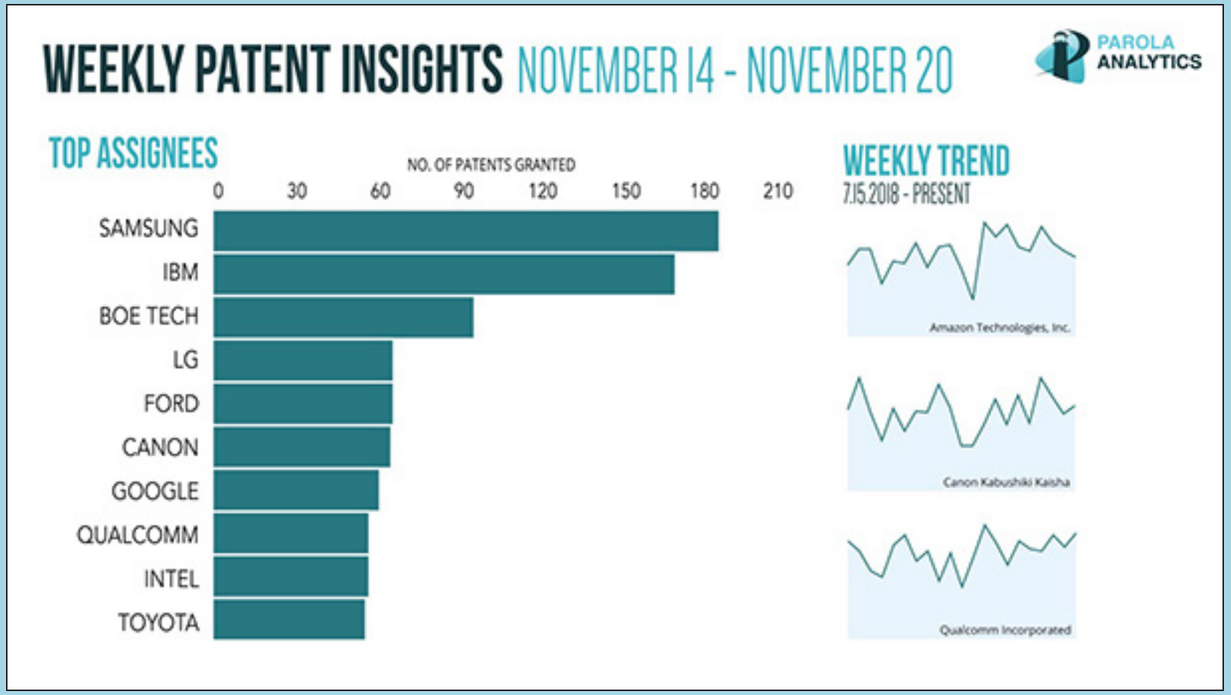
8. Attack the cells of our bodies to cause cancer. Such attacks are thought to act via 15 different mechanisms during cancer causation.

There is also a substantial literature showing that EMFs also cause other effects including life threatening cardiac effects (Chapter 3). In addition substantial evidence suggests EMF causation of very early onset dementias, including Alzheimer's, digital and other types of dementias (Chapter 3); and there is evidence that EMF exposures in utero and shortly after birth can cause ADHD and autism (Chapter 5). Each of these effects is produced via the main mechanism of action of microwave/lower frequency EMFs, activation of voltage-gated calcium channels (VGCCs) (Chapter 2). Each of them is produced via what are called downstream effects of VGCC activation. It follows from this that we have a good understanding not only that these effects occur, but also how they can occur. The extraordinary sensitivity of the VGCC voltage sensor to the forces of the EMFs tells us that the current safety guidelines allow us to be exposed to EMF levels that are something like 7.2 million times too high. That sensitivity is predicted by the physics. Therefore, the physics and the biology are each pointing to the same mechanism of action of non-thermal EMFs.

The different effects produced are obviously very deep concerns. They become much deeper and become existential threats when one considers that several of these effects are both cumulative and eventually irreversible. There is substantial evidence for the cumulative nature and eventual irreversibility of the neurological/neuropsychiatric effects, of the reproductive effects, the mutational DNA effects, the cardiac effects, of some but not other of the hormonal effects (Chapter 3); any causation of ADHD and autism may add additional concerns (here the cumulative nature is probably limited to the perinatal period). When we know that sperm counts have dropped by more than 50% throughout the technologically advanced countries on earth, it is difficult to avoid the conclusion that the vast majority of the population in those countries is already substantially impacted. The same conclusion can be made based on the widespread nature of the neuropsychiatric effects in those countries. Both of those effects will get much much worse even with no increase in current exposures, due to the cumulative nature and irreversibility of these effects. I expect we will see crash in human reproduction almost to zero as happened in the Magras and Xenos mouse study which I estimate to occur within about 5 years, without any increases in our exposures. Obviously 4G and 5G will make the situation much worse. Similarly I expect that the deterioration in brain function that we are already seeing will seal our fate if we fail to act rapidly and vigorously. Our collective brain function may become completely incapable of dealing with such a mega-crisis situation.

Now it can be argued that some of these may not develop as I expect, although those expectations are based on the best available evidence. One may even be able to argue this for all of those expectations. However, when we have substantial risk of multiple existential threats to every single technologically advanced country on earth, failure to act vigorously means there is a very high probability of complete destruction of these societies. And the chaos which would inevitably ensue, in a world that still has nuclear weapons, may well lead to extinction. In the face of these types of risk, the only reasonable course is to move with great vigor to stop new exposures and lower current exposures. One can still access the internet, using wired connections. And we can lower cell phone tower and cell phone radiation substantially. Smart meters, if needed, can work via wired connections.

Over 60% of this document (Chapters 5 & 6), is focused on the failures of statements from SCENIHR, the telecommunications industry, the U.S. FCC and the U.S. FDA to reflect the science. Their statements repeatedly omit much, often all of the most important science. Their statements are rife not only with omissions, but also with easily demonstrable falsehoods and with false logic. These have often occurred at times where we know that they knew better. These have occurred along with vigorous efforts by the telecommunications industry to corrupt the science by attacking individual scientists whose only fault is that they have obtained important findings that the industry does not like. These attacks have occurred along with vigorous efforts to corrupt two agencies that have important regulatory roles. There are also possible concerns about individual industry-linked research studies. All wireless communication devices put out polarized EMFs that carry information via pulsations. Both the pulsations and the polarization make these EMFs much more biologically active. There are three other factors that also influence the production of effects. Several industry-linked studies may have used these factors, along with using very tiny numbers of individual animals in their studies, to produce studies which may have been designed to fail (Chapter 5). It is not clear at this point whether this type of concern is quite limited or whether it is very broad. The European Commission has done nothing to protect European citizens from any of these very serious health hazards and the U.S. FDA, EPA and National Cancer Institute have done nothing to protect American citizens. The U.S. FCC has been much worse than that, acting vigorously with wanton disregard for our health.



Preface

The document that follows was, in its original form, sent to many of the authorities of the European Union, in conjunction with other documents sent to the same people by a group of European scientists. It was in response to documents that were, in turn, written by Mr. Ryan and Dr. Vinciūnas responding to a large group of European and other international scientists expressing great concern about the safety of 5G. I was asked by the leaders of the group of scientists to write my own response to those two documents. Mr. Ryan made the statement that "*There is consistent evidence presented by national and international bodies (International Commission on Non Ionising Radiation Protection - ICNIRP, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) that exposure to electromagnetic fields does not represent a health risk, if it remains below the limits set by Council Recommendation 1999/519/EC1.*" In fact, that is not either the ICNIRP or SCENIHR position – their position, and similar positions have been taken by the U.S. FCC, FDA and the National Cancer Institute, is that the evidence is inconsistent or conflicting and therefore, in their view, no conclusions can be drawn. Some of these organization have also stated that there is no known mechanism by which effects can be produced. What is shown below is that there is a vast amount of evidence in the independent scientific literature that conflicts with both the conclusion about lack of demonstrated effects and the conclusion about lack of mechanism.

The European Commission, according to the Ryan and Vinciūnas documents and the U.S. National Cancer Institute, according to their web site, are each depending on the SCENIHR 2015 document to make judgments about EMF effects. Consequently, the reliability of SCENIHR 2015 is an essential element in determining the reliability of both of their assessments.

The document that is presented below, differs from the document that was emailed to EU authorities in three different ways: 1. The original document was sent as an email with multiple attachments. In this document attachments are simply provided as citations. The current document is a stand-alone document. 2. Some material is inserted to discuss positions taken by the U.S. FCC, FDA and National Cancer Institute, so as to be particularly relevant to the U.S. situation. 3. Substantial additional evidence is also provided.

The revised document contains seven chapters followed by a citation list for the entire document:

Chapter 1: Eight Extremely Well-Documented Effects of Non-Thermal EMF Exposures: Role of Pulsations, Other Factors that Influence EMF Effects, pp. 4-17

Chapter 2: How Each Such EMF Effect Is Directly Produced via Voltage-Gated Calcium Channel Activation: Role of the Voltage Sensor in Producing the Extraordinary Sensitivity to EMF Effects, pp. 17-23

Chapter 3: Strong Evidence for Cumulative and Irreversible EMF Effects pp. 23-27

Chapter 4: EMFs Including Wi-Fi May Be Particularly Damaging to Young People pp. 27,28

Chapter 5: The Importance of the SCENIHR 2015 Document and the Many Omissions, Flaws and False-

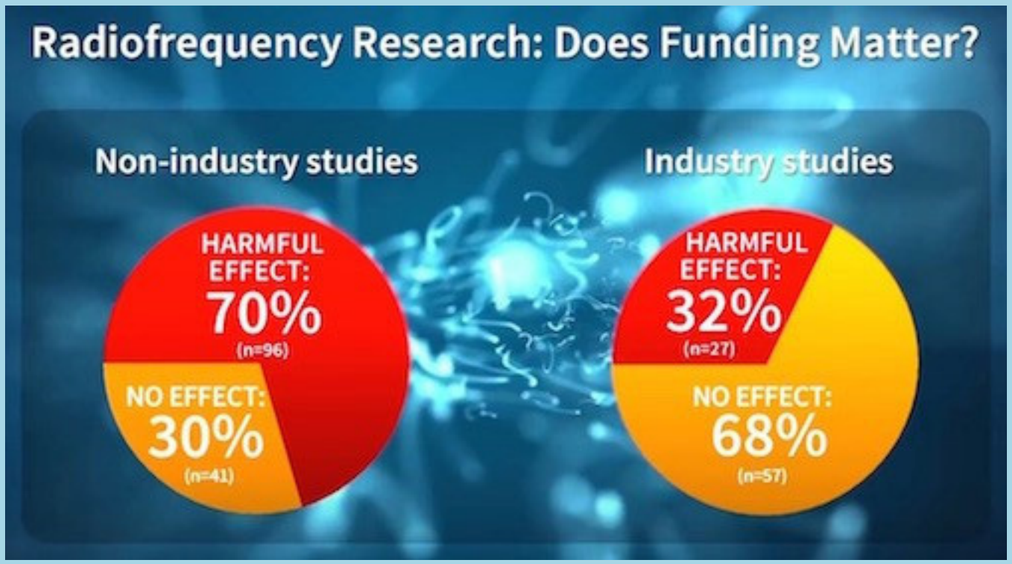
hoods in That Document pp. 28-58

Chapter 6: The U.S. Early Role in Recognizing Non-Thermal EMF Effects and How This Was Abandoned Starting in 1986: U.S. Failure to Research Health Impacts of Cell Phone Towers, Cell Phones, Wi-Fi, Smart Meters and Now 5G. What Is the Current Position of U.S. Government Agencies? pp. 58-78

Chapter 7: The Great Risks of 5G: What We Know and What We Don't Know pp. 78-82

CHAPTER ONE

Eight Extremely Well-Documented Effects of Non-Thermal EMF Exposures: Role of Pulsations, Other Factors that Influence EMF Effects



Both the earlier Ryan document and the more recent Arūnas document each fail to pay any attention to the extensive scientific literature that has been accumulated on non-thermal electromagnetic field (EMF) effects. The scientific consensus of independent scientists based on information accumulated over the last 7 decades is just the opposite of what each of them states. I am copying into this document, at the end of Chapter 1, a series of 8 extremely well- documented effects of such EMF exposure, together with a list of review articles, most of them being peer reviewed articles published in well respected journals in the PubMed database, that have each reviewed a body of evidence demonstrating the existence of each such effect.

What are the effects produced by non-thermal exposures to microwave frequency EMFs, where we have an extensive scientific literature? Each of the following effects has been documented in from 12 to 34 reviews, listed at the end of Chapter 1.

1. Three types of cellular DNA attacks, producing single strand breaks in the cellular DNA, double strand breaks in cellular DNA and oxidized bases in cellular DNA. Each of these DNA changes have roles in cancer causation and in producing the most important mutational changes in humans and diverse animals. Double stranded DNA breaks produce chromosomal breaks, rearrangements, deletions and duplications and copy number mutations; they also produce gene amplification, an important mechanism in cancer causation. Single strand breaks in cellular DNA cause aberrant recombination events leading to copy number mutations. Oxidized bases cause point mutations. When these occur in somatic cells, they can each have roles in causing cancer. When these occur in germ line cells (and they have be shown to occur in sperm following EMF exposures), they cause the three most important types of mutations in future generations, chromosomal mutations, copy number mutations and point mutations. (21 different reviews documenting these types of cellular DNA damage).

2. A wide variety of changes leading to lowered male fertility, lowered female fertility, increased spontaneous abortion, lowered levels of estrogen, progesterone and testosterone, lowered libido (18 reviews). Human sperm count has dropped to below 50% of what used to be considered normal throughout the technologically advanced countries of the world [1]. Reproductive rates have fallen below replacement levels in every technologically advanced country of the world, with a single exception. These include every EU country, the U.S., Canada, Japan, South Korea, Taiwan, Singapore, Australia and New Zealand. Reproduction averages, in these countries, about 73% of replacement levels according to 2015 or 2016 data. A study on mouse reproduction [2] showed that radio/microwave frequency EMF exposure at doses well within our current safety guidelines produced substantial dose-dependent decreases in reproduction within the first set of litters; further exposure produced dose-dependent complete or almost complete sterility that was found to be largely irreversible. When we have a technology that is universally present in these technologically advanced countries, that we know impacts reproduction, and reproduction has already dropped well below replacement levels, and we may be facing a catastrophic and irreversible decline in reproduction and there are more and more plans to expose us still further, don't you think that we should take note of the science? Mr. Ryan and Dr. Vinciūnas seem to be saying not at all. (Please note that the U.S. FCC and FDA also completely ignore this existential threat).

3. Neurological/neuropsychiatric effects (25 reviews). My own paper on this [3] and two earlier reviews cited in it found that there are whole series of repeatedly found EMF effects which have also become extremely widespread complaints in our technologically advanced societies, namely: sleep disturbance/insomnia; fatigue/tiredness; headache; depression/depressive symptoms; lack of concentration/attention/cognitive dysfunction; dizziness/vertigo; memory changes; restlessness/tension/anxiety/stress/agitation; irritability. These findings are not just based on epidemiological findings but are also based on profound impacts of EMFs, at levels well within our safety guidelines, on brain structure and function and also on the mechanism of non-thermal EMF action discussed below. When we have these neuropsychiatric effects becoming more and more common in technologically advanced societies all over the world, and we know each of these is caused EMF exposures, shouldn't we take note of this relationship?

4. Apoptosis/cell death (13 reviews). The two most important consequences of large increases in apoptosis (programmed cell death) are in causation of the neurodegenerative diseases and lowered reproduction although there are others.

5. Oxidative stress/free radical damage (19 reviews). Oxidative stress has roles in all or almost all chronic diseases. It is reported to have essential roles in producing the reproductive effects and the attacks on cellular DNA and may also have roles in producing the neurological effects and some of the cancer-causing effects shown to be produced here by EMF exposures.

6. Widespread endocrine (that is hormonal) effects (12 reviews). The steroid hormone levels drop with EMF exposure, whereas other hormone levels increase with initial exposure. The neuroendocrine hormones and insulin levels often drop with prolonged EMF exposure, possibly due to endocrine exhaustion.

7. Increases in intracellular calcium ([Ca2+]i) levels following EMF exposure (15 reviews). Calcium sig-

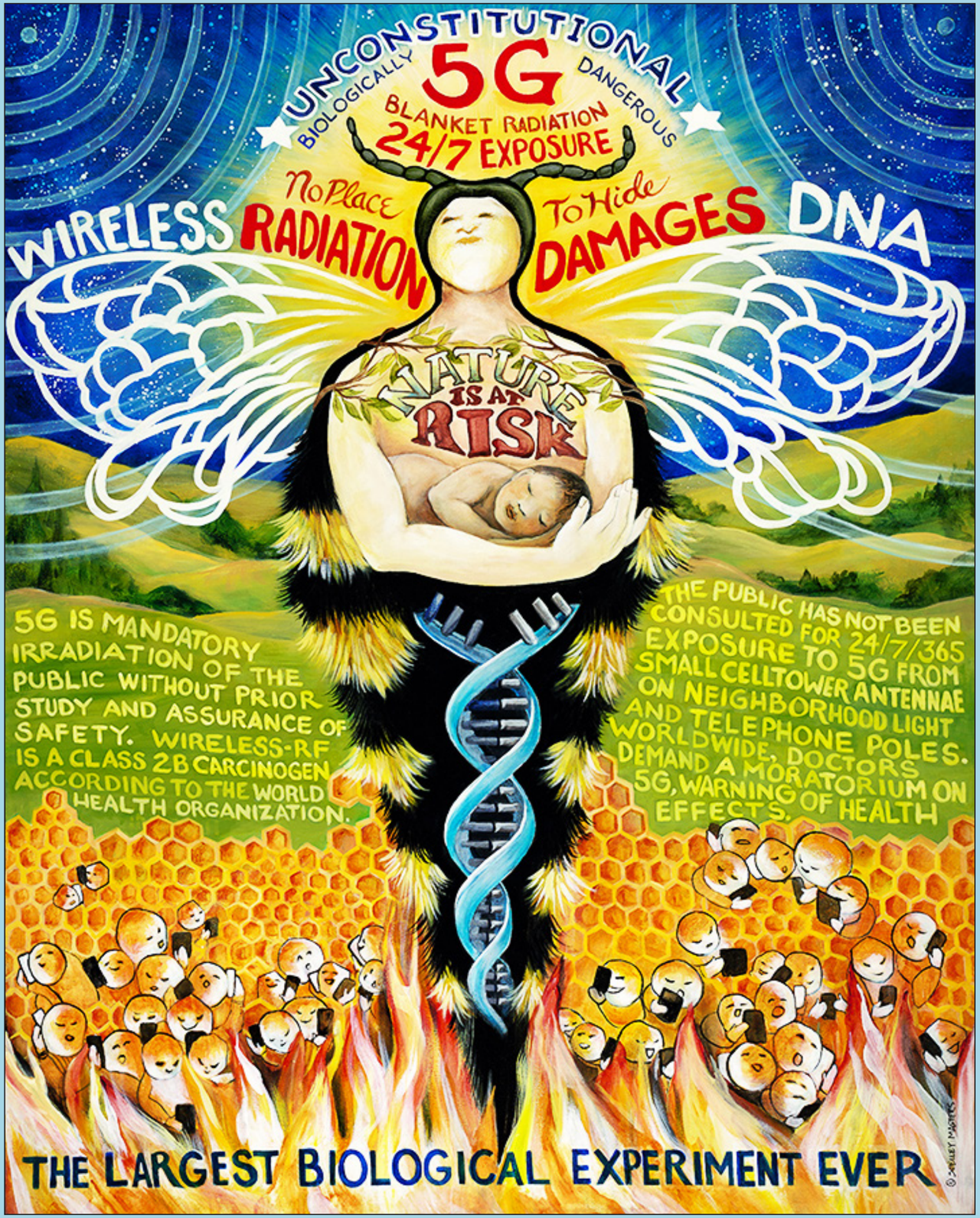
naling also increases following EMF exposure.

8. Cancer causation (35 reviews). Brain cancer, salivary cancer, acoustic neuromas and two other types of cancer go up with cell phone use. People living near cell phone towers have increased cancer rates. Other types of EMFs are each implicated. Short wave radio, radio ham operators and people exposed to radar all are reported to have increased cancer incidence. Perhaps most telling, heavy-long term cell phone users have the highest incidence of brain cancer and have predominantly cancer increases on the ipsilateral side of the head (the side they use their cell phones), as opposed to the contralateral side. I have a paper [7], focused not on whether EMFs cause cancer but rather on how they can cause cancer. The paper shows that "downstream effects" of the main target of the EMFs in the cells of our bodies, can cause cancer in 15 different ways, including increases in cancer initiation, promotion and progression. Progression effects include both tissue invasion and metastasis. Each of these cancer causation effects are caused via mechanisms produced by downstream effects of the main non-thermal EMF mechanism, as discussed in Chapter 2.

Therapeutic effects of such EMFs. Such EMFs when focused on a specific region of the body where there is some dysfunction and when used at specific intensities, can have therapeutic effects. In my 2013 paper [4], I cited 12 different reviews where EMF stimulation of bone growth was used therapeutically. There are something like 4000 papers on various therapeutic effects. Strangely, the telecommunications industry does not acknowledge these therapeutic effects, preferring rather to maintain the fiction that there are no non-thermal effects.

There is another set of reviews, 13 in this case, with each showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed EMFs. This is particularly important because all wireless communication devices communicate via pulsations, making them potentially much more dangerous. It follows from this that if you wish to study the effects of Wi- Fi, cell phones, cordless phones, cell phone towers, smart meters or 5G, you had better study the real thing or at least something that pulses very much like the real thing. There are many studies that don't do this, but falsely claim to be genuine Wi-Fi, cell phone or cordless phone studies. Other factors that influence the occurrence of non-thermal EMF effects include the frequency being used, the polarization of the EMFs and the cell type being studied [4,5,8-11]. Furthermore there are intensity "windows" that produce maximum biological effects, such that both lower and higher intensities produce much less effect [5,8,9]. These window effect studies clearly show that dose-response curves are both non-linear and non-monotone, such that it is difficult or impossible to predict effects based on relative intensity even when all other factors are the same. The role of each of these factors is completely ignored by ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute as well as by many other industry-friendly groups. When each of these organizations concludes that "results are inconsistent" they are comparing studies based on superficial similarities but not on these demonstrated causal factors. What is being observed, therefore, is genuine biological heterogeneity, not inconsistency. It has been known since the beginning of modern science in the 16th century that how you do your studies is important in determining what results are obtained. How is it possible that ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute have forgotten this important fact?

The primary literature studies demonstrating roles of pulsation, frequency, polarization, cell type and intensity windows in determining biological effects are entirely dependent on having genuine effects to study. None of these studies could have been done without an effect to study. Conse-



quently, the claims that there are no well-documented EMF effects are nonsense, based not only on the eight extremely well-documented effects summarized above, but also on the entire literature demonstrating the role of pulsation, frequency, polarization, cell type and intensity windows. Now I haven't said anything about how these non-thermal EMF effects are produced. I am taking much of Chapter 2 from a recent paper [11]. Categorized peer reviewed reports, each showing important health-related non-thermal effects of microwave frequency electromagnetic fields (EMFs) follow. These review lists were prepared by Dr. Martin L. Pall, Professor Emeritus of Biochemistry and Basic Medical Sciences, Washington State University (martin_pall@wsu.edu). Pall has a BA degree in Physics, Phi Beta Kappa, with honors, Johns Hopkins University; PhD in Biochemistry & Genetics, Caltech.

Specific Effects And Reviews Each Reporting The Effect In Multiple Primary Literature Studies:

1. Cellular DNA damage: Single strand and double strand breaks in cellular DNA and oxidized bases in cellular DNA, leading to chromosomal and other mutational changes:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+-medical+microwave+radio- frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)

2. Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect 105(Suppl 6):1579-1587.

3. Yakymenko IL, Sidorik EP, Tsybulin AS. 1999 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999), 2011 Mar-Apr:20-28.

4. Aitken RJ, De Iuliis GN. 2007 Origins and consequences of DNA damage in male germ cells. Reprod Biomed Online 14:727-733.

5. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.

6. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109- 1117.

7. Phillips JL, Singh NP, Lai H. 2009 Electromagnetic fields and DNA damage. Pathophysiology 16:79-88.

8. Ruediger HW. 2009 Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology. 16:89-102.

9. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.

10. Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.

11. Yakimenko IL, Sidorik EP, Tsybulin AS. 2011 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999). 2011 Mar-Apr;83(2):20-28.

12. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1

13. Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.

14. Pall, M. L. 2015 Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99- 116. doi: 10.1515/reveh-2015-0001.

15. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.

16. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263- R276.

17. Batista Napotnik T, Reberšek M, Vernier PT, Mali B, Miklavčič D. 2016 Effects of high voltage nanosecond electric pulses on eukaryotic cells (in vitro): A systematic review. Bioelectrochemistry. 2016 Aug;110:1-12. doi: 10.1016/j.bioelechem.2016.02.011.

18. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655- 2662. doi: 10.19082/2655.

19. Pall ML. 2018 How cancer can be caused by microwave frequency electromagnetic field (EMF) exposures: EMF activation of voltage-gated calcium channels (VGCCs) can cause cancer including tumor promotion, tissue invasion and metastasis via 15 mechanisms. Chapter 7 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 167-188.

20. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

21. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

2. Lowered fertility, including tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovarian remodeling, oocyte (follicle) loss, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, lowered libido:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+-medical+microwave+radio- frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)

2. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by B Haigh. Consultants Bureau, New York/London, 146 pages.

3. Goldsmith JR. 1997 Epidemiological evidence relevant to radar (microwave) effects. Environ Health Perspect 105(Suppl 6):1579-1587.

4. Aitken RJ, De Iuliis GN. 2007 Origins and consequences of DNA damage in male germ cells. Reprod Biomed Online 14:727-733.

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7. Kang N, Shang XJ, Huang YF. 2010 [Impact of cell phone radiation on male reproduction]. Zhonghua Nan Ke Xue 16:1027-1030.

8. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi. org/10.5653/cerm.2012.39.1.1

9. La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. 2012 Effects of the exposure to mobile phones on male reproduction: a review of the literature. J Androl 33:350-356.
10. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.

11. Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. 2013 Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol 246:869-875.

12. Adams JA, Galloway TS, Mondal D, Esteves SC, Mathews F. 2014 Effect of mobile telephones on sperm quality: a systematic review and meta-analysis. Environ Int 70:106- 112.
13. Liu K, Li Y, Zhang G, Liu J, Cao J, Ao L, Zhang S. 2014 Association between mobile phone use and semen quality: a systematic review and meta-analysis. Andrology 2:491- 501.

14. K Sri N. 2015 Mobile phone radiation: physiological & pathophysiological considerations. Indian J Physiol Pharmacol 59:125-135.

15. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
16. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263- R276

17. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

18. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

3. Neurological/neuropsychiatric effects:

1. Marha K. 1966 Biological Effects of High-Frequency Electromagnetic Fields (Translation). ATD Report 66-92. July 13, 1966 (ATD Work Assignment No. 78, Task 11). http://www.dtic.mil/docs/citations/AD0642029 (accessed March 12, 2018)

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7. Lai H. 1994 Neurological effects of radiofrequency electromagnetic radiation. In: Advances in Electromagnetic Fields in Living Systems, Vol. 1, J.C. Lin, Ed., Plenum Press, New York, pp. 27-88.

8. Grigor'ev IuG. 1996 [Role of modulation in biological effects of electromagnetic radiation]. Radiats Biol Radioecol 36:659-670.

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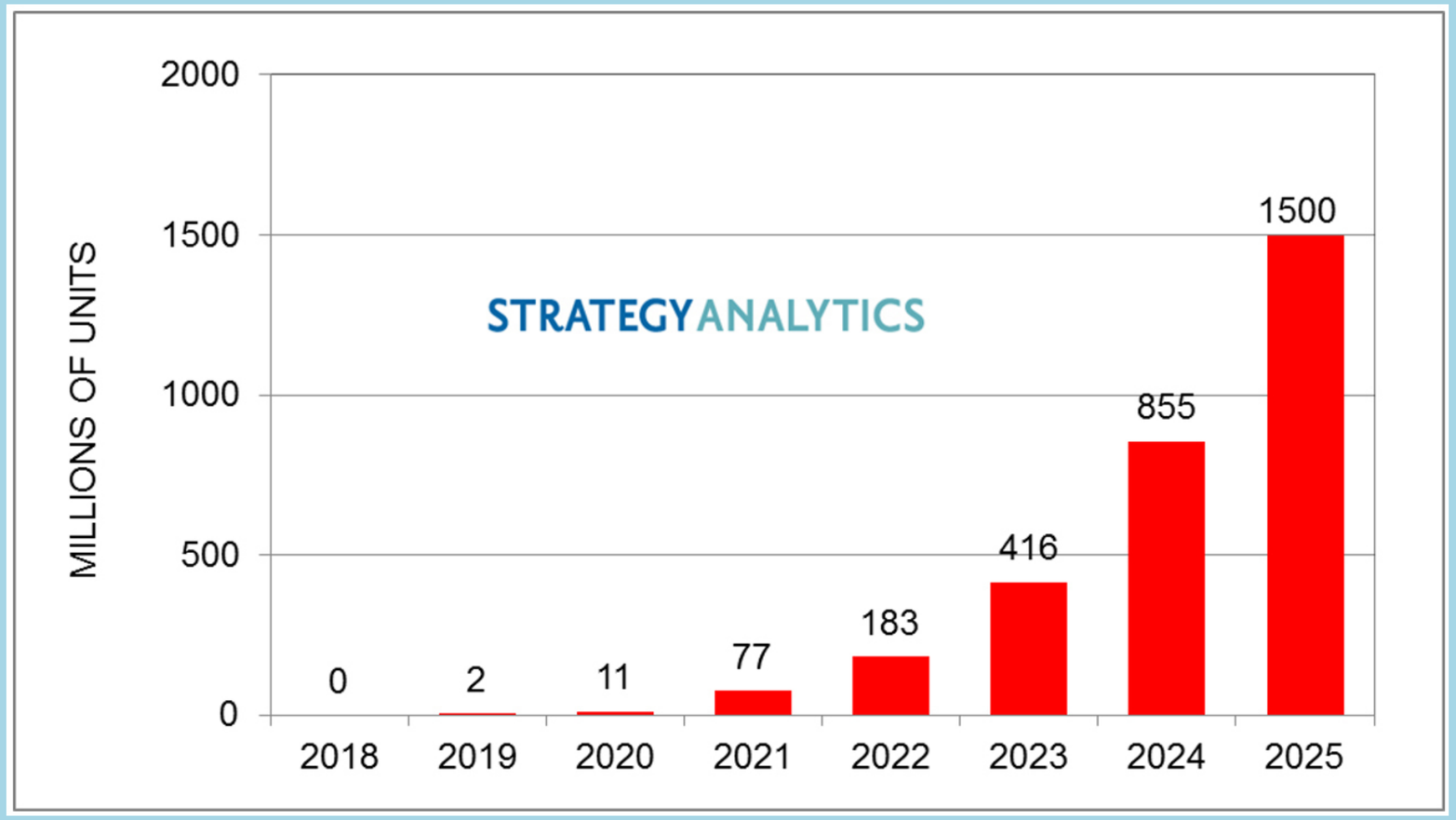
13. Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M, Ahonen M. 2010 Epidemiological evidence for a health risk from mobile phone base stations. Int J Occup Environ Health 16:263-267.

14. Levitt, B. B., Lai, H. 2010. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18, 369-395. doi.org/10.1139/A10-018

15. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.

16. Politański P, Bortkiewicz A, Zmyślony M. 2016 [Effects of radio- and microwaves emitted by wireless communication devices on the functions of the nervous system selected elements]. Med Pr 67:411-421.

17. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.



18. Pall ML. 2016 Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75(Pt B):43-51. doi: 10.1016/j.jchemneu.2015.08.001.

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21. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. 2016 EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health DOI 10.1515/reveh- 2016-0011.

22. Zhang J, Sumich A, Wang GY. 2017 Acute effects of radiofrequency electromagnetic field emitted by mobile phone on brain function. Bioelectromagnetics 38:329-338. doi: 10.1002/bem.22052.

23. Lai H. 2018. A Summary of Recent Literature (2007–2017) on Neurological Effects of Radio Frequency Radiation. Chapter 8 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 189-224.

24. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

25. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

4. Apoptosis/Cell Death: an important process in production of neurodegenerative diseases that is also important in producing infertility responses):

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised:
https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)

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12. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655- 2662. doi: 10.19082/2655.

13. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404- 416.

5. Oxidative stress/free radical damage: an important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage

1. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.

2. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.

3. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109-1117

4. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.

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16. Dasdag S, Akdag MZ. 2016 The link between radiofrequencies emitted from wireless technologies and oxidative stress. J Chem Neuroanat 75(Pt B):85-93.

17. Wang H, Zhang X. 2017 Magnetic fields and reactive oxygen species. Int J Mol Sci. 2017 Oct

18;18(10). pii: E2175. doi: 10.3390/ijms18102175.

19. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404- 416.
20. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

6. Endocrine, that is hormonal effects:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio- frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)

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12. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

7. Increased intracellular calcium: intracellular calcium is maintained at very low levels (typically about 2 X 10-9 M) except for brief increases used to produce regulatory responses, such that sustained elevation of intracellular calcium levels produces many pathophysiological (that is disease-causing) responses).

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2. Walleczek, J. 1992. Electromagnetic field effects on cells of the immune system: the role of calcium signaling. FASEB J. 6, 3177-3185.

3. Adey, WR. 1993 Biological effects of electromagnetic fields. J Cell Biochem 51:410- 416.

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um channels via their voltage sensor. Curr Chem Biol 10: 74-82.

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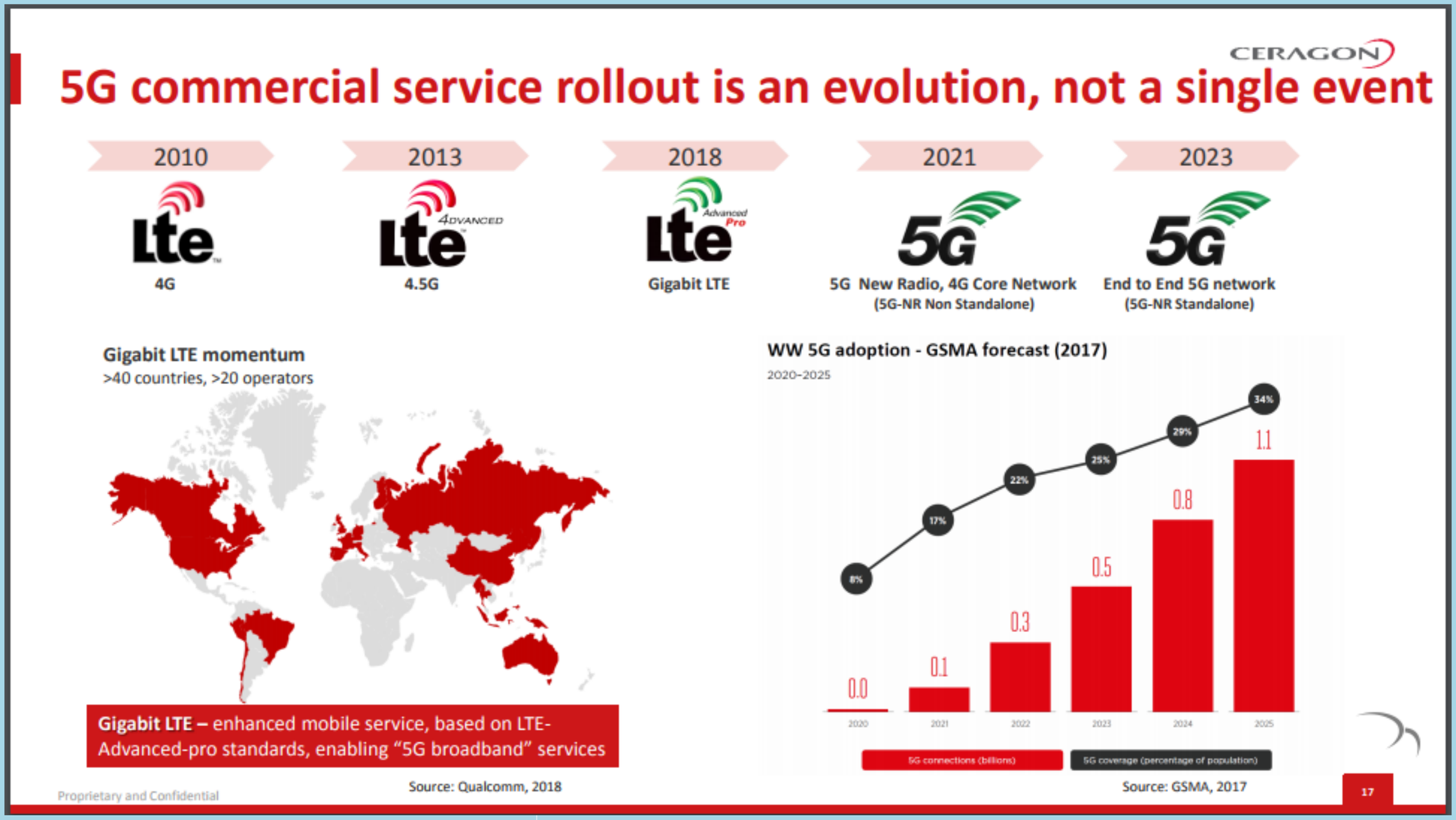

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“Each of the reviews on the previous pages typically cite from 5 to over 100 primary literature citations, each showing that non-thermal EMF exposures produce the effect under which they are listed.

It follows from this, that there are not only 11 or more reviews documenting each of these effects, but there is also a massive primary literature documenting these effects as well.

It follows from this that the ICNIRP, FCC and International Safety Guidelines, which are entirely based only on thermal effects are inadequate and there have been petitions and other statements of international groups of scientists expressing great concern about this.

It follows that the ICNIRP, FCC and International safety guidelines are completely unscientific and cannot be relied upon to protect our safety.”

National Institutes Of Health • US Department Of Health And Human Services • March 28, 2018

National Toxicology Program

NPT Technical Report On The Toxicology & Carcinogenesis Studies In Hsd:Sprague Dawley Rats Exposed To Whole-Body Radio Frequency Radiation At A Frequency (900 MHz) And Modulations (GSM And CDMA) Used Cell Phones

National Institutes of Health
Public Health Service
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

At 2 years, there were similarities in neoplastic and nonneoplastic responses between modulations. Following exposure to GSM- or CDMA-modulated cell phone RFR, there were increases in the incidences of malignant schwannoma in the heart of male rats, with a significant positive trend in the incidences in GSM- and CDMA-exposed males and a significant pairwise increased incidence in CDMA 6 W/kg males. Also observed in the heart were significantly increased incidences of right ventricular cardiomyopathy in 3 and 6 W/kg GSM male and female rats and 6 W/kg CDMA male rats.

Several other, weaker, responses were observed in both modulations including malignant glioma in the brain, adenomas in the pituitary gland (pars distalis), and pheochromocytomas of the adrenal medulla. Additionally, in GSM male rats there were marginal responses in the prostate gland, granular cell tumors of the brain, and in pancreatic islets that were not observed in CDMA-exposed rats, and in CDMA-exposed male rats, there was a response in the liver. The relationship between these responses and exposure to GSM or CDMA RFR was uncertain.

There were significantly increased incidences of benign, malignant or complex pheochromocytoma (combined) in the adrenal medulla of the 1.5 and 3 W/kg GSM male rats and 1.5 W/kg CDMA female rats. In GSM female rats, there were increased incidences of hyperplasia in the adrenal medulla at 6 W/kg.

There was a significantly increased incidence of adenoma or carcinoma (combined) in pancreatic islets in 1.5 W/kg GSM male rats.

Under the conditions of this 2-year whole-body exposure study, there was some evidence of carcinogenic activity of GSM-modulated cell phone RFR at 900 MHz in male Hsd:Sprague Dawley SD rats based on the incidences of malignant schwannoma in the heart. The incidences of adenoma or carcinoma (combined) in the prostate gland, malignant glioma and benign or malignant granular cell tumors in the brain, adenoma of the pars distalis in the pituitary gland, pheochromocytoma (benign, malignant, or complex combined) in the adrenal medulla, and pancreatic islet cell adenoma or carcinoma (combined) may have been related to cell phone RFR exposure.

There was some evidence of carcinogenic activity of CDMA- modulated cell phone RFR at 900 MHz in male Hsd:Sprague Dawley SD rats based on the incidences of malignant schwannoma in the heart. The incidences of malignant glioma in the brain, adenoma of the pars distalis in the pituitary gland, and adenoma or carcinoma (combined) of the liver may have been related to cell phone RFR exposure. There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 900 MHz in female Hsd:Sprague Dawley SD rats based on the incidences of malignant glioma in the brain and pheochromocytoma (benign, malignant, or complex combined) in the adrenal medulla.

Increases in nonneoplastic lesions in the heart, brain, and prostate gland of male rats, and of the heart, thyroid gland, and adrenal gland in female rats occurred with exposures to GSM cell phone RFR at 900 MHz. Increases in nonneoplastic lesions of the heart, brain, and prostate gland occurred in males, and of the brain in females exposed to CDMA cell phone RFR at 900 MHz.

Oxidative Medicine and Cellular Longevity • November 2018 • 18 pages

Role Of Mitochondria In The Oxidative Stress Induced By Electromagnetic Fields: Focus On Reproductive Systems

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Modern technologies relying on wireless communication systems have brought increasing levels of electromagnetic field (EMF) exposure. This increased research interest in the effects of these radiations on human health. There is compelling evidence that EMFs affect cell physiology by altering redox-related processes. Considering the importance of redox milieu in the biological competence of oocyte and sperm, we reviewed the existing literature regarding the effects of EMFs on reproductive systems. Given the role of mitochondria as the main source of reactive oxygen species (ROS), we focused on the hypothesis of a mitochondrial basis of EMF-induced reproductive toxicity. MEDLINE, Web of Science, and Scopus database were examined for peer-reviewed original articles by searching for the following keywords: "extremely low frequency electromagnetic fields (ELF- EMFs)," "radiofrequency (RF)," "microwaves," "Wi-Fi," "mobile phone," "oxidative stress," "mitochondria," "fertility," "sperm," "testis," "oocyte," "ovarian follicle," and "embryo." These keywords were combined with other search phrases relevant to the topic. Although we reported contradictory data due to lack of uniformity in the experimental designs, a growing body of evidence suggests that EMF exposure during spermatogenesis induces increased ROS production associated with decreased ROS scavenging activity. Numerous studies revealed the detrimental effects of EMFs from mobile phones, laptops, and other electric devices on sperm quality and provide evidence for extensive electron leakage from the mitochondrial electron transport chain as the main cause of EMF damage. In female reproductive systems, the contribution of oxidative stress to EMF-induced damages and the evidence of mitochondrial origin of ROS overproduction are reported, as well. In conclusion, mitochondria seem to play an important role as source of ROS in both male and female reproductive systems under EMF exposure. Future and more standardized studies are required for a better understanding of molecular mechanisms underlying EMF potential challenge to our reproductive system in order to improve preventive strategies.

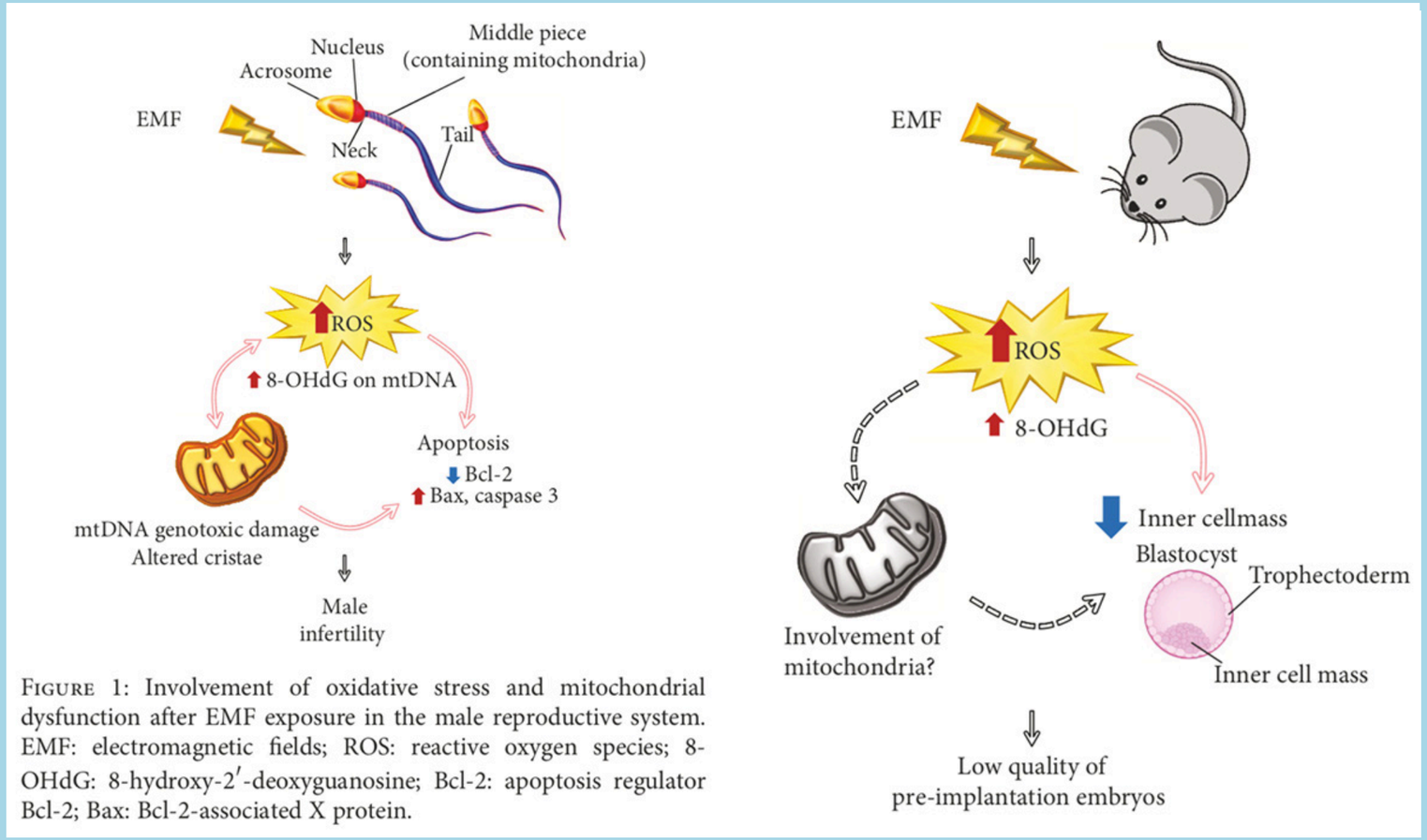

FIGURE 1: Involvement of oxidative stress and mitochondrial dysfunction after EMF exposure in the male reproductive system. EMF: electromagnetic fields; ROS: reactive oxygen species; 8-OHdG: 8-hydroxy-2′-deoxyguanosine; Bcl-2: apoptosis regulator Bcl-2; Bax: Bcl-2-associated X protein.

Environmental Research • September 2018

Real World Cellular Phone Radio-Frequency Electromagnetic Field Exposure

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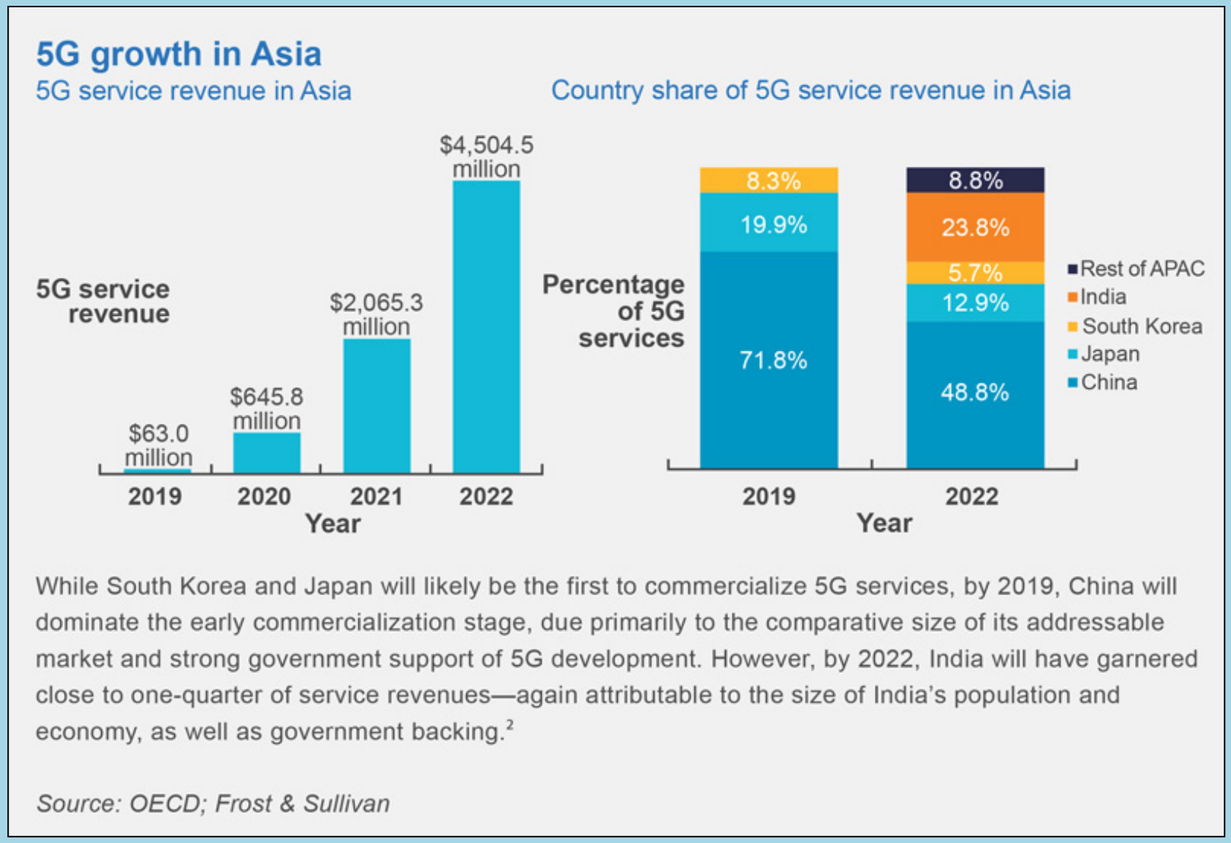
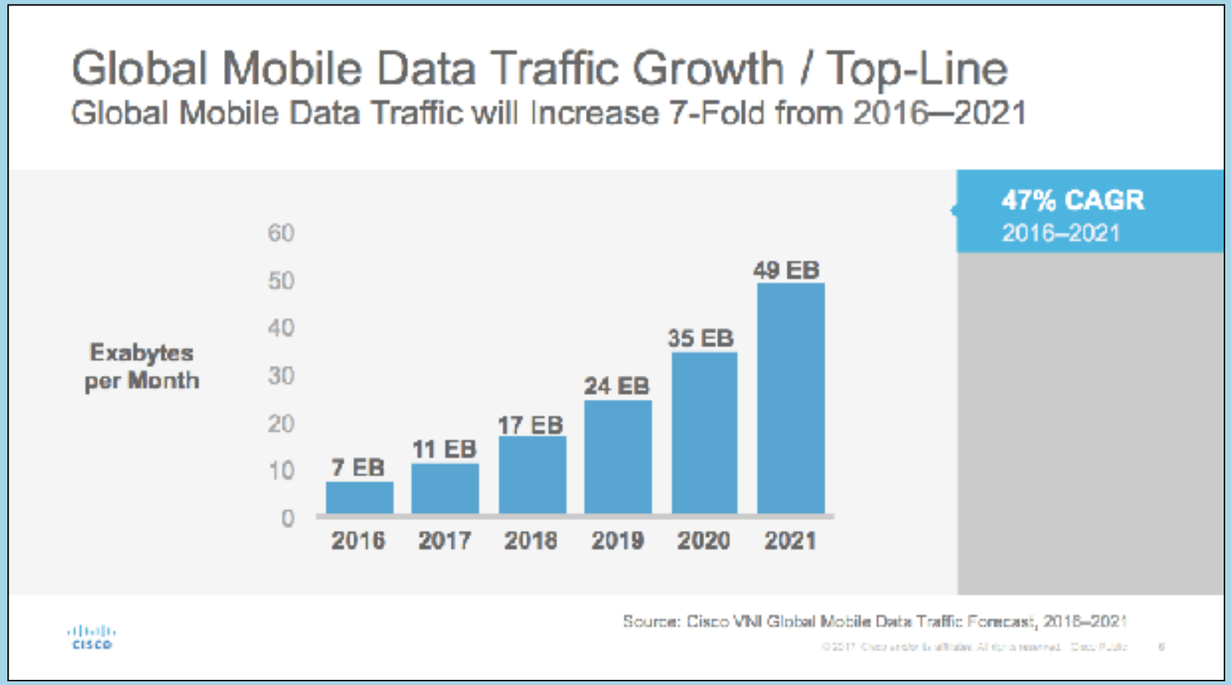
In 2011 the International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields (RF EMF) from cellular phones as possibly carcinogenic to humans. The National Toxicology Program (NTP) and the Ramazzini Institute have both reported that RF EMF significantly increases glioma and Schwannoma of the heart in rodent studies. Recent studies indicate that the RF EMF exposure from cellular phones have negative impact on animal cells and cognitive and/or behavior development in children. Case-controlled epidemiologic studies have found evidence for mobile phone use and increased risk for glioma and localization of the glioma associated with the consistent exposure site of regular mobile phone use. Understanding the exposure level, or power density, from RF EMF emitted by cell phones under real-world usage and signal reception conditions, as distinct from the published measurements of maximum Specific Absorption Rate (SAR) values, may help cell phone users decide whether to take behavioral steps to reduce RF EMF exposure. Exposure measurements were conducted on phone models from four major mobile network operators (MNOs) in the USA for calls received under strong and weak reception signal conditions, near the phone face and at several distances up to 48 cm. RF EMF exposure from all phones were found to be greater under weak (1-2 display bars) than under strong (4-5 display bars) reception signal conditions by up to four orders of magnitude. Notably, RF EMF exposure levels under weak reception signal conditions at a distance of 48 cm from the phone were similar to or greater than those detected under strong reception signal conditions at a distance of 4 cm. Under weak reception signal conditions, power density reductions by 10 times occurred at 16 cm typical for speaker phone or texting modes over the 4 cm near ear exposure. Reduced and precautionary use of cell phones under weak signal conditions could lessen a user's RF EMF exposure by a factor of up to 10,000. Bluetooth headset power density exposures were 10 to 400 times lower than those of the phones to which they were connected and dependent on the headset rather than the connected mobile phone. The new CDPH guidance includes practical steps both adults and children could take to reduce exposure to radio frequency energy from cell phones.

Keywords:
Cellular phones, Radiofrequency, Electromagnetic fields,
Exposure assessment, Power density, Maximum permissible exposure





Decreased Dopamine In Striatum And Difficult Locomotor Recovery From MPTP Insult After Exposure To Radiofrequency Electromagnetic Fields

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Concern is growing about possible neuronal effects of human exposure to radiofrequency electromagnetic fields because of the increasing usage of cell phones and the close proximity of these devices to the brain when in use. We found that exposure to a radiofrequency electromagnetic field (RF-EMF) of 835 MHz (4.0W/kg specific absorption rate [SAR] for 5 h/day for 12 weeks) affects striatal neurons in C57BL/6 mice. The number of synaptic vesicles (SVs) in striatal presynaptic boutons was significantly decreased after RF-EMF exposure. The expression levels of synapsin I and II were also significantly decreased in the striatum of the RF-EMF-exposed group. RF-EMF exposure led to a reduction in dopamine concentration in the striatum and also to a decrease in the expression of tyrosine hydroxylase in striatal neurons. Furthermore, in behavioral tests, exposure to RF-EMF impeded the recovery of locomotor activities after repeated treatments with 1-methyl-4-phenyl- 1,2,3,6-tetrahydropyridine (MPTP). These results suggest that the observed decrease in dopamine concentration in the striatum was caused by both a reduction in the number of dopaminergic neurons and a decline in the number of SVs. The decreased dopamine neuron numbers and concentration seen after RF-EMF exposure would have caused the difficult recovery after MPTP treatment. In summary, our results strongly suggest that exposing the brain to RF-EMF can decrease the number of SVs and dopaminergic neurons in the striatum. These primary changes impair the recovery of locomotor activities following MPTP damage to the striatum.

The use of cell phones has become a universal and popular means of communication around the world. This social revolution has been accompanied by persistent concerns that exposure to the radiofrequency-electromagnetic fields (RF-EMF) emitted by cell phones has a detrimental effect on human health. Notably, in 2011, the International Agency for Research on Cancer (IARC) classified RF-EMF as a potentially carcinogenic group 2B agent and informed the public of possible risks to health resulting from mobile phone use1. Recently, the U.S. National Toxicology Program has conducted comprehensive studies and found high exposure to RF-EMF to be associated with cancer2. In addition, a possibility that RF-EMF exposure causes lesions in various organs, including brain, heart, and endocrine glands, has been suggested.

Use of a cell phone usually involves direct contact of the device with the head, and close-range exposure to the phone's RF-EMF may affect the nervous system. Despite many controversies, evidence is accumulating for biological effects of RF-EMF exposure in the central nervous system (CNS), such as changes in blood-brain barrier permeability, homeostasis of intracellular calcium, neurotransmitters, and neuronal damage3–7. Moreover, RF-EMF exposure activates a diversity of intracellular events including events on the apoptotic pathway, on brain extracellular signaling pathways, and in the autophagy mechanism8–10. Epidemiological studies have reported headache, tremor, dizziness, loss of concentration, sleep disturbance, and cognitive dysfunction attributable to exposure to RF-EMF11–13. It has also been suggested that frequent use of cell phones may be associated with a risk of attention deficit hyperactivity disorder in children14.

Previously, we found that exposure to RF-EMF could induce changes in synaptic vesicle (SV) number and in cross-sectional areas at presynaptic terminals on cortical neurons15. The study implicated changes in synapsin expression in causing the SV results. SVs are small organelles nearly 40 nm diameter situated at the pre-synaptic terminal, and are mainly implicated in the storage, release, and secretion of neurotransmitters, which is achieved in cooperation with diverse synaptic proteins such as synapsins16. Synapsins are a family of abundant, SV-associated phosphoproteins and critical regulators of SV dynamics and neurotransmitter release17,18. Moreover, abnormal levels of synapsins in the brain are implicated in neuropsychiatric disorders such as autism19,20, bipolar disorder21, schizophrenia21–23, and epilepsy19,24–27. In transgenic animal models, a deficiency of synapsins has also been shown to result in cognitive impairments, behavioral abnormalities, and deficits in social behavior19,23. Therefore, the expression changes of synapsins induced by exposure to RF-EMF could affect the number and size of SVs at synaptic terminals. However, the question of whether the observed changes in SV numbers could affect the release amount of neurotransmitters has not been studied. Moreover, it is not established that such changes can cause behavioral changes in an animal model.

The striatum, a major part of the basal ganglia, receives dopaminergic input through the mesolimbic and nigrostriatal dopamine systems28. The striatum has a variety of functions, such as cognition, but is best known for facilitating voluntary movement; dopamine plays an important role in the organization of reward-seeking behavior and motor responses28. The striatum is divided into the dorsal (caudate, putamen) striatum and the ventral (nucleus accumbens) striatum29.

In this study, we investigated in the striatum of C57BL/6 mice the possible effects of exposure to 835-MHz (high UHF) RF-EMF at a 4.0 W/kg specific absorption rate [SAR] for 5 hours daily for 12 weeks and looked for changes in the dopaminergic neurons and terminals. Specifically, we tested whether the expression level of synapsin transcripts and proteins are altered and whether the number and size of SVs at the presynaptic terminal are altered in the striatum. Furthermore, we directly measured the level of dopamine in the striatum to test for physiological changes resulting from the changes in synapsin expression and SV trafficking. Finally, we tested for possible behavioral effects attributable to the observed decrease in dopamine concentration, changes in synapsins, and changes in SVs in striatum following RF-EMF exposure, following an MPTP challenge, because the dopaminergic projections to the striatum are essential for locomotor activities.

Discussion

In this study, we provide the first direct evidence for neurological effects of RF-EMF exposure, including changes in neurotransmitter levels in the mouse striatum and in the level of difficulty of locomotor recovery after MPTP treatment. The present findings demonstrated that 835-MHz, RF-EMF at 4.0 W/kg SAR for 5 h daily for 12 weeks resulted in alteration of neurological function in the striatum of the mouse brain, which led to a decrease in dopamine level due to decreased numbers of SVs and dopaminergic terminals in the striatum, thereby leading to increased difficulty in locomotor recovery following MPTP treatment.

The trafficking of SVs is regulated by various proteins such as synaptogyrin, synaptophysin, synaptotagmin, VAMP, SNARE, and so on [29]. However, synapsins are the key regulators of SV dynamics in presynaptic terminals [17,18]. Three kinds of synapsin are known in mammals, each with at least two isoforms [30]. The best-known function of synapsin proteins is to regulate synaptic transmission by controlling the storage and mobilization of SVs within a reserve pool (RP) [18,31]. Thus, synapsins were used here as a synaptic-vesicle marker and were found to be changed in expression level, which may affect SV morphology in the striatum after RF-EMF exposure. We previously reported that RF-EMF exposure could lead to alteration in SVs and changes in synapsin levels in cortical neurons [15]. The expression of synapsin I/II transcripts and proteins was here significantly downregulated in the striatum after RF-EMF exposure (Figs 1 and 2). Moreover, the gene profile results by microarray revealed that exposure to RF-EMF led to decreases in synapsins I/II in the striatum of mice (Table S1). However, no significant changes in synapsin III mRNA level were observed since the basal level of the synapsin III gene is very low in adult mice and is highly expressed only at the developmental stage32. Further, this is consistent with our microarray data, which shows that the basal level of synapsin III gene expression is more than 100 times lower than that of synapsins I/II (Table S1).

We tested whether the reduced levels of synapsin I and II seen after RF-EMF exposure could influence SV morphology in the striatum. In this study, counting the number of SVs per unit area and measuring the size of single SVs by TEM served for the morphological evaluation of SVs. The density of SVs (numbers/μm2) was significantly decreased, but the size of the SVs was significantly increased in striatal neurons in the RF-EMF exposed group (Fig. 3). The increased size of SVs may have partly compensated for the reduced number of SVs. This is consistent with other published results showing that lack of synapsin I and/or II in mice decreases the number of SVs in hippocampal, spinal, and visual cortex neurons [27,33,34] but in parts of the forebrain, the SVs are larger in size [35]. Moreover, synapsins interact with SV proteins and phospholipids and play an important role in the regulation of SV trafficking and stability by cross-linking SVs to each other and to the actin cytoskeleton. The membranes of SVs are mostly made of phospholipids, which form a bilayer, and are normally coated with synapsins, especially synapsin I [35]. Therefore, the normal SV is tightly wrapped in synapsins. However, it was reported that synapsin-depleted SVs in the rat forebrain became larger in size, i.e., a spherical shape but with a diameter of up to 70 nm vs. the typical diameter of 40 nm, due to the absence of synapsin I surrounding the phospholipid bilayer [35]. As shown in our data, the expression levels of synapsin genes and proteins were reduced by exposure to RF-EMF, which may account for the observed larger size. These results suggested that deceased levels of synapsins directly affect SV stability, reducing the number of SVs seen in the striatum in the RF-EMF-exposed group. We conclude that RF-EMF exposure leads to a decrease in the number of SVs in the striatum via reductions in the expression of synaptic proteins such as synapsin I and II.

The striatum is a subcortical area of the forebrain and the major input area of the basal ganglia, and receives dopaminergic input through the mesolimbic and nigrostriatal dopamine systems [28]. Interestingly, the present study showed that the level of dopamine dramatically decreased in the mouse striatum following RF-EMF exposure for 12

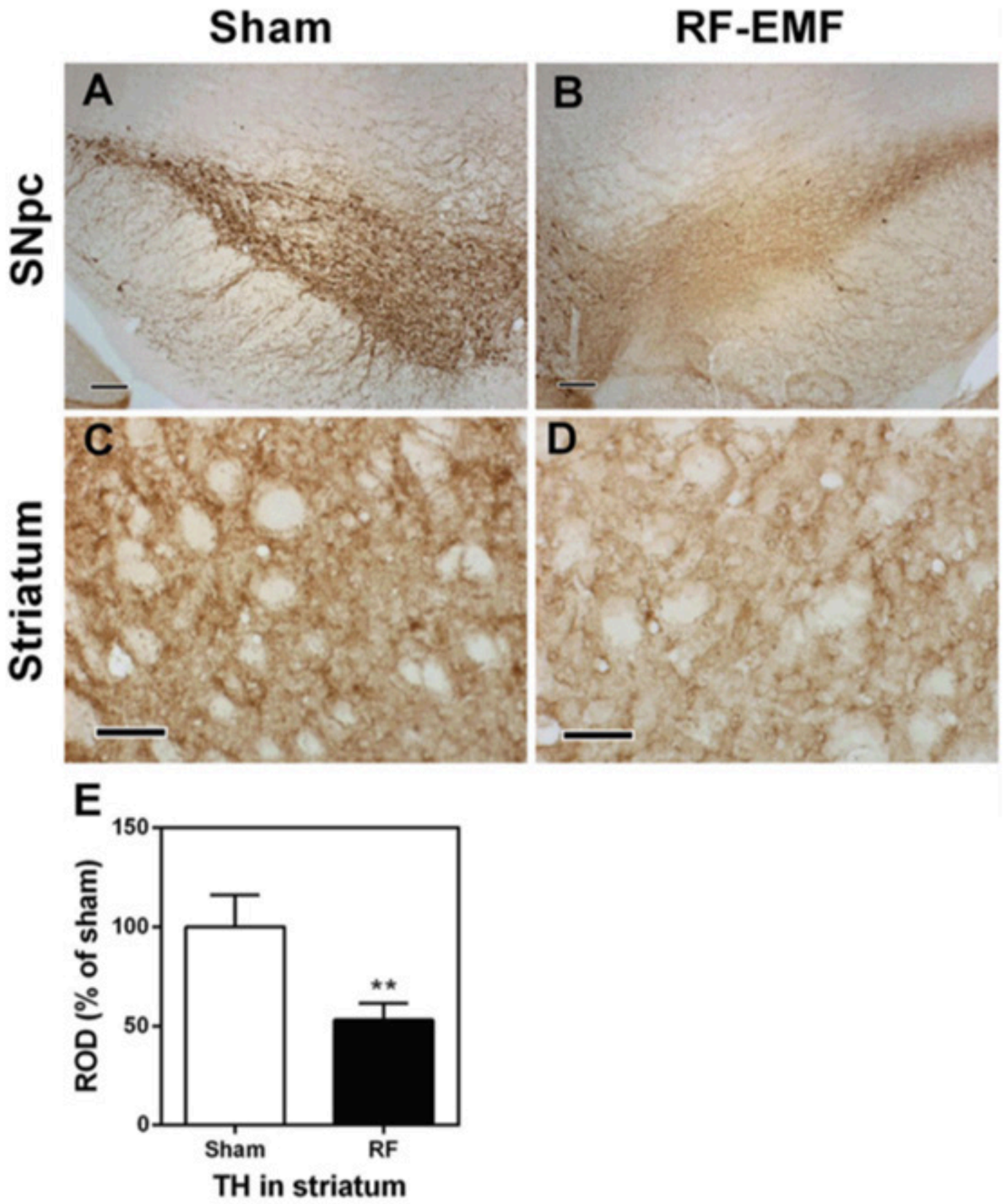

Figure 6. Striatal dopaminergic terminals are reduced after RF-EMF exposure. TH immunohistochemical analysis in substantia nigra pars compacta (SNpc) (**A,B**) and striatum (**C,D**) in sham-exposed (**A,C**) and RF-EMF exposed (**B,D**) mice. TH immunoreactivities are markedly decreased in the SNpc and striatum in the RF-EMF-exposed group. Scale bar = 100 μm. (**E**) Relative optical density (ROD) as % for TH-immunoreactive structures in the striatum in the sham- and RF-EMF groups. Bars indicate mean ± SEM. Statistical significance was evaluated using two-tailed, unpaired Student's *t*-test (**$P < 0.01$; vs. sham).

weeks (Fig. 4). Previously, it had been reported that low-level, extremely low frequency (ELF)-EMFs at 1000 milliGauss for 1 month caused slight alterations in levels of neurotransmitters, including dopamine, in the hypothalamus and striatum of rats [36]. Moreover, exposure to 1800 MHz RF-EMF with a 0.843 W/kg SAR resulted in changes in monoamines such as dopamine, NE, and 5-HT in the hippocampus, hypothalamus, midbrain, and medulla oblongata of the rat brain [37]. These findings are also consistent with a preliminary result by our research group that the dopamine level decreased by about 25% in the mouse striatum after RF-EMF exposure for 4 weeks, as shown by LC-MS/MS analysis (data not shown).

Of interest, the levels of TH expression in the striatum were also significantly decreased in the RF-EMF exposed group (Fig. 5). Additionally, the TH immunohistochemical study showed that the proportions of TH-immunoreactive neurons in the SNpc and striatum were significantly decreased in the RF-EMF exposed group compared with the sham-exposed group (Fig. 6). TH is the rate-limiting enzyme for dopamine synthesis and a marker of dopaminergic neurons [38]. Moreover, TH expression in dopaminergic neurons directly influences the quantitative regulation of dopamine in dopaminergic neurons, and hence TH expression can be indicative of the survival as well as the functional status of dopaminergic neurons [39]. Thus, a deficiency in TH causes impaired synthesis of dopamine [40]. Our results strongly suggest that the significant reduction in striatal dopamine concentration we saw is attributable the decreased number of SVs and the reduced population of dopaminergic neurons in the striatum we found after RF-EMF exposure.

Previously, we had reported that exposing mice to RF-EMF could cause demyelination of cortical neurons and hyperactivity on behavioral testing [41]. In this study, we further investigated the behavioral changes in the RF-EMF exposed group because we found the dopamine concentration to be decreased in the striatum by RF-EMF exposure. To maximize dopaminergic-neuron related motor behaviors, behavioral tests were combined with challenge by MPTP, which destroys dopaminergic neurons in the SNpc and the striatum and finally leads to a Parkinsonian syndrome [42–44] involving slow movements, tremors, and rigidity [45,46]. As previously reported [41], behavioral analysis showed hyperactivity in the RF-EMF-exposed group before MPTP treatment (day 0), representing increases in general locomotor and motor activities (Fig. 7). Although we found no significant differences in moving distance, the mean moving distance was significantly decreased in the RF-EMF-exposed group at day 2–3 after MPTP treatment (Fig. 7A,B). The moving distance is the total length moved in a given time and the mean moving distance is the average distance from the start point to the stop point after 30 min. In addition, RF-EMF-exposed mice exhibited lessened moving durations compared with sham after MPTP treatment (Fig. 7C,D). Overall, the general locomotor and basic motor activities were significantly lower in the RF-EMF-exposed group at day 2–3 after MPTP administration (Fig. 7). These data indicated that behavioral recovery from acute damage to dopaminergic neurons was more difficult in the RF-EMF-exposed group because of reduced numbers of SVs in the striatum. Overall, the mice exposed to RF-EMF before MPTP administration were hyperactive, their locomotor activity was sharply reduced after MPTP treatment, and then gradually recovered. In contrast, the behavioral activities of the sham group started to recover from MPTP injection sooner and maintained a higher level of moving distance and duration, rearing frequency, and falling latency by day 4 than the RF-EMF-exposed group. These results suggest that the recovery processes of striatal dopaminergic neurons damaged by MPTP administration are more difficult or delayed in RF-EMF-exposed mice due to additional reductions in SVs at striatal neurons.

In summary, exposure to 4 W/kg SAR, 835 MHz RF-EMF for 12 weeks leads to decreased numbers of SVs associated with a reduced level of synapsin I/II in presynaptic terminals as well as a reduced level of TH expression in striatum, thereby decreasing the dopamine level in the striatum, and eventually these changes might lead to behavioral alterations. Therefore, the observed changes in striatal dopaminergic neurons induced by exposure to RF-EMF might influence locomotor activity under conditions of impaired neuronal function.

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Effects Of Electromagnetic Fields Exposure On The Antioxidant Defense System

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Technological devices have become essential components of daily life. However, their deleterious effects on the body, particularly on the nervous system, are well known. Electromagnetic fields (EMF) have various chemical effects, including causing deterioration in large molecules in cells and imbalance in ionic equilibrium. Despite being essential for life, oxygen molecules can lead to the generation of hazardous by-products, known as reactive oxygen species (ROS), during biological reactions. These reactive oxygen species can damage cellular components such as proteins, lipids and DNA. Antioxidant defense systems exist in order to keep free radical formation under control and to prevent their harmful effects on the biological system. Free radical formation can take place in various ways, including ultraviolet light, drugs, lipid oxidation, immunological reactions, radiation, stress, smoking, alcohol and biochemical redox reactions. Oxidative stress occurs if the antioxidant defense system is unable to prevent the harmful effects of free radicals. Several studies have reported that exposure to EMF results in oxidative stress in many tissues of the body. Exposure to EMF is known to increase free radical concentrations and traceability and can affect the radical couple recombination. The purpose of this review was to highlight the impact of oxidative stress on antioxidant systems.

Conclusion

The biological effect of exposure to EMF is a subject of particular research interest. The results of the recent studies not only clearly demonstrate that EMF exposure triggers oxidative stress in various tissues, but also that it causes significant changes in levels of blood antioxidant markers. Fatigue, headache, decreased learning ability, and cognitive impairment are among the symptoms caused by EMF. The human body should therefore be protected against exposure to EMF because of the risks this can entail. As reported in many studies, people may use various antioxidants such as vitamin E, MEL and FA to prevent the potential adverse effects of exposure to EMF.

Radiating slow death

Cellphone radiation can cause irreparable harm to you

IMAGINE a life without WiFi Internet, microwaved food, laptops and mobile phones. Now, imagine living with an invisible, dense fog that damages your brain, heart, lungs, eyes, thyroid gland and nervous system, besides risking your pregnancy and sending you into depression.

Plenty of research has been done on the dangers of the 'electro-smog' that is enveloping us steadily in our increasingly wired world.

Mobile phone companies and service providers challenged all research claims except the ones on radiation. Now, an IIT-Bombay professor, Girish Kumar, and his daughter Neha, who has done B.Tech in biotechnology, have put together the research data to highlight the damage done by the radiation that is necessary for a cellphone to function.

It can lead to cancer and heart damage

Prof Kumar, who tracked his bloated fingers to the extraordinary radiation in his study, found that IIT Bombay, despite its dense foliage, could not block the radiation from a cluster of transmitting towers. This spurred him to look up available literature on the subject.

There are a number of studies which have sought to establish a link between mobile phones and brain tumours, sleep problems and hearing loss. The report compiled by Neha and Prof Kumar, who has invented a device to block radiation, also looks at other lesser known effects.

WHAT IS MICROWAVE RADIATION?

These are electromagnetic waves with frequencies in the range of 1,000-3,00,000 MHz. All transmitting towers, such as AM and FM towers and TV and mobile phone towers, emit microwave radiation. So do wireless computers, cordless phones and their base units, cellphones and all other wireless devices, as well as home appliances like the microwave oven >>

>>WHY SHOULD WE FEAR IT?

Microwave radiation can have thermal and non-thermal effects.

THERMAL EFFECT| Just as the water content in any food heats up almost immediately when put inside a microwave oven, body fluids absorb microwave radiation from the atmosphere. The effect on the brain, made up 90 per cent of water, is more pronounced

NON-THERMAL EFFECT| This relates to cell membrane permeability. Current safety standards are purely based on the thermal effect — ignoring the non-thermal effects

>> HOW DOES IT EFFECT US?

The radiation can cause a host of debilitating illnesses including brain tumour, acoustic neuroma, lymphoma, decrease in immune function, sleep disorder, anxiety, autism, multiple sclerosis, Alzheimer's disease, cataract, hypothyroidism, diabetes, malignant melanoma, testicular cancer, heart attack and strokes in young people. Children are even more vulnerable as their skulls are thinner and their nervous systems are still developing

THE SILENT KILLER

THE CONVENIENCE OF USING ELECTRONIC GADGETS COMES AT A HIGH COST. HERE IS A LOOK HOW

>> HOW CAN WE PROTECT OURSELVES?

- Minimise time on cellphone and use briefly when you have to
- Don't call when the signal is weak
- Hold the phone away from the body while calling
- Use headsets with a plastic air-tube between the earpiece and the phone
- Use a loud-speaker phone
- Avoid WiFi connections
- Avoid cordless phones
- Stay away from radiation towers

>> ARE ALL APPLIANCES EQUALLY DANGEROUS?

No. Radiation absorption by the human body is called the specific absorption rate (SAR) and is measured in watts per kg of tissue (W/kg). Every mobile phone comes with an SAR rating. Radiation depends on the phone's design, antenna and how it is used. Thermal effects occur when the body's energy absorption exceeds an SAR of 4 W/kg. But non-thermal effects beginning from 0.1 W/kg can harm

MOBILE PHONE MODEL (W/KG)	SAR OUTPUT
Motorola V195s	1.6
Nokia E710	1.53
LG Rumor 2	1.51
Sony Ericsson W350a	1.48
Samsung Instinct	1.46
Samsung Soul	0.24
Nokia 9300	0.21

By **Seema Kamdar**
in Mumbai

the results are confirmed in further studies, we can engineer our

cancer than those living 400 metres away from it.

Data was gathered from nearly 1,000 patients who had been living at the same address for 10 years. The study showed that

Developed countries like Sweden, France, Germany, Italy, Greece and Israel are facing the aftermath of radiation. For example, the advent of the new third generation wireless phones

Prof Kumar's study revealed that several residential areas had more than 1,000 microwatts per square metres.

He said, "The blood-brain barrier, or tight junctions between

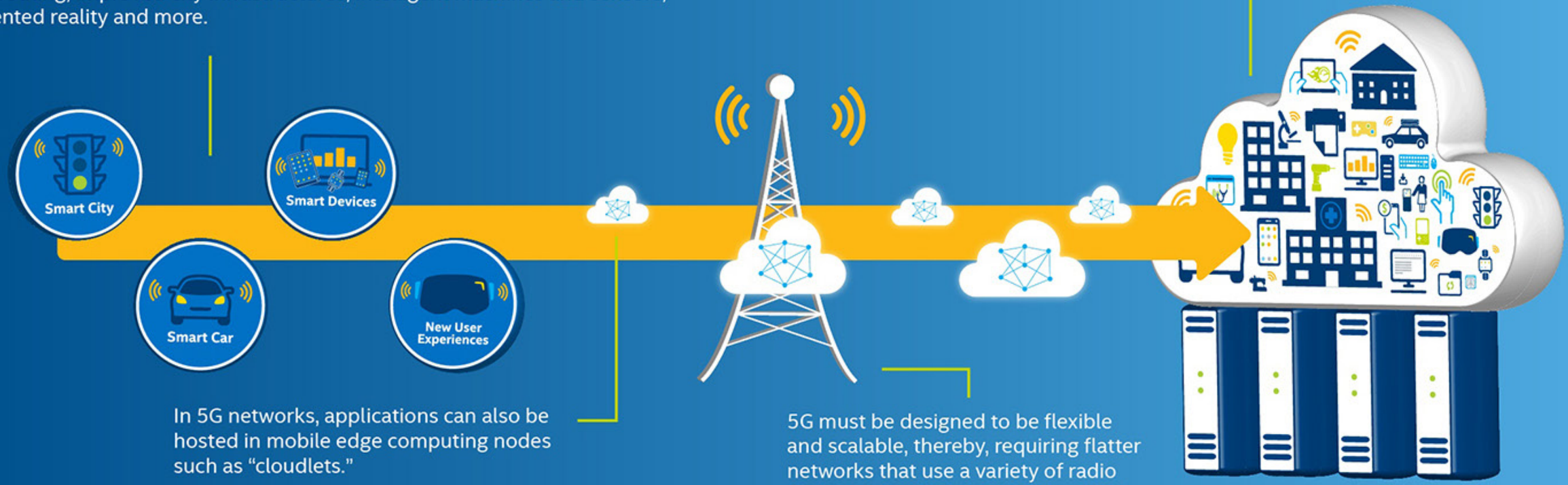
"The results of the recent studies not only clearly demonstrate that EMF exposure triggers oxidative stress in various tissues, but also that it causes significant changes in levels of blood antioxidant markers. Fatigue, headache, decreased learning ability, and cognitive impairment are among the symptoms caused by EMF. "

5G: FROM DEVICE TO DATA CENTER WITH A PERMANENT STOPOVER IN YOUR BODY

By 2020, 50 billion smart devices are expected to be in use.* 5G will help support the massive growth in the Internet of Things and enable devices to communicate with each other seamlessly through the convergence of mobile communications and computing. 5G networks will also diffuse intelligence across the entire network, from the device to the data center.

Using fast wireless connection to cloud computing and data services, and to other connected devices, 5G will enable a variety of new capabilities, user experiences and devices such as self-driving cars with built-in intelligent traffic routing, improved city infrastructures, intelligent machines and sensors, augmented reality and more.

5G's combination of high-speed wireless communications and efficient cloud computing means that even the tiniest devices can access virtually unlimited computing power.



In 5G networks, applications can also be hosted in mobile edge computing nodes such as "cloudlets."

5G must be designed to be flexible and scalable, thereby, requiring flatter networks that use a variety of radio access technologies, including cellular, Wi-Fi, centimeter and millimeter waves.

* Cisco Global Cloud Index: Forecast and Methodology, 2013–2018 (white paper).

Effects Of 900-MHz Radiation On The Hippocampus And Cerebellum Of Adult Rats And Attenuation Of Such Effects By Folic Acid And Boswellia Sacra

by Elfide Gizem Kivrak, Berrin Zuhal Altunkaynak, Isinsu Alkan
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Abbreviations: BS, Boswellia sacra; CA, cornu ammonis; CAT, catalase; CE, coefficient of error; CV, coefficient of variation; DG, dentate gyrus; DNA, deoxyribonucleic acid; EMF, electromagnetic field; EBS, the group that is exposed to EMF and received a single daily gavage of BS (500 mg/kg/day) during 21 days; EEG, electroencephalogram; EFA, the group that is exposed to EMF and received a single daily gavage of folic acid (50mg/kg/day) during 21 days; FA, folic acid; gr, granular layer; H2O2, hydrogen peroxide; MHz, Megahertz; ml, molecular layer; RF, radiofrequency; ROS, reactive oxygen specimens; SEM, standard error of the mean.

Technological devices now occupy a very important place in daily life. However, while making life easier, they may also cause a number of health problems [1–3], since electronic devices emit a surrounding electromagnetic field (EMF). This has been investigated in many previous studies, and EMF has been shown to have deleterious effects on various tissues in living organisms [4–7]. A wide spectrum of electromagnetic waves is emitted from radar equipment, communication devices, mobile phone base stations, high voltage power lines, radio and television transmitters and substations, and particularly from electrical appliances at home and in the office, and other electrical systems [8]. Some studies have suggested that these devices have adverse effects on human health [9,10].

Numerous experimental and clinical studies have been performed in order to determine the effects of EMF on the central and peripheral nervous systems, and important findings have been obtained [11,12]. Mobile phone use has been shown to exacerbate headaches [1,5]. Insomnia and significant changes in electroencephalography (EEG) findings have been also reported [13–15]. Even low-frequency exposure significantly changes nervous system activity, and modifications may be observed in synaptic plasticity and neurotransmitter release, together with functional changes in hearing perception, balance, learning and memory [6,16].

Hippocampus

Stereological methods provide quantitative descriptions about three-dimensional structures using two-dimensional images [34]. The optical fractionator technique is the most commonly used method in stereological counting calculations. The mean number of neurons estimated using the optical fractionator in the hippocampal regions of the EMF group was significantly lower compared with the control group ($p < 0.05$, One-Way ANOVA) (Fig. 2A–D). Significant differences were also determined between the numbers of neurons in the EFA (EMF + FA exposure) and EMF groups, and between the EBS (EMF + BS exposure) and EMF groups ($p < 0.05$, One-Way ANOVA) (Fig. 2A–D). However, there were no significant differences among Cont, EFA and EBS ($p>0.05$, One-Way ANOVA). Coefficient of error (CE) and coefficient of variation (CV) values for all groups are shown in Table 1.

Dentate Gyrus

Mean granular cell numbers in the DG were estimated using the optical fractionator method. Granular cell numbers in the EMF group were lower compared to the Cont group ($p < 0.05$). Neuron numbers in the EFA and EBS groups were significantly higher compared to the EMF group, while neuron numbers in the EFA and EBS groups were significantly lower compared to the Cont group ($p<0.05$). No significant difference was determined between the EFA and EBS groups ($p > 0.05$) (Fig. 3A). CE and CV values for all groups are shown in Table 1.

Cerebellum

Mean Purkinje cell numbers in the cerebellum were estimated using the optical fractionator method. A significant decrease in total numbers of Purkinje cells was observed in the EMF group compared to the Cont group ($p < 0.05$. In the EFA group, a highly significant decrease in Purkinje cell numbers was observed compared to the Cont group ($p < 0.01$). The significant difference was observed between the EMF and EBS groups ($p < 0.05$). There was also a significant difference between the EMF and EFA groups ($p < 0.05$) (Fig. 3B). CE and CV values for all groups are shown in Table 1.

Some studies have also investigated the effects of EMF on the cerebellum. Sonmez et al.'s study of female rats exposed to a 900-MHz EMF determined a significant decrease in Purkinje cell numbers in the cerebellum [32]. Aslan et al. show that long-term and continuous exposure of rats to 900 MHz EMF during early and middle adolescence can produce pathological effects including a decreased number of Purkinje cells [70].

The Animal Ethic Committee of Ondokuz Mayıs University approved the protocol, and appropriate measures were taken by our study group to minimize pain or discomfort to the animals involved (date 28.08.2013, No. 2013/23). The experimental part of this study and stereological examinations were performed at the Department of Histology and Embryology, Ondokuz Mayıs University.

Author contributions

BZA designed the project. EGK and KKY performed the experimental procedures. EGK, AK, IA and KKY analyzed the data and MEO contributed important revisions. All authors approved the final version of the manuscript.

Conflict of interest

The authors have no conflict of interest to declare.

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Evaluation Of The Effect Of Radiofrequency Radiation Emitted From Wi-Fi Router And Mobile Phone Simulator On The Antibacterial Susceptibility Of Pathogenic Bacteria Listeria Monocytogenes And Escherichia Coli

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Mobile phones and Wi-Fi radiofrequency radiation are among the main sources of the exposure of the general population to radiofrequency electromagnetic fields (RF-EMF). Previous studies have shown that exposure of microorganisms to RF-EMFs can be associated with a wide spectrum of changes ranged from the modified bacterial growth to the alterations of the pattern of antibiotic resistance. Our laboratory at the nonionizing department of the Ionizing and Non-ionizing Radiation Protection Research Center has performed experiments on the health effects of exposure to animal models and humans to different sources of electromagnetic fields such as cellular phones, mobile base stations, mobile phone jammers, laptop computers, radars, dentistry cavitrons, magnetic resonance imaging, and Helmholtz coils. On the other hand, we have previously studied different aspects of the challenging issue of the ionizing or nonionizing radiation-induced alterations in the susceptibility of microorganisms to antibiotics. In this study, we assessed if the exposure to 900 MHz GSM mobile phone radiation and 2.4 GHz radiofrequency radiation emitted from common Wi-Fi routers alters the susceptibility of microorganisms to different antibiotics. The pure cultures of Listeria monocytogenes and Escherichia coli were exposed to RF-EMFs generated either by a GSM 900 MHz mobile phone simulator and a common 2.4 GHz Wi-Fi router. It is also shown that exposure to RF-EMFs within a narrow level of irradiation (an exposure window) makes microorganisms resistant to antibiotics. This adaptive phenomenon and its potential threats to human health should be further investigated in future experiments. Altogether, the findings of this study showed that exposure to Wi-Fi and RF simulator radiation can significantly alter the inhibition zone diameters and growth rate for L monocytogenes and E coli. These findings may have implications for the management of serious infectious diseases.

Keywords:
radiofrequency radiation, bacteria, Wi-Fi, antibiogram

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Biological Effects From Exposure To Electromagnetic Radiation Emitted By Cell Tower Base Stations And Other Antenna Arrays

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The siting of cellular phone base stations and other cellular infrastructure such as roof-mounted antenna arrays, especially in residential neighborhoods, is a contentious subject in land-use regulation. Local resistance from nearby residents and landowners is often based on fears of adverse health effects despite reassurances from telecommunications service providers that international exposure standards will be followed. 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. The objective of this paper is to review the existing studies of people living or working near cellular infrastructure and other pertinent studies that could apply to long-term, low-level radiofrequency radiation (RFR) exposures. While specific epidemiological research in this area is sparse and contradictory, and such exposures are difficult to quantify given the increasing background levels of RFR from myriad personal consumer products, some research does exist to warrant caution in infrastructure siting. Further epidemiology research that takes total ambient RFR exposures into consideration is warranted. Symptoms reported today may be classic microwave sickness, first described in 1978. Non-ionizing electromagnetic fields are among the fastest growing forms of environmental pollution. Some extrapolations can be made from research other than epidemiology regarding biological effects from exposures at levels far below current exposure guidelines.

Keywords:
radiofrequency radiation (RFR), antenna arrays,
cellular phone base stations, microwave sickness,
nonionizing electromagnetic fields, environmental pollution

Recent Advances In The Effects Of Microwave Radiation On Brains

Wei-Jia Zhi, Li-Feng Wang* and Xiang-Jun Hu*

Abbreviations

AMPA: α-amino-3-hydroxy-5-methyl-4-soxazole propionic acid; Asp: Asparaginic acid; ATP: Adenosine triphosphate; BBB: Blood-brain barrier; CaM kinases: Ca2+/calmodulin-dependent protein kinases; CMOR: Cross-modal visual-tactile object recognition; COX: Cytochrome coxidase; CTFs: Carboxyl-terminal fragments; DECT: Digital enhanced cordless telecommunications/telephone; DG: Dentate gyrus; EEG: Electroencephalograph; EMF: Electric magnetic field; FR: Frequency radiation; GABA: Gamma-aminobutyric acid; GFAP: Fibrillary acidic protein; Glu: Glutamic acid; Gly: Glycine; GMF: Glial maturation factor; GSM: Global system for mobile communication; IARC: International agency for research on cancer; LTP: Long term potentiation; MAPK: Mitogen-activated protein kinase; MEPSCs: Miniature excitatory postsynaptic currents; MPP: Medial perforant path; MRI: Magnetic resonance imaging; NMDA: N-methyl-D- aspartate; NMDAR: N-methyl-D-aspartic acid receptors; PARP: Poly-ADP-ribose polymerase; PSD-95: Postsynaptic density 95; RNS: Reactive nitrogen species; ROS: Reactive oxygen species; SAR: Specific absorption rate; SCENIHR: Scientific committee on emerging and newly identified health risks; SDH: Succinate dehydrogenase; SNP: Single nucleotide polymorphism; SOR: Spontaneous object recognition

This study concerns the effects of microwave on health because they pervade diverse fields of our lives. The brain has been recognized as one of the organs that is most vulnerable to microwave radiation. Therefore, in this article, we reviewed recent studies that have explored the effects of microwave radiation on the brain, especially the hippocampus, including analyses of epidemiology, morphology, electroencephalograms, learning and memory abilities and the mechanisms underlying brain dysfunction. However, the problem with these studies is that different parameters, such as the frequency, modulation, and power density of the radiation and the irradiation time, were used to evaluate microwave radiation between studies. As a result, the existing data exhibit poor reproducibility and comparability. To determine the specific dose-effect relationship between microwave radiation and its biological effects, more intensive studies must be performed.

Microwaves are electromagnetic waves with frequencies ranging from 300 MHz to 300 GHz. Microwaves are widely used in households, industry, communications, and medical and military buildings, and they provide substantial contributions to the development of human society. However, with its popularization, increasing attention has been paid to its influence on humans. Electromagnetic radiation can be absorbed by organisms, in which it causes a series of physiological and functional changes. Many intricate electrical activities occur in the central nervous system, including learning and memory, which are therefore vulnerable to electromagnetic radiation. Moreover, the popularization of mobile phones has made them the main source of brain exposure to radiation. Therefore, the central nervous system is considered one of the most sensitive organs that is targeted by microwave radiation [1, 2]. A large number of studies have shown that microwave radiation can cause a series of adverse reactions in the central nervous system, including sleep disorders in addition to learning and memory impairments.

Microwaves are widely used in broadcasting, communications and many industrial fields. In broadcasting, the sources of microwaves are mainly FM radio and TV broadcasting antennas, which produce frequencies ranging from 80 to 800 MHz. In communications, the microwaves come from mobile phones and their base stations and microwave links, in addition to cordless phones, terrestrial trunked radios, blue tooth devices, wireless local area networks and many other applications. The frequencies of these devices are listed in Table 1. In industrial fields, exposure is usually occupational, and its sources include the surgical and physiotherapeutic use of diathermy, dielectric heating (i.e., heating and vulcanization applications), microwave ovens, magnetic resonance imaging (MRI) medical diagnostic equipment, radar, military and research microwave systems, electricity-supplying networks, and electricity-distributing and transmitting equipment [3].

Based on this background, in this review, we first summarized the effects of microwave radiation on the central nervous system, including the epidemiology, morphology, electroencephalograms, learning and memory abilities and mechanisms of underlying brain dysfunction from the perspective of synaptic structures and functions, oxidative stress and apoptosis, protein synthesis, genes and individual susceptibility and energy metabolism.

Funding

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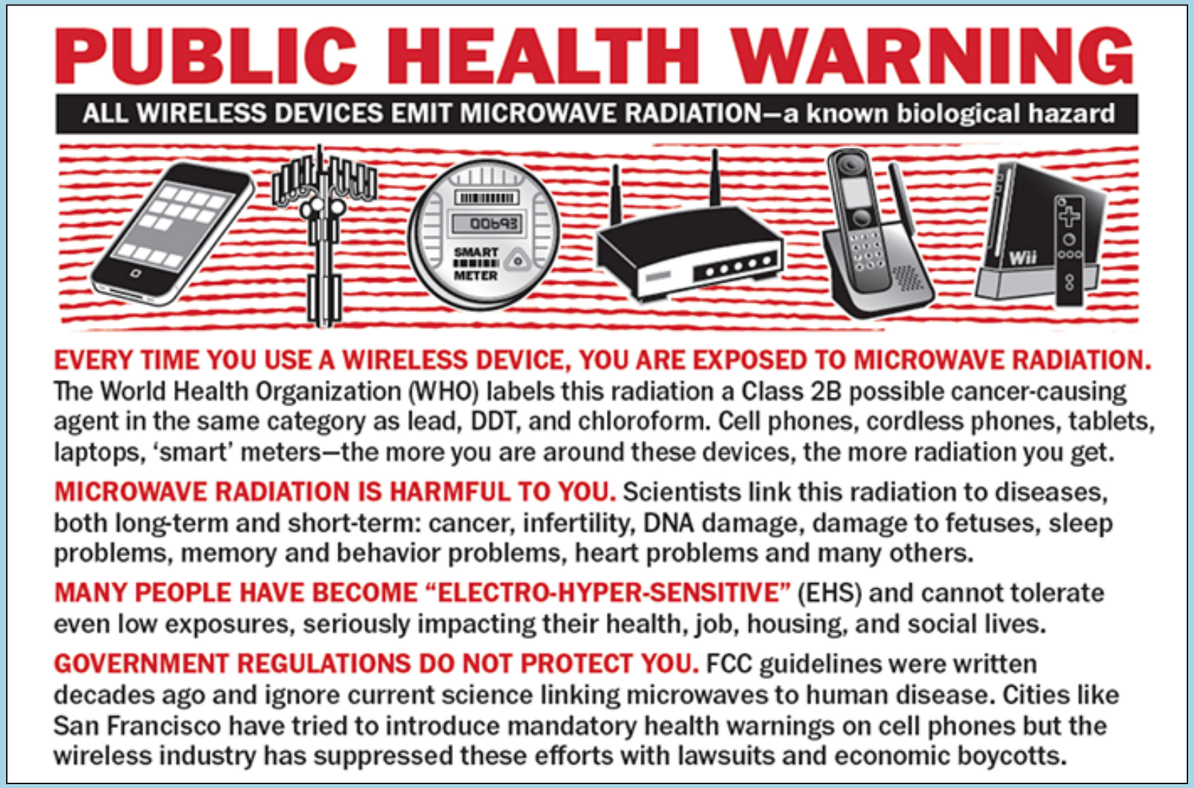
Competing Interests

The authors declare that they have no competing interests.

Keywords

Microwave, Central nervous system, Dysfunction of learning and memory abilities



Study On Dose-Dependent, Frequency-Dependent, And Accumulative Effects Of 1.5 GHz And 2.856 GHz Microwave On Cognitive Functions In Wistar Rats

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Many studies have revealed the cognitive decline induced by microwave radiation. However, the systematic study on dose-dependent, frequency-dependent and accumulative effects of microwave exposure at different frequencies was lacking. Here, we studied the relationship between the effects and the power and frequency of microwave and analyzed the accumulative effects of two different frequency microwaves with the same average power density. After microwave radiation, declines in spatial learning and memory and fluctuations of brain electric activities were found in the 10 mW/cm2 single frequency exposure groups and accumulative exposure groups. Meanwhile, morphological evidences in hippocampus also supported the cognitive dysfunction. Moreover, the decrease of Nissl contents in neurons indicated protein-based metabolic disorders in neurons. By detecting the key functional proteins of cholinergic transmitter metabolism, cytokines, energy metabolism and oxidative stress in the hippocampus, we found that microwave could lead to multiple metabolic disorders. Our results showed that microwave-induced cognitive decline was largely determined by its power rather than frequency. Injury effects were also found in accumulative exposure groups. We are particularly concerned about the safety dose, injury effects and accumulative effects of microwaves, which might be very valuable in the future.

In the past century, microwaves have been widely used in many aspects, such as communication, industry, medicine and military [1–3]. As a kind of nonionizing radiation, the potential health hazards of microwave have been getting more and more attentions. In recent decades, electromagnetic waves have been considered as a new form of environmental pollution by the World Health Organization (WHO) and classified as "*possibly carcinogenic to humans*" (Group 2B) by the International Agency for Research on Cancer (IARC)4. The relevant safety standards (C95.1) were established by the Institute of Electrical and Electronics Engineers (IEEE).

It was reported that microwave could induce the impairment in learning and memory functions, brain electric activities, and brain structures [5–7]. Besides, many studies were made to test the health hazards of microwave and the nervous system was believed very sensitive to microwave exposure [8]. Study showed that the microwaves induced biological effects were related with their power densities, frequencies, waveforms, modulation and durations of exposure [9]. Effects caused by different kinds of microwave might be different. However, microwaves in the experimental studies were mostly of single frequency, the frequency-dependent effects had never been talked. In our studies, the frequency-dependent effects between 2.856 GHz and 1.5 GHz at same power density and the does-dependent effects between 5 mW/cm2 and 10 mW/cm2 at same frequency were studied.

However, microwaves in the experimental studies were mostly of single frequency, while the real environment was usually consisted of many different frequency or power microwaves. The accumulative effects of different microwaves were ignored.

Results

Temperatures increased less than 1 °C. We measured the rats' surface temperatures (n = 4) before and immediately after microwave exposure by infrared temperature sensor. According to the results, temperatures increased less than 1°C after microwave exposure (Table 2), indicated that the thermal effects could be compensated by the physiological temperature regulation of organism and the effects discussed in this paper were basically non-thermal effects.

Spatial learning and memory ability of rats declined after microwave exposure. AELs prolonged after 2.856 GHz and 1.5 GHz microwave exposure. The MWM was performed at 1d, 2d, 7d, 14d, and 28d after microwave exposure. AEL was the time for rats to find the platform. As shown in Fig. 2, compared with control group: (1) the single or accumulative 5 mW/cm2 microwave exposure (S5, L5, SL5) caused no significant changes in AELs; (2) the single 10 mW/cm2 2.856 GHz microwave exposure caused significantly prolonged AELs at 2d ($p = 0.016$, $n = 15$), 7d ($p = 0.011$, $n = 15$), and 14d ($p = 0.033$, $n = 15$) after microwave exposure; (3) the single 10 mW/cm2 1.5 GHz microwave exposure significantly prolonged AELs at 1d ($p = 0.010$, $n = 15$), 2d ($p = 0.036$, $n = 15$) and 14d ($p = 0.013$, $n = 15$) after microwave exposure; (4) the 10 mW/cm2 accumulative exposure significantly prolonged AELs at 1d ($p=0.005$, $n=15$), 2d ($p=0.012$, $n=15$), 7d ($p=0.007$, $n=15$), 14d ($p=0.018$, $n = 15$) and 28d ($p = 0.022$, $n = 15$) after microwave exposure.

Alterations of electroencephalography (EEG) after microwave exposure. 2.856 GHz and 1.5 GHz microwave induced fluctuations in EEGs. The frequency of EEG is an integrated reflection of 4 kinds of brain wave: α (12–30 Hz), β (8–12 Hz), θ (4–8 Hz), δ (1–4 Hz). The frequencies of EEG and the powers of α, β, θ, δ waves in each group were recorded at 7days after microwave exposure. As shown in Fig. 3, in comparison with the control group: (1) the single 5 mW/cm2 microwave exposure (S5, L5) did not cause any changes in EEG; (2) the accu- mulative 5 mW/cm2 microwave exposure (SL5) significantly reduced power of α wave ($p = 0.049$, $n = 5$); (3) the single 10 mW/cm2 2.856 GHz microwave exposure (L10) significantly reduced the EEG frequency ($p = 0.002$, $n = 5$) and power of α wave ($p = 0.005$, $n = 5$) and β wave ($p = 0.015$, $n = 5$) and significantly increased power of θ wave ($p = 0.011$, $n = 5$); (4) the single 10 mW/cm2 1.5 GHz microwave exposure (L10) significantly reduced the EEG frequency ($p = 0.033$, $n = 5$) and power of α wave ($p = 0.030$, $n = 5$); (5) the accumulative 10 mW/cm2 microwave exposure (SL10) significantly reduced the EEG frequency ($p = 0.002$, $n = 5$) and power of α wave ($p = 0.002$, $n = 5$) and β wave ($p = 0.002$, $n = 5$) and significantly increased power of θ wave ($p = 0.006$, $n = 5$). No significant differences were found in δ wave after microwave exposure when compared to the control group.

Pathological changes of hippocampus caused by microwave exposure. Microwave exposure caused microstructural changes in hippocampus. In order to assess the morphological changes in hippocampus which were related with the cognitive abilities and brain electric activities, histological examinations of hippocampus were carried out. In each group, 5 brains containing hippocampus that fixed by formalin at 7d after microwave exposure were observed by H&E staining. Compared with the control group, no obvious changes were found in the S5 and L5 groups, but obvious injuries were observed in

the SL5 group and the S10, L10, SL10 groups (Fig. 4A1–A7). Injury changes such as karyopyknosis, irregular arrangement, cell edema, and broadening pericellular space were distributed in DG, CA1 and CA3 region. Moreover, changes in DG region were the most significant. The most serious injured group was considered as the SL10 group.

Microwave exposure caused ultrastructure changes in hippocampus. The effects of microwave radiation on the hippocampal ultrastructure were examined by TEM at 7d after microwave exposure (Fig. 4B1–B7). Compared with the control group, no obvious changes of ultrastructure were found in the S5 and L5 groups, but the obvious injuries were observed in the SL5 group and the S10, L10, SL10 groups. The injured neurons showed cytoplasmic relaxation, mitochondrial swelling and ridge rupture, even cavitation, rough endoplasmmicreticulum degranulation and swelling, broadening of the nuclear membrane gap, and concentration and margination of the chromatin. Injuries in the SL10 group were considered to be most serious.

Nissl substance reduced in neurons after microwave exposure. 2.856 GHz and 1.5 GHz microwave exposure reduced the content of Nissl substance. Figure 5 showed the toluidine blue staining of Nissl substance in hippocampus, which were then quantitatively analyzed by MOD. The Nissl substances were dyed deep blue and existed in the cytoplasm of the neurons.

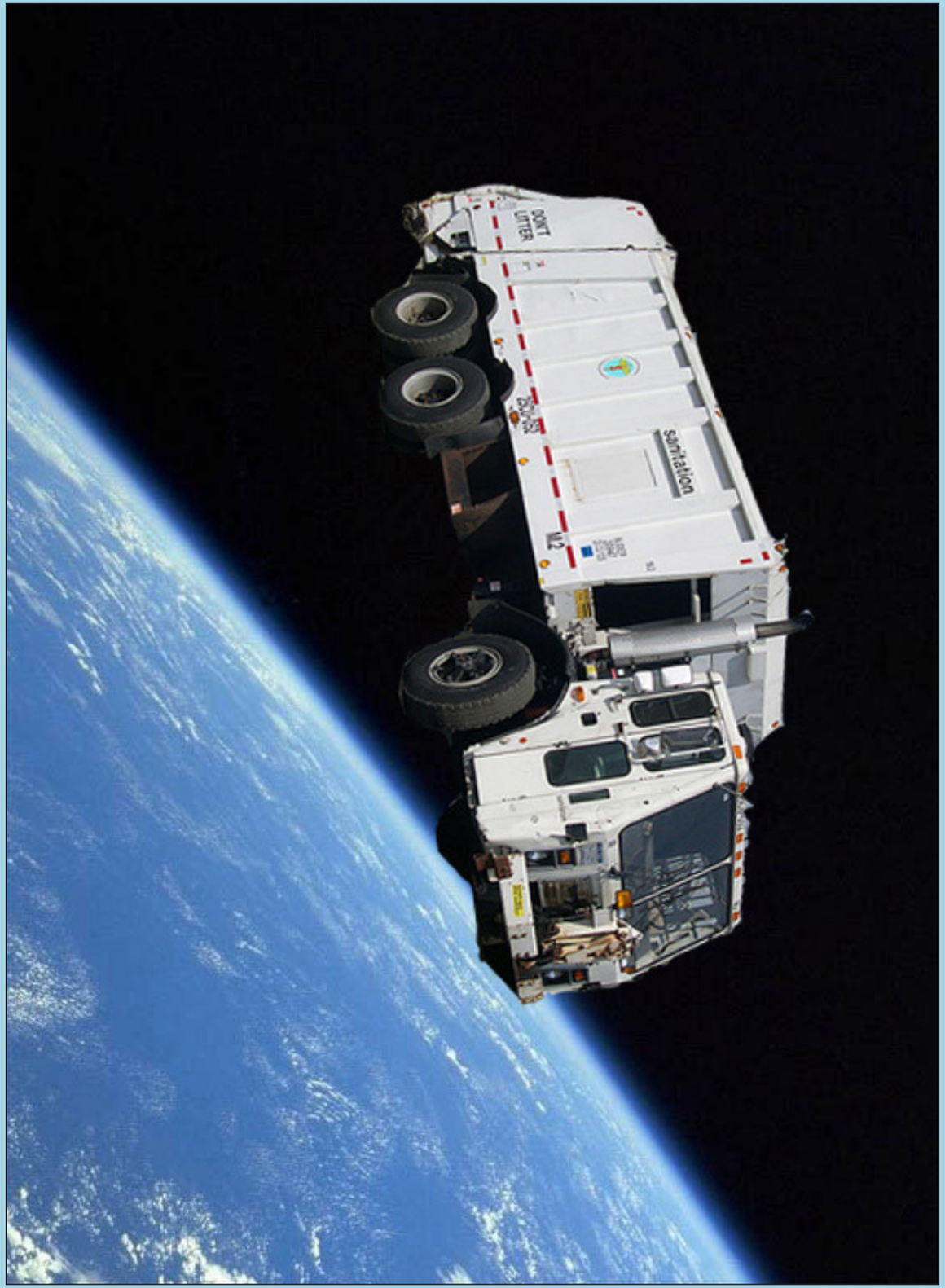
Abnormal metabolism in hippocampus after microwave exposure. 2.856 GHz and 1.5 GHz microwave exposure reduced the expressions of AchE, BDNF, COX and SOD. Figure 6 showed the immunohistochem- istry images for AchE, BDNF, COX and SOD in hippocampus, which were then quantitatively analyzed by MOD. The positive results of the AchE, BDNF, COX and SOD immunohistochemistry staining showed that brown particles existed in the cytoplasm of the neurons.

Discussion

The cognitive declines induced by microwave were closely related with the power density. Studies in the last decade suggested that the microwave might have special influences on chemical processes, including the promoting and inhibiting effects [20, 21]. As we all known, biochemical reaction is the nature of human body's physiological process which happens at every moment. Every system in human bodies depends on the normal and regulated biochemical reaction procession, especially the highly complex nervous system.

Microwave can be absorbed by the biological tissues. The effects caused by absorbed energy can be divided into thermal effects and non-thermal effects [22]. In this study, we had detected the body surface temperature changes before and immediately after microwave exposure and the changes were less than 1°C. Parts of microwave energy would be absorbed when passing through the biological body. The living body has abilities to take away the partial heat by blood flow and other physiological regulations. The microwave under this experimental condition did not exceed the range of the organism's thermoregulation capacity, so the effects in this study were considered to be primarily non-thermal effects.

Changes in behavior were important outcomes for assessing the effects of microwave exposure on cognitive functions [23, 24]. In these studies, microwave could prolong the AELs of rats, which suggested the spatial learning and memory ability was disrupted by microwave exposure [25, 26]. To meet the need of potential hazards prevention, groups with different doses were set up in our study. The 10 mW/cm2 microwave caused more serious injuries than the 5 mW/cm2 microwave groups. The injury effects



were more closely related with the microwave power density. The electric activities of brain were direct reflections of brain functional statuses and the EEGs were primary tools to detect the dynamic brain functions [27]. In cognitive disorders, the alterations of EEG occurred which conformed with injuries of cognitive (especially mnemonic) abilities [28–31]. In our study, according to the power spectral analysis of EEGs, the 2.856 GHz and 1.5 GHz microwave significantly decreased the EEG frequency and power of α, β waves and significantly increased the power of θ, δ waves. According to Thuroczy's data, local brain exposure of 4 GHz continues wave (CW) caused an increase in the power of δ wave [32]. Chizhenkova's study also exhibited an increase of slow waves in rabbits after 2400 MHz CW radiation [33]. The inhibition of the electrical activity of the brain and decreased in spatial learning and memory ability suggested the hazards effects of 2.856 GHz and 1.5 GHz microwave on nervous system. In our study, there were no significant differences between the 10 mW/ cm2 groups and the 5 mW/cm2 groups. The EEG frequency and power of α, β waves had a decreasing trend with the increase of microwave power, while the power of θ, δ waves had an increasing trend.

The hippocampus was closely related with the learning and memory ability, which was the main area of the limbic system [34]. The results of pathological examination suggested that the 2.856 GHz and 1.5 GHz microwave induced synapse damages as well as mitochondria injuries in hippocampus,which were consistent with the functional study. Injuries in hippocampus were found more serious in the 10 mW/ cm2 groups than that of the 5 mW/ cm2 groups.

Based on the morphological results, we hypothesized that the behavioral degeneration and brain electrophysiological disturbances were caused by prominent plasticity lesions and abnormal energy metabolisms. The Nissl substances, rough endoplasmic reticulum (RER) with rosettes of free ribosomes, are important for the protein synthesis [35]. The lost and dissolved of Nissl substances were observed in many neurodegeneration diseases, which were considered as importance factors for cognitive decline [36, 37]. The quantitative analysis showed that the 2.856 GHz and 1.5 GHz microwave significantly reduced the contents of Nissl substances. Moreover, the degrees of reduction was closely related to the power density.

Considering the Nissl substances were of great importance for protein synthesis, the changes in neuronal metabolisms were detected. The expressions of AchE, BDNF, COX and SOD in hippocampus were detected by the immunohistochemistry. AchE was closely related to the metabolism of acetylcholine, which was a kind of neurotransmitter and played an important role in learning and memory [38, 39]. BDNF, a kind of growth factor, was closely related with the synaptic plasticity [40]. COX was the key enzyme in the mitochondrial electron transport chain [41]. SOD was one of the most important antioxygen in biological body [42]. The quantitative analysis showed that all expressions of them declined in varying degrees after S and L band microwave exposure. Our study found that the microwave could affect many metabolic processes in neurons, including oxidative stress, energy metabolism, growth factors and neurotransmitters. We predicted that the general injuries induced by microwave induced the declined cognitive functions. Compared to 5 mW/cm2 groups, the contents of AchE, COX and SOD in the 10 mW/cm2 groups declined significantly.

Besides, the does-dependent effects were also found in studies on other organs. Liu's study found that structural damages in the sinoatrial node in rats aggravated with the increase of microwave power [16]. Higher power density groups would have higher SAR values when other conditions were consistent. The SAR values in the 10 mW/cm2 groups were much higher than that of 5 mW/cm2 groups (S10: 3.3 W/kg, S5: 1.7 W/kg; L10: 3.7 W/kg, L5: 1.8 W/kg). In addition, the exposures of 5 mW/cm2 of 1.5~100 GHz

microwave for 6 min were described as safe in safe standards (IEEE C95.1).

The injury effects on cognitive function were similar between 2.856GHz and 1.5GHz microwave.

As we all know, the physical properties of electromagnetic wave have been closely related with its frequency. The properties of electromagnetic wave are different when the frequency changes. For example, ultraviolet rays could cause ionizing effects while infrared rays mainly caused non-ionizing effects with thermal effects, which was same for microwaves. Properties such as penetrability, carrier ability, reflectivity, and absorptivity were closely related with microwave frequencies.

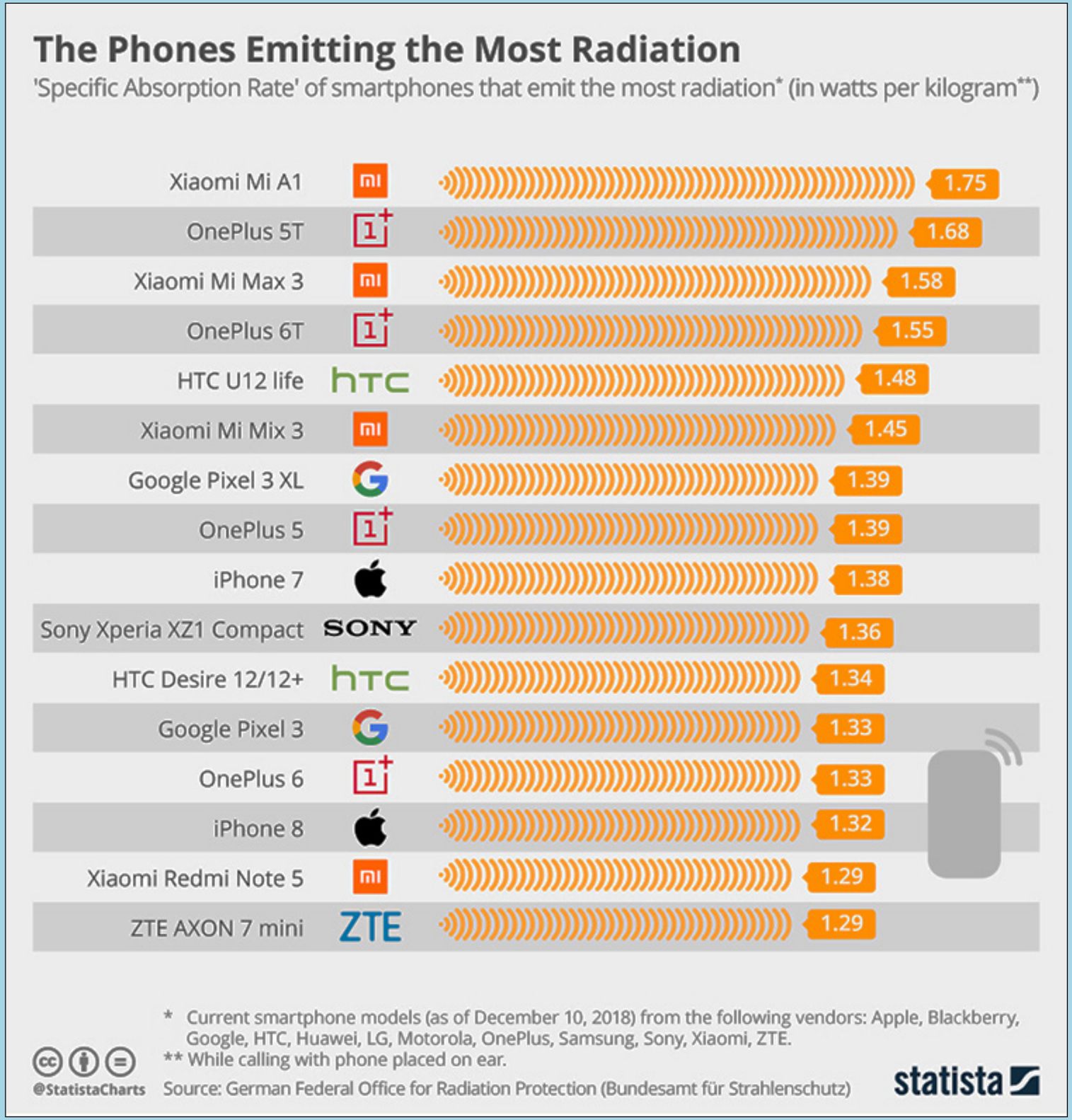
Microwaves were divided into various bands according to their frequencies. Each band was used for certain applications based on its suitable properties. The frequency-dependent effects on nervous system of microwave should be mentioned.

Nowadays, the does-effect relationship of microwave is attracting many scholars' attentions, which is very essential for its safety assessment. Therefore, the mostly experimental conditions were microwaves of various power levels but with same frequencies [43, 44]. Therefore, the explorations about frequency-dependent effects were neglected. In this study, the animals were treated with 2 different frequencies: 2.856 GHz and 1.5 GHz. In the cases of identical power density, there were no significant differences of results in the 2.856 GHz groups and the 1.5 GHz groups. The two kinds of microwaves could induce similar results, including prolonged AELs in space navigation tests, fluctuations in EEGs, injuries in morphology and turbulences in various metabolisms.

This was an elementary attempt in the explorations of frequency-dependent effects. The SAR values of the S5 and L5 groups were 1.7 W/kg and 1.8 W/kg respectively. The SAR values of S10 and L10 were 3.3 W/kg and 3.7 W/ kg respectively. The SAR values of 2.856 GHz and 1.5 GHz under the same average power density were different, because the radiation parameters were different. However, the SAR values with different frequencies were close. The effects of S5 and L5 or S10 and L10 could be compared.

We believed there would be more findings in the future researches. The frequency-effect relationship might be found in the other bands and frequencies.

Possible interaction effects were found in accumulative exposure, but the accumulative effect of power cannot be ruled out. Most of the experiments tried to study the effects of certain single frequency microwave exposure, while the interaction effects of multiple frequencies microwaves exposure, especially the 2.856 and 1.5 GHz, were never discussed. Some studies aimed at finding the combined effects of cell phone communication signals [10, 45–48], but they stopped at the hazard evaluation. In those studies, the interaction effects



between CDMA and WCDMA were never discussed. During the cold war, researchers of the superpower focused on the possible military applications of microwave and the ionizing radiation. Michaelson et al. [13] found that the previous exposure of microwave could reduce the mortality of dogs caused by ionizing radiation, while the microwave and ionizing radiation have harmful effects respectively. Those findings suggested the existence of interaction effects of different frequencies electromagnetic waves.

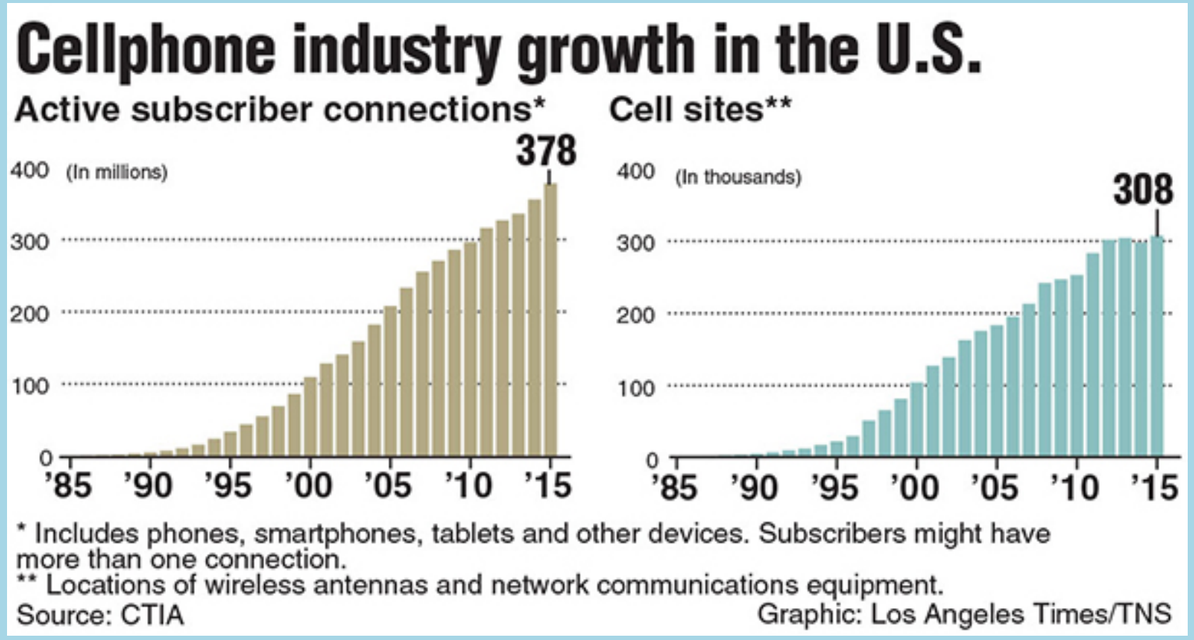
According to the results of statistical analysis, the possible interaction effects were found in in the Nissl substances and AchE expressions. Those findings indicated aggravated interaction effects between 2.856 GHz and 1.5 GHz exposure.

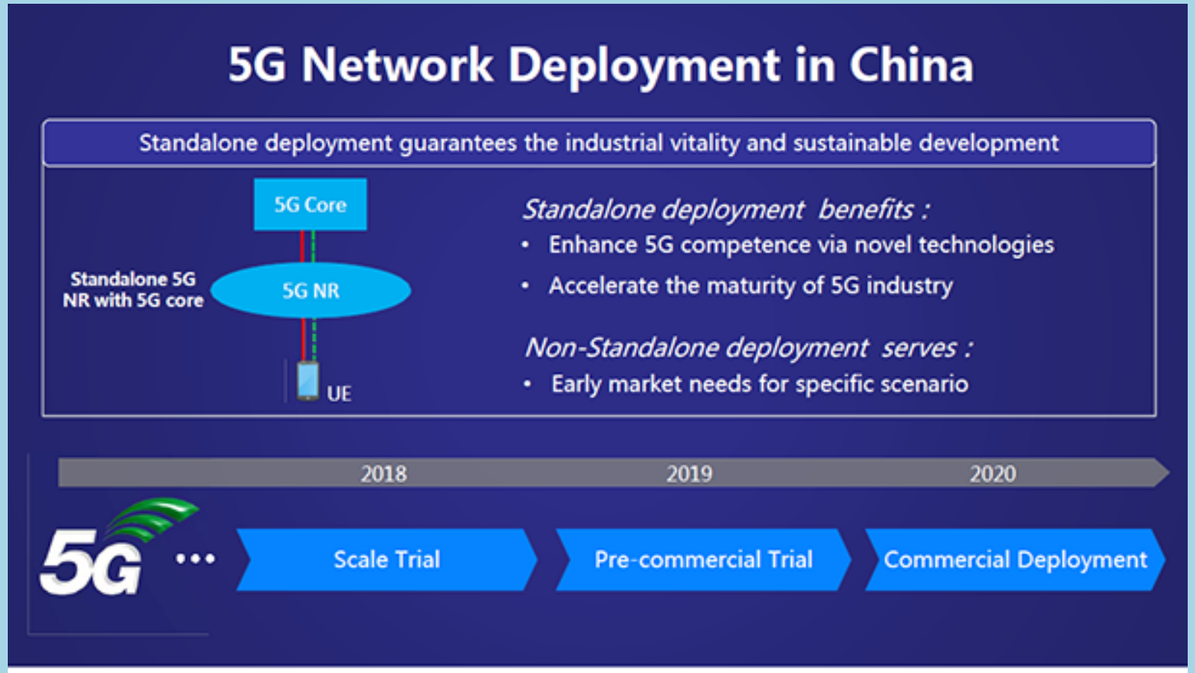
At the same time, the dose-dependent effects indicated the injury effects were dominated by power. According to the SAR values provided (Table 1), the accumulative power in accumulative groups was higher than single frequency exposure groups. The worst injury effects of accumulative exposure could also be explained by the accumulative power. The energy absorbed in accumulative groups was larger than that of single frequency exposure groups. All in all, the interaction effects between 2.856 GHz and 1.5 GHz were statistically proved, but the cumulative effect of power cannot be ruled out, so we carefully described our findings as possible interaction effects.

The possible application of findings in this study. In this study, it was demonstrated that the 2.856 GHz and 1.5 GHz microwave could cause generalized injuries in nervous system, including disorders in neurotransmitter, cytokines, oxidative stress and cellular respiration. Data showed that microwave-induced damage was closely related with the molecular mechanism of metabolism. Zuo's data showed that RKIP might act as a key regulator of neuronal damage caused by microwave exposure [49]. Besides, Zhao et al. [50] found that modulating mitochondrial functions could help against microwave-induced injuries in mitochondria, which indicated that there were ways to treat microwave injuries. There were many studies of the drugs for treating microwave-induced injuries, but these drugs were mostly aimed at one type of metabolic or molecular target [51, 52]. Based on our study, it was not enough to cure the microwave-induced injuries by unilateral therapy because of the generalized effects caused by microwaves on the organism.

Our study found that the microwave had damaging effects on the neuron structure, which indicated that microwave could be used to destroy the nervous system. At present, the clinical microwave ablation therapy requires the microwave antenna be implanted into the target area, which is an invasive method [53]. Therefore, aggravated injuries in accumulative exposure were noteworthy, which might make the non-invasive microwave ablation possible.

If the organism is considered as a homogeneous object, multiple beams of certain interactive frequency microwaves can converge exactly at one point and cause aggravating interaction effects. The tissue at that point would be destroyed while the surrounding tissue was safe. This provided a new idea for non-invasive radiofrequency treatment. However, the structure of the organism is not homogeneous, how to avoid the linear propagation of the microwave disturbed by the complex structure and to achieve accurate focus is still a problem.





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Cardiovascular Disease: Time To Identify Emerging Environmental Risk Factors

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Vernon et al. [1] recently reported a significant increase in the proportion of first-time ST elevation myocardial infarction (STEMI) patients without standard modifiable cardiovascular risk factors (hypercholesterolaemia, hypertension, diabetes and smoking). While the authors correctly highlighted the need for discovering new mechanisms of coronary heart disease based on theirs and other complementing data, we would like to draw the attention of researchers in cardiovascular disease (CVD) to emerging environmental risk factors, focusing here on microwave radiofrequency electromagnetic radiation (RF-EMR).

Human exposure to RF-EMR has exponentially increased over the past three decades due to rapid and widespread deployment of wireless communication and surveillance infrastructure and the use of personal wireless devices. Public exposures have increased from extremely low natural radiofrequency levels [2] below 10~15 W/m2, to above 10~2 W/m2 now.3,4 RF-EMR is an environmental pollutant with cytotoxic effects [5,6].

Despite the European Academy for Environmental Medicine (EUROPAEM) [7] and the American Academy of Environmental Medicine (AAEM) [8] publishing evidence linking RF-EMR to adverse health effects and calling for exposure reduction, there is widespread ignorance about the scientific evidence of radiofrequency-induced biological/health effects within the medical fraternity. This appears to be largely due to the controversial approach by the International EMF Project at the World Health Organization (WHO), [4] which has ignored the calls by a large group of international electromagnetic field (EMF) scientists [9] for improved exposure regulation.

The WHO's International Agency for Research on Cancer (IARC) appointed an expert panel to examine the evidence related to cancer in 2011 which classified RF-EMR as a group 2B possible carcinogen [10]. The new scientific evidence that has emerged since then, particularly epidemiological evidence linking mobile/cordless phone use to brain tumours [11,12] and experimental evidence of genotoxicity and carcinogenicity [6,13] warrants an update to this classification [14]. However, no such evaluation of CVD risk has been carried out. Furthermore, there are serious shortcomings in the few panel reports that have so far evaluated biological/health effects [15].

In our latest review, 242 RF-EMR studies that investigated experimental endpoints related to oxidative stress (OS) [16] were identified. A staggering 216 (89%) of them found significant effects related to OS, similar to a previous review [17]. These are being further analysed following presentation at the recent Australasian Radiation Protection Society conference [18]. Mostly in-vivo animal studies and in-vitro studies have demonstrated increased markers of endogenous OS and/or affected antioxidant levels in different tissue/cell types upon exposure to RF-EMR. Some studies have further demonstrated amelioration of RF-induced OS upon treatment with various antioxidants. Limited human studies at this stage complement these studies demonstrating OS and/or reduced antioxidant status upon acute radiofrequency exposure under experimental settings, [19] in mobile phone users [20] and residents near mobile phone base stations [21]. Renowned physical scientists have recently presented experimental evidence and a theoretical explanation on how low-intensity RF-EMR can generate OS [22].

OS is known to be implicated in CVD [23,24] and therefore RF-EMR, a new ubiquitous environmental exposure, may contribute to CVD by maintaining chronic OS, and thereby causing oxidative damage to cellular constituents and altering signal transduction pathways.

Acute RF-EMR exposure has been shown to increase blood pressure under experimental conditions, [25] while chronic exposure has been found to be associated with an increased CVD risk [26] as well as alteration in the diurnal rhythms of blood pressure and heart rate [27] in studies investigating clinical, anthropometric, behavioural, environmental and socioeconomic parameters.

Research on biological/health effects of RF-EMR started mostly within the military due to RF use in radar, [28] with former Soviet Bloc countries conducting the most. A US Army medical intelligence document [29] reporting on Soviet research stated:

Comparison of a group of engineers and administrative officials who were exposed to microwaves for a period of years and an unexposed control group revealed a significantly higher incidence of coronary disease, hypertension, and disturbances of lipid metabolism among the exposed individuals. Hereditary predisposition to heart disease was approximately the same for both groups, but overt disorders developed much more frequently in the previously exposed group. It was concluded that microwaves may act as a nonspecific factor which, under certain conditions, interferes with adaptation to unfavorable influences. Exposure may, therefore, promote an earlier onset of cardiovascular disease in susceptible individuals.

However, despite substantial evidence of biological effects and some evidence of adverse health effects even back in the 1970s, the west did not stringently control public exposure as did the Soviet Bloc countries, and conflicts of interest are apparent in same military report:

If the more advanced nations of the West are more stringent in the enforcement of stringent exposure standards, there could be unfavorable effects on industrial output and military functions.

This divergent approach to recognition of radiofrequency-induced health effects and exposure regulation still continues today between the USA and Russia and their allies.

Early epidemiological evidence from chronically exposed populations near radiofrequen-

cy transmitters (radio/TV/radar towers) before RF-EMR emitters became common everyday gadgets is extremely valuable. Now everyone is exposed and, therefore, it is very difficult to obtain reliable epidemiological data. However, there is still great variation in the level of exposure which can be assessed only by individual measurement in controlled studies. A 1994 US Air Force report [30] gives important insights on early epidemiological evidence:

In response to earlier Soviet reports, the World Health Organization (WHO) decided to conduct a comprehensive study on the biological effects of exposure to RF/MW radiation. In 1976, M. Zaret published the results of the study (reference found in [8]). The WHO investigation focused on the population of North Karelia, a remote area of Finland that borders the Soviet Union. This region was selected because of its close proximity to a then Soviet early warning radar station. North Karelia is geographically located in the path of intercontinental ballistic missiles that would originate from the midwest United States. To detect these missiles, the Soviets constructed a number of high power tropospheric scattering radar units adjacent to nearby Lake Ladoga. The operation of these units exposes the residents of North Karelia to large doses of ground and scatter radiation. The WHO investigation found evidence linking exposure of RF/MW radiation to cardiovascular disease and cancer. The North Karelian population suffered from an unusually high number of heart attacks and cases of cancer. In addition, it was found that the affliction rate of these diseases was much higher among residents living closest to the radar site.

Although the success of the North Karelia project lifestyle intervention programme that reduced the CVD mortality is well known, [31] how many are aware of this reported CVD risk identified by the WHO related to chronic RF-EMR exposure? While a PubMed search with 'North Karelia' and 'cardiovascular' picked up 191 publications, 'North Karelia' and 'radar/radiofrequency/radiation' picked up none (on 2 September 2017). We therefore assume that this WHO/military knowledge about RF-EMR risk in CVD was not passed on to the scientific community for investigation. The success of the North Karelia project by increasing the consumption of fruit and vegetables, i.e. antioxidant therapy, supports our hypothesis that chronic exposure to RF-EMR causes CVD via redox mechanisms of OS which can be countered, albeit not fully, with increased dietary intake of antioxidants. However, what about measures to reduce exposure? While regular use of/being close to personal wireless devices such as phones, computers and WiFi routers as well as living close to wireless infrastructure such as mobile phone base stations can greatly increase one's exposure, the common habit of carrying a connected mobile phone in a shirt pocket is of particular concern regarding radiofrequency exposure to the heart.

As for recovery from STEMI, restoration of myocardial perfusion can be compromised by changes of endothelial integrity, platelet aggregation, neutrophil infiltration and inflammation after an acute thrombotic coronary occlusion. At a cellular level, these processes are controlled by redox mechanisms/signalling pathways and therefore, actively reducing exposure to RF-EMR warrants consideration as part of post-STEMI patient management. Indeed, we require high quality clinical studies to investigate if such an approach is effective.

Radiofrequency exposure may also contribute to standard modifiable cardiovascular risk factors. The risk of hypertension, hypercholesterolaemia and truncal obesity was significantly higher in the occupationally radiofrequency-exposed radio/TV station operators (mean age 47.9 years) compared to their occupationally unexposed colleagues in a study by researchers at the Bulgarian National Centre of Public Health Protection [26]. This was despite a lower incidence of smoking in the radiofrequency-exposed group. Similar to several other studies, these researchers also found increased excretion rates of stress hormones: cortisol, adrenaline and noradrenaline in the radiofrequency-exposed [32]. It is very concerning that the occupational RF-EMR exposure levels of this group of radio and TV station workers are now common in the general public due to widespread wireless technologies, with little investigation of the health consequences.

Apart from an OS-mediated chronic effect in coronary heart disease, there may be chronic and acute effects involving OS/other mechanisms on cardiac electrophysiology. Dysregulation of the autonomic control of the cardiovascular system in healthy men (under 50 years) occupationally exposed to RF-EMR has been reported [27,33] compared to their unexposed colleagues, as well as altered heart rate variability under acute experimental exposure to cordless and mobile phones [34,35]. There is also evidence for immediate responses of voltage-gated ion channels, particularly Ca2þ channels (VGCC) upon radiofrequency exposure [36]. The downstream effects of VGCC disruption may involve alteration of important functions of Ca2þ/calmodulin-dependent enzymes (such as nitric oxide synthase and protein kinase II), influencing the pathophysiology of CVD [37]. Chronic disturbance of ion channels directly/via OS by persistent RF-EMR exposure may lead to pathologies of the heart muscle similar to primary electrical diseases (i.e. channelopathies). While the manufacturers of pacemakers have developed shielding to prevent electromagnetic interference from RF-EMR over the years, we note that the natural cardiac electrical network remains susceptible to interference by common RF-EMR emitters.

Although a few western countries have recently taken steps to reduce public exposure to RF-EMR, particularly of children, such as discouraging the use of wireless devices by children and banning/restricting WiFi in schools, [38,39] there is largely inaction at this stage. Intriguingly, a professor in public health at the University of California recently went to court and accessed the cell phone safety 'fact sheet' (on health risks with instructions to reduce exposure compared by the Californian Department of Public Health [40]. It is reported that this document, originally prepared in 2009 and revised 27 times up to 2014, was abandoned due to influences from vested interests. Meanwhile in France, a physician took legal action to access data from government testing of mobile phones [41] revealing that most phones would not even pass the entirely thermally based (tissue heating) current exposure standards if held directly against the body, such as in a garment pocket.

It is clearly time to investigate the potential role of RF-EMR exposure from common wireless device use on CVD. Noting that existing research findings are influenced by the funding source, [42] fresh directives are necessary for objective high quality research to expand current primary and secondary prevention strategies [43].

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Evaluation Of Mobile Phone And Cordless Phone Use And Glioma Risk Using The Bradford Hill Viewpoints From 1965 On Association Or Causation

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Objective. Bradford Hill's viewpoints from 1965 on association or causation were used on glioma risk and use of mobile or cordless phones.

Methods. All nine viewpoints were evaluated based on epidemiology and laboratory studies.

Results. Strength: meta-analysis of case-control studies gave odds ratio (OR) = 1.90, 95% confidence interval (CI) = 1.31–2.76 with highest cumulative exposure.

Consistency: the risk increased with latency, meta-analysis gave in the 10+ years' latency group OR = 1.62, 95% CI = 1.20–2.19.

Specificity: increased risk for glioma was in the temporal lobe. Using meningioma cases as comparison group still increased the risk.

Temporality: highest risk was in the 20+ years' latency group, OR = 2.01, 95% CI =1.41–2.88, for wireless phones.

Biological Gradient: cumulative use of wireless phones increased the risk.

Plausibility: animal studies showed an increased incidence of glioma and malignant schwannoma in rats exposed to radiofrequency (RF) radiation. There is increased production of reactive oxygen species (ROS) from RF radiation.

Coherence: there is a change in the natural history of glioma and increasing incidence.

Experiment: antioxidants reduced ROS production from RF radiation.

Analogy: there is an increased risk in subjects exposed to extremely low-frequency electromagnetic fields.

Conclusion. RF radiation should be regarded as a human carcinogen causing glioma.

In Sir Austin Bradford Hill's classic epidemiology paper from 1965, "The Environment and Disease: Association or Causation?," he warned not to overrate the value of statistical significance since it often leads people to "*grasp the shadow and loose the substance*" of what is in the data [1]. In the interpretation of epidemiological studies on cancer there may be no explanation about how the strength of a link between a cause and an effect can vary from a "*scientific suspicion of risk*" to a "*strong association*" through "*reasonably certainty*" and to "*causality*" which requires the strongest evidence. This continuum in strengths of evidence, which was illustrated in Bradford Hill's paper, written at the height of the tobacco and lung cancer controversy, is not always explained. This means that the media and the public may assume that "*not causal*" means "*no link*," with mobile phone use and brain tumour risk as one example.

In the Interphone study on mobile phone use and brain tumours an increased risk for glioma was found among the heaviest mobile phone users [2]. In an editorial accompanying the Interphone results published in the International Journal of Epidemiology [3], the main conclusion of the results was described as "*both elegant and oracular. . . (which) tolerates diametrically opposite readings*." They also pointed out several methodological reasons why the Interphone results were likely to have underestimated the risks, such as the short latency period since first exposures became widespread; less than 10% of the Interphone cases had more than 10 years of exposure. "*None of the today's established carcinogens, including tobacco, could have been firmly identified as increasing risk in the first 10 years or so since first exposure*." The concluding sentences from the Interphone study were "*oracular*": "*Overall, no increase in risk of either glioma or meningioma was observed in association with use of mobile phones. There were suggestions of an increased risk of glioma, and much less so meningioma, at the highest exposure levels, for ipsilateral exposures and, for glioma, for tumours in the temporal lobe. However, biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation*." This allowed the media to report opposite conclusions.

Due to the widespread use of wireless phones (mobile and cordless phones) an evaluation of the scientific evidence on the brain tumour risk was necessary. Thus, in May 2011 the International Agency for Research on Cancer (IARC) at WHO evaluated at that time published studies. The scientific panel reached the conclusion that radiofrequency (RF) radiation from mobile phones, and from other devices, including cordless phones, that emit similar nonionizing electromagnetic field (EMF) radiation in the frequency range 30 kHz–300 GHz, is a Group 2B, that is, a "*possible*," human carcinogen [4, 5]. The IARC decision on mobile phones was based mainly on case-control human studies by the Hardell group from Sweden [6–13] and the IARC Interphone study [2, 14, 15]. These studies provided supportive evidence of increased risk for brain tumours, that is, glioma and acoustic neuroma.

No doubt the IARC decision started a worldwide spinning machine to question the evaluation, perhaps similar to the one launched by the tobacco industry when IARC was studying and evaluating passive smoking as a carcinogen in the 1990s [16]. Sowing confusion and manufacturing doubt is a well-known strategy used by the tobacco and other industries [17–19]; see also Walker [20].

A fact sheet from WHO issued in June 2011 shortly after the IARC decision in May 2011 stated that "*to date, no adverse health effects have been established as being caused by mobile phone use*" [21]. This statement contradicted the IARC evaluation and was not based on evidence at that time on a carcinogenic effect from RF radiation and was certainly remarkable since IARC is part of WHO. Furthermore WHO wrote that "*currently, two international bodies have developed exposure guidelines for workers and for the general public, except patients undergoing medical diagnosis or treatment. These guidelines are based on a detailed assessment of the available scientific evidence.*" These organizations were the International

Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE).

ICNIRP is a private organization (NGO) based in Germany that selects its own members. Their source of funding is not declared. IEEE is the world's most powerful federation of engineers. The members are or have been employed in companies or organizations that are producers or users of technologies that depend on radiation frequencies, such as power companies, the telecom industry, and military organizations. IEEE has prioritized international lobbying efforts for decades especially aimed at the WHO.

The IARC conclusion was soon also questioned by, for example, some members of ICNIRP [22]. The article by Swerdlow et al. appeared online 1, July 2011, one month after the IARC decision, and concluded that "*the trend in the accumulating evidence is increasingly against the hypotheses that mobile phone use can cause brain tumours in adults.*"

Soon after that other persons affiliated with ICNIRP, Repacholi and associates, made a review on wireless phone use and cancer risks. The paper appeared online October 21, 2011 [23], with similar conclusions as the Swerdlow et al. paper [22].

The exposure guideline by ICNIRP was established in 1998 [24] and was based only on thermal (heating) effects from RF-EMF neglecting nonthermal biological effects. It was updated in 2009 [25] and stated that "*it is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields. . . .Therefore, ICNIRP reconfirms the 1998 basic restrictions in the frequency range 100 kHz–300 GHz until further notice*." The guideline still provided by ICNIRP for RF radiation is 2 to 10 W/m2 depending on frequency. It should be noted that the ICNIRP guideline is used in most European countries as well as in many other countries. Unfortunately it is based on old data with no acknowledgment of cancer effects or nonthermal biological effects from RF-EMF exposure.

There are a vast number of scientific articles that show nonthermal adverse health effects from RF radiation. These, as well as thermal effects, have been evaluated in several reports. In contrast to ICNIRP the BioInitiative Reports from 2007 [26], updated in 2012 [27], based the evaluation of health hazards also on nonthermal health effects from RF radiation. The BioInitiative 2012 Report, with updated references, defined the scientific benchmark for possible health risks as 30 to 60 uW/m2. Considering also chronic exposure and sensitivity among children the precautionary target level was proposed to one-tenth of this, 3–6 uW/m2 [27].

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Measurements Of Radiofrequency Radiation With A Body-Borne Exposimeter In Swedish Schools With Wi-Fi

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Keywords: radiofrequency radiation, wireless fidelity, Wi-Fi exposimetric measurements, schools, children, health

Introduction: Wireless access to the Internet is now commonly used in schools. Many schools give each student their own laptop and utilize the laptops and wireless fidelity (Wi-Fi) connection for educational purposes. Most children also bring their own mobile phones to school. Since children are obliged by law to attend school, a safe environment is important. Lately, it has been discussed if radiofrequency (RF) radiation can have long-term adverse effects on children's health.

Method: This study conducted exposimetric measurements in schools to assess RF emissions in the classroom by measuring the teachers' RF exposure in order to approximate the children's exposure. Teachers in grades 7–12 carried a body-borne exposimeter, EME-Spy 200, in school during 1–4 days of work. The exposimeter can measure 20 different frequency bands from 87 to 5,850 MHz.

Results: Eighteen teachers from seven schools participated. The mean exposure to RF radiation ranged from 1.1 to 66.1 µW/m2. The highest mean level, 396.6 µW/m2, occurred during 5 min of a lesson when the teacher let the students stream and watch YouTube videos. Maximum peaks went up to 82,857 µW/m2 from mobile phone uplink.

Discussion: Our measurements are in line with recent exposure studies in schools in other countries. The exposure levels varied between the different Wi-Fi systems, and if the students were allowed to use their own smartphones on the school's Wi-Fi network or if they were connected to GSM/3G/4G base stations outside the school. An access point over the teacher's head gave higher exposure compared with a school with a wired Internet connection for the teacher in the classroom. All values were far below International Commission on Non-Ionizing Radiation Protection's reference values, but most mean levels measured were above the precautionary target level of 3–6 µW/m2 as proposed by the Bioinitiative Report. The length of time wireless devices are used is an essential determinant in overall exposure. Measures to minimize children's exposure to RF radiation in school would include preferring wired connections, allowing laptops, tablets and mobile phones only in flight mode and deactivating Wi-Fi access points, when not used for learning purposes.

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World Health Organization, Radiofrequency Radiation And Health — A Hard Nut To Crack (Review)

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Keywords:
electromagnetic fields, EMF, radiofrequency radiation, public exposure, cancer, WHO, monograph, conflict of interest, ICNIRP, non-thermal effects, health risks

In May 2011 the International Agency for Research on Cancer (IARC) evaluated cancer risks from radiofrequency (RF) radiation. Human epidemiological studies gave evidence of increased risk for glioma and acoustic neuroma. RF radiation was classified as Group 2B, a possible human carcinogen. Further epidemiological, animal and mechanistic studies have strengthened the association. In spite of this, in most countries little or nothing has been done to reduce exposure and educate people on health hazards from RF radiation. On the contrary ambient levels have increased. In 2014 the WHO launched a draft of a Monograph on RF fields and health for public comments. It turned out that five of the six members of the Core Group in charge of the draft are affiliated with International Commission on Non-Ionizing Radiation Protection (ICNIRP), an industry loyal NGO, and thus have a serious conflict of interest. Just as by ICNIRP, evaluation of non-thermal biological effects from RF radiation are dismissed as scientific evidence of adverse health effects in the Monograph. This has provoked many comments sent to the WHO. However, at a meeting on March 3, 2017 at the WHO Geneva office it was stated that the WHO has no intention to change the Core Group.

The use of wireless digital technology has grown rapidly during the last couple of decades (http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf). During use, mobile phones and cordless phones emit radiofrequency (RF) radiation. The brain is the main target organ for RF emissions from the handheld wireless phone (1,2). An evaluation of the scientific evidence on the brain tumour risk was made in May 2011 by the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO). IARC is independently financed and has its own governing and scientific councils, which WHO staff only attend as observers (http://www.who.int/ionizing_radiation/research/iarc/en/).

Epidemiological studies provided supportive evidence of increased risk for head and brain tumours, i.e., acoustic neuroma and glioma. The working group reached the conclusion that RF radiation from devices that emit non-ionizing RF radiation in the frequency range 30 kHz-300 GHz, is a Group 2B, i.e. a 'possible', human carcinogen (3,4). Later studies have corroborated these findings and have thus strengthened the evidence (5-8).

Several laboratory studies have indicated mechanisms of action for RF radiation carcinogenesis such as on DNA repair, oxidative stress, down regulation of mRNA and DNA damage with single strand breaks (9-13). A report was released from The National Toxicology Program (NTP) under the National Institutes of Health (NIH) in USA on the largest ever animal study on cell phone RF radiation and cancer (14). An increased incidence of glioma in the brain and malignant schwannoma in the heart was found in rats. Acoustic neuroma or vestibular schwannoma is a similar type of tumour as the one found in the heart, although benign. Thus, this animal study supported human epidemiological findings on RF radiation and brain tumour risk (8).

The IARC cancer classification includes all sources of RF radiation. The exposure from mobile phone base stations, Wi-Fi access points, smart phones, laptops and tablets can be long-term, sometimes around the clock, both at home and at school. For children this risk may be accentuated because of a cumulative effect during a long lifetime use (15). Developing and immature cells can also be more sensitive to exposure to RF radiation (9).

In spite of the IARC evaluation little has happened to reduce exposure to RF fields in most countries. On the contrary, with new technology increasing environmental exposure levels are found as in measurements of ambient RF radiation at e.g. Stockholm Central Station and Stockholm Old Town in Sweden (16,17). The exposure guideline used by many agencies was established in 1998 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and was based only on established short-term thermal (heating) effects from RF radiation neglecting non-thermal biological effects (18). The heating effects arise when radiation is so high that it warms up the whole body by 1°C or more after 30 min exposure at 4 W/kg specific absorption rate. The guidelines are set with a safety factor of 50 for the general public
(http://www.who.int/peh-emf/about/ WhatisEMF/en/index4.html).

Basis for limiting exposure according to ICNIRP: 'Only established effects were used as the basis for the proposed exposure restrictions. Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures

resulting from absorption of energy during exposure to EMF. In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects.'
(http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf).

This is an exceptional statement by ICNIRP, and found in many statements of groups following the ICNIRP philosophy like the AGNIR and on the WHO EMF Project's homepage as well, that epidemiology found 'suggestive, but unconvincing' evidence. What is convincing or not is so decidedly subjective that no scientific body will ever make this as a basis for a decision. There might be gaps in knowledge that make it difficult to decide about the mechanisms that underlie an observation and even an observation could be considered unreliable but the conviction must not enter a rational discourse about a scientific issue.

The guidelines were updated in 2009 but still do not cover cancer and other long-term or non-thermal health effects. ICNIRP gives the guideline 2 to 10 W/m2 for RF radiation depending on frequency, thus only based on a short-term immediate thermal effect (19). ICNIRP is a private organisation (NGO) based in Germany. New expert members can only be elected by members of ICNIRP. Many of ICNIRP members have ties to the industry that is dependent on the ICNIRP guidelines. The guidelines are of huge economic and strategic importance to the military, telecom/IT and power industry.

In contrast to ICNIRP, the BioInitiative Reports from 2007 and updated in 2012, based the evaluation also on non-thermal health effects from RF radiation (20,21). The scientific benchmark for possible health risks was defined to be 30 to 60 µW/m2. Thus, using the significantly higher guideline by ICNIRP gives a 'green card' to roll out the wireless digital technology thereby not considering non-thermal health effects from RF radiation. Numerous health hazards are disregarded such as cancer (8), effects on neurotransmitters and neuroprotection (22,23), blood-brain-barrier (24,25), cognition (26-29), psychological addiction (30-32), sleep (33-36), behavioral problems (37-41) and sperm quality (13,42,43).

No doubt the IARC decision started a world-wide spinning machine to question the evaluation. It was similar to the one launched by the tobacco industry when IARC was studying and evaluating passive smoking as a carcinogen in the 1990s (44). Sowing confusion and manufacturing doubt about scientific facts is a well-known strategy used by the tobacco and other industries (8,45-48).

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High Radiofrequency Radiation At Stockholm Old Town: An Exposimeter Study Including The Royal Castle, Supreme Court, Three Major Squares And The Swedish Parliament

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Keywords: radiofrequency radiation, radiofrequency electromagnetic field base stations, exposimeter, public exposure, health, cancer

Exposure to radiofrequency (RF) radiation was classified as a possible human carcinogen, Group 2B, by the International Agency for Research on Cancer at WHO in 2011. The exposure pattern is changing due to the rapid development of technology. Outdoor RF radiation level was measured during five tours in Stockholm Old Town in April, 2016 using the EME Spy 200 exposimeter with 20 predefined frequencies. The results were based on 10,437 samples in total. The mean level of the total RF radiation was 4,293 µW/m2 (0.4293 µW/cm2). The highest mean levels were obtained for global system for mobile communications (GSM) + universal mobile telecommunications system (UMTS) 900 downlink and long-term evolution (LTE) 2600 downlink (1,558 and 1,265 µW/m2, respectively). The town squares displayed highest total mean levels, with the example of Järntorget square with 24,277 µW/m2 (min 257, max 173,302 µW/m2). These results were in large contrast to areas with lowest total exposure, such as the Supreme Court, with a mean level of 404 µW/m2 (min 20.4, max 4,088 µW/m2). In addition, measurements in the streets surrounding the Royal Castle were lower than the total for the Old Town, with a mean of 756 µW/m2 (min 0.3, max 50,967 µW/m2). The BioInitiative 2012 Report defined the scientific benchmark for possible health risks as 30-60 µW/m2. Our results of outdoor RF radiation exposure at Stockholm Old Town are significantly above that level. The mean exposure level at Järntorget square was 405-fold higher than 60 µW/m2. Our results were below the reference level on 10,000,000 µW/m2 established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which, however, are less credible, as they do not take non-thermal effects into consideration and are not based on sound scientific evaluation. Our highest measured mean level at Järntorget was 0.24% of the ICNIRP level. A number of studies have found adverse, non-thermal (no measurable temperature increase) health effects far below the ICNIRP guidelines.

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Exposure To Magnetic Field Non-Ionizing Radiation And The Risk Of Miscarriage: A Prospective Cohort Study

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Author Contributions
De-Kun Li conceived the concept, designed the study, obtained funding, oversaw the data gathering and analyses,
and is responsible for the interpretation of results, and drafting and finalizing the manuscript.
Jeannette Ferber and Hong Chen were responsible for data management.
Hong Chen was involved in data analysis and interpretation of the results.
Roxana Odouli was involved in the study management and preparation of the manuscript.
Charles Quesenberry was involved in interpretation of results and preparation of the manuscript.
De-Kun Li is the guarantor of this paper who took full responsibility for the conduct of the study,
had access to the data, and controlled the decision to publish.

Additional Information
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Magnetic field (MF) non-ionizing radiation is widespread and everyone is exposed to some degree. This prospective cohort study of 913 pregnant women examined the association between high MF exposure and miscarriage risk. Cox (proportional hazards) regression was used to examine the association. After controlling for multiple other factors, women who were exposed to higher MF levels had 2.72 times the risk of miscarriage (hazard ratio = 2.72, 95% CI: 1.42–5.19) than those with lower MF exposure. The increased risk of miscarriage associated with high MF was consistently observed regardless of the sources of high MF. The association was much stronger if MF was measured on a typical day of participants' pregnancies. The finding also demonstrated that accurate measurement of MF exposure is vital for examining MF health effects. This study provides fresh evidence, directly from a human population, that MF non-ionizing radiation could have adverse biological impacts on human health.

Magnetic field (MF) non-ionizing radiation is a ubiquitous environmental exposure and a serious looming public health challenge. MFs are emitted from both traditional sources that generate low frequency MFs (e.g., power lines, appliances, transformers, etc.) and from emerging sources that generate higher frequency MFs (e.g., wireless networks, smart meter networks, cell towers, wireless devices such as cell phones, etc.). Humans are now widely exposed to MF with ever-increasing intensity, due to the proliferation of MF-generating apparatuses.

The steep increase in MF exposure has renewed concerns about the potential health effects of this invisible, man-made environmental exposure. A recent NIEHS multi-year project conducted by the National Toxicology Program (NTP) has revealed an increased risk of cancer associated with MF non-ionizing radiation exposure [1,2]. More specifically, the NTP study found that the cancer risk due to MF exposure observed in their experimental animals matched the cancer cell types that had been reported in previous epidemiologic studies in human populations [1]. This finding has made it more difficult to continue to dismiss possible biological effects of MF exposure. Such outright dismissal could be especially troublesome given the high prevalence of human exposure (with almost everyone being exposed to MF non-ionizing radiation to some degree). This includes vulnerable populations such as pregnant women and young children. The International Agency for Research on Cancer (IARC) has classified MF as a possible carcinogen [3,4].

Miscarriage is one of the potential adverse health outcomes that are sensitive to MF exposure and also an endpoint that the WHO has recommended to be further studied in the context of MF health effects5. Over the years, a few observational studies in human populations have suggested a possible link be-

tween MF exposure during pregnancy and an increased risk of miscarriage [6–11] including two studies published in 2002 that increased the public awareness of such an association [12,13]. In addition, one study examined human embryonic tissues to assess the association between EMF exposure and embryonic growth, and observed an increased risk of impaired embryonic bud growth and apoptosis associated with exposure to higher MF level [14], providing some direct evidence of adverse biological impact of EMF exposure on embryonic development.

Nevertheless, the association between MF exposure and risk of miscarriage remains largely unknown and overlooked. We conducted this prospective cohort study among a large population of pregnant women to further examine whether exposure to MF non-ionizing radiation during pregnancy increases the risk of miscarriage.

Discussion

After initial reports that provided evidence of an increased risk of miscarriage associated with high MF exposure during pregnancy12,13, the current NIEHS-funded study provides additional evidence that exposure to high MF levels in pregnancy is associated with increased risk of miscarriage. This finding is also supported by four other studies published during the past 15 years that examined the relationship between high MF exposure and the risk of miscarriage8–11,19. Two of those studies measured EMF both inside, and in the surrounding areas, of the residence of participating pregnant women, and observed a higher risk of miscarriage associated with higher EMF exposure levels8,9. Two other studies examined the impact of EMF emitted from cell phones and wireless networks, and observed that more frequent cell phone use and close proximity to wireless base stations were both associated with an increased risk of miscarriage10,11. Although none of these studies conducted any personal MF measurements to capture actual MF exposure from all sources, as the current study has done, all four studies reported an increased risk of miscarriage associated with high MF exposure.

One of the most challenging aspects of assessing the health impact of MF exposure is the ability to measure MF exposure accurately as well as in the relevant etiological period. Prospectively measuring MF exposure in the etiologically relevant timeframe is essential and preferable to retrospective measurements. It is especially problematic to ascertain MF exposure long after the relevant window of exposure has passed. While logistically challenging, a prospective study design with a device that captures actual MF levels from all emitting sources in an etiologically relevant period will notably improve the accuracy of MF exposure assessment in epidemiological studies in a human population. In addition, as both this study and a previous study [12] demonstrated, even with a prospective design, if measurements were not conducted on a typical day to reflect true MF exposure during pregnancy, such study design could still fail to detect any MF health risk due to misclassification of MF exposure (see Table 2). Therefore, to ensure accurate exposure assessment, MF measurements need to be conducted prospectively during an etiologically relevant window and to reflect a participant's typical MF exposure patterns. The determination of whether the activity pattern was typical needs to be verified after measurement is complete since planned activities can change during the measurement day. It is clear that, if MF exposure is measured subjectively (e.g., interview based on participants' recall) or based on surrogate measures (e.g., wire codes, distance from power lines, job matrix, spot measurement at home, etc.), it would be very difficult for such studies to detect any MF health effect in epidemiological studies due to gross inaccuracies in measuring actual MF exposure levels. By definition, inaccurate MF measures lead to misclassification of MF exposure, which generally result in null findings. Unfortunately, the vast majority of epidemiological studies on MF health effects in the literature so far have been based on subjective and unreliable MF measurements. Thus, it is not surprising that many of the past studies failed to detect MF health effects. In addition, the focus on studying MF effects on cancer has exacerbated the problem, since the development of cancer usually has a long latency period between exposure and outcome that could span several decades. This has made accurately measure MF exposure in the etiologically relevant period (decades before the diagnosis of cancer) almost impossible. Those "*null findings*" have left a false impression of the "*safety*" of MF exposure.

The strength of this current study is that, in addition to using an objective measuring device (EMDEX Lite meter), we examined an outcome (miscarriage) with a short latency period (days or weeks rather than years or decades as in the case of cancers or autoimmune diseases). Thus, we were able to measure MF exposure prospectively in the relevant time period (during pregnancy). Furthermore, at the end of the measurement day, we ascertained whether activity patterns on that day reflected a typical day, which allowed us to identify participants with MF exposure measurements that more accurately reflected MF exposure during their pregnancies.

In this study, we found an almost three-fold increased risk of miscarriage if a pregnant woman was exposed to higher MF levels compared to women with lower MF exposure. The association was independent of any specific MF exposure sources or locations, thus removing the concern that other factors connected to the sources of the exposure might account for the observed associations. While nausea and vomiting were hypothesized to be potential confounders, adjustment for both nausea and vomiting did not change the results in this study or in a previous study [20]. Although we did not observe a dose-response relationship for MF exposure above 2.5 mG, this could be due to a threshold effect of MF exposure in which MF levels at or above 2.5 mG could lead to fetal demise, thus examining further higher levels of MF exposure were not able to confer additional risk.

Given the ubiquitous nature of exposure to this non-ionizing radiation, a small increased risk due to MF exposure could lead to unacceptable health consequences to pregnant women. Although the number of epidemiological studies examining the adverse impact of MF exposure in humans remains limited, the findings of this study should bring attention to this potentially important environmental hazard to pregnant women, at least in the context of miscarriage risk, and stimulate much needed additional research.

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Toxicology Reports • October 2017

Exposure To Radio-Frequency Electromagnetic Waves Alters Acetylcholinesterase Gene Expression, Exploratory And Motor Coordination-Linked Behaviour In Male Rats

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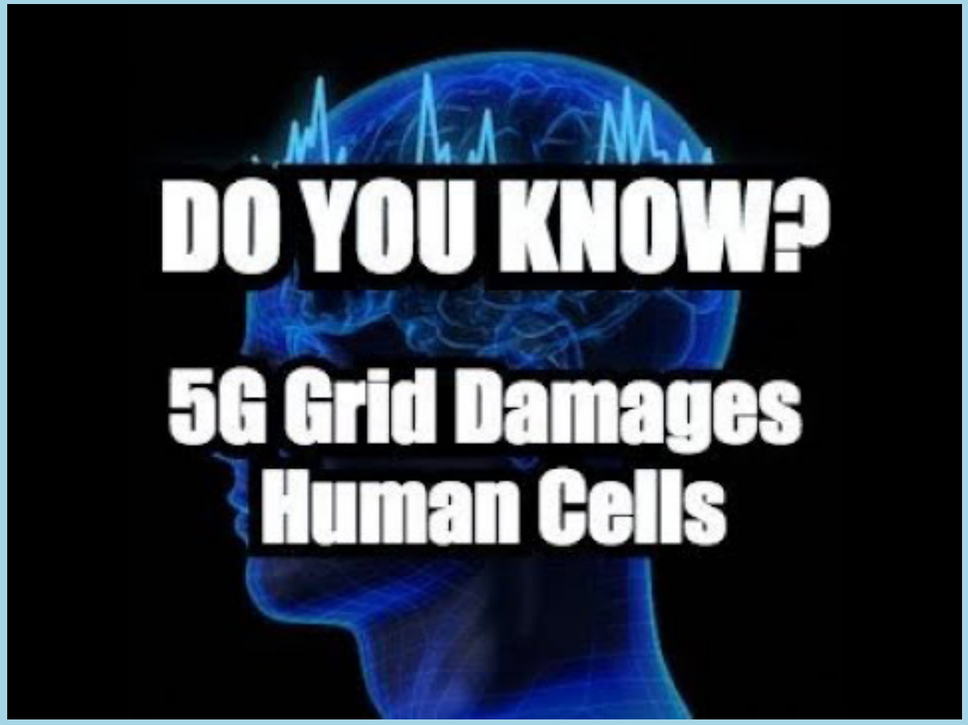
Keywords:
Acetylcholinesterase, Radiofrequency, Electromagnetic waves, mRNA, Gene expression

Humans in modern society are exposed to an ever-increasing number of electromagnetic fields (EMFs) and some studies have demonstrated that these waves can alter brain function but the mechanism still remains unclear. Hence, this study sought to investigate the effect of 2.5 Ghz band radio-frequency electromagnetic waves (RF- EMF) exposure on cerebral cortex acetylcholinesterase (AChE) activity and their mRNA expression level as well as locomotor function and anxiety-linked behaviour in male rats. Animals were divided into four groups namely; group 1 was control (without exposure), group 2–4 were exposed to 2.5 Ghz radiofrequency waves from an installed WI-FI device for a period of 4, 6 and 8 weeks respectively. The results revealed that WiFi exposure caused a significant increase in anxiety level and affect locomotor function. Furthermore, there was a significant decrease in AChE activity with a concomitant increase in AChE mRNA expression level in WiFi exposed rats when compared with control. In conclusions, these data showed that long term exposure to WiFi may lead to adverse effects such as neurodegenerative diseases as observed by a significant alteration on AChE gene expression and some neurobehavioral parameters associated with brain damage.



Acta Neurologica • May 2017

Controlled Population-Based Comparative Study Of USA And International Adult [55-74] Neurological Deaths 1989-2014

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Keywords:
comparison, international, mortality, neurological, USA

Objectives: A population-based controlled study to determine whether adult (55-74 years) neurological disease deaths are continuing to rise and are there significant differences between America and the twenty developed countries 1989-91 and 2012-14.

Method: Total Neurological Deaths (TND) rates contrasted against control Cancer and Circulatory Disease Deaths (CDD) extrapolated from WHO data. Confidence intervals compare USA and the other countries over the period. The Over-75's TND and population increases are examined as a context for the 55-74 outcomes.

Results: Male neurological deaths rose >10% in eleven countries, the other countries average rose 20% the USA 43% over the period. Female neurological deaths rose >10% in ten counties, averaging 14%, the USA up 68%. USA male and female neurological deaths increased significantly more than twelve and seventeen countries, respectively. USA over-75s population increased by 49%, other countries 56%. Other countries TND up 187% the USA rose fourfold. Male and female cancer and CDD fell in every country averaging 26% and 21%, respectively, and 64% and 67% for CDD. Male neurological rates rose significantly more than Cancer and CCD in every country; Female neurological deaths rose significantly more than cancer in 17 countries and every country for CDD. There was no significant correlation between increases in neurological deaths and decreases in control mortalities.

Conclusions: There are substantial increases in neurological deaths in most countries, significantly so in America. Rises in the 55-74 and over-75's rates are not primarily due to demographic changes and are a matter of concern warranting further investigation.

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The Carcinogenic Potential Of Non-Ionizing Radiations: The Cases Of S-50Hz MF And 1.8GHz GSM RFR

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Key Words:
Extremely low frequency magnetic fields; radiofrequency radiation; mobile phone; Sprague Dawley rats; carcinogenicity; cancer promotion; co-carcinogenesis; schwannoma.

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Conflict Of Interest:
The authors declare no conflict of interest in relation to this work. The research was supported by Ramazzini Institute and by "Ruberti- Schileo" European Foundation. The funding sources had no direct role in the interpretation of the data or in the decision to publish the work.

Epidemiological studies have suggested that human exposure to extremely low-frequency electromagnetic fields (ELFEMF) from the electric power and to mobile phone radiofrequency electromagnetic fields (RFEMF) induce an increased risk of developing malignant tumours. However, no adequate laboratory data, in particular long-term carcinogenicity bioassays to support the epidemiological evidence, have yet been available. This motivated the Ramazzini Institute to embark on a first project of four large life-span carcinogenic bioassays conducted on over 7,000 Sprague Dawley rats exposed from prenatal life until natural death to S-50Hz MF alone or combined with gamma radiation or formaldehyde or aflatoxinB1. Results now available from these studies, which started concurrently, have shown that exposure to Sinusoidal-50Hz Magnetic Field (S-50Hz MF) combined with acute exposure to gamma radiation or to chronic administration of formaldehyde in drinking water induces a significantly increased incidence of malignant tumours in males and females. A second project of two large life-span carcinogenic bioassays was conducted on over 3,000 Sprague Dawley rats exposed from prenatal life until natural death to 1.8 GHz GSM of mobile phone radio base station, alone or combined with acute exposure to gamma radiation. Early results from the experiment on 1.8 GHz GSM alone show a significant increase in the incidence of heart malignant schwannoma among males exposed at the highest dose.

Cyberpsychology, Behavior And Social Networking • 2018

Mobile Phone-Use Habits Among Adolescents: Predictors Of Intensive Use

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Keywords:
mobile phone, extensive use, children, adolescence

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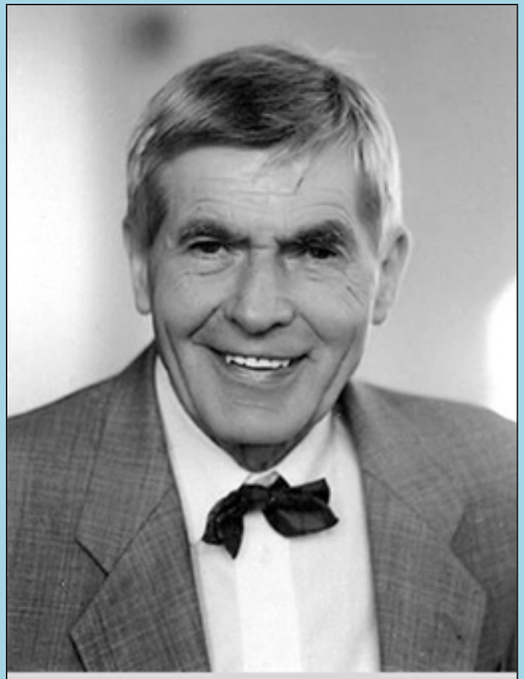
Concern has been raised regarding the possible effects of mobile phone use on health, especially by children and adolescents. Thus, it is important to evaluate factors affecting their patterns of use. This study aimed to identify determinants of heavy mobile phone use among Israeli adolescents. Data were collected using a self-report questionnaire regarding mobile phone usage, leisure activity, sociodemographics, and opinion regarding mobile phone use. "Heavy use" was defined as >1 hour of daily duration of voice calls, or >50 daily text messages. The survey included 1,688 seventh and ninth graders in eight middle schools. The vast majority (96.1 percent) used the mobile phone for voice calls daily. Girls were heavier users than boys, and ninth graders were heavier users than seventh graders. Among students attending religious schools, the rate of heavy users was lower than among those attending secular schools. About half of the students did not use hands-free devices at least half of the time. Leisure activities were significantly associated with mobile phone use. This study demonstrates that several variables, including sociodemographics and leisure activities, may predict heavy mobile phone use among teenagers. This information can be useful for exposure assessment and for designing intervention programs for reducing radio frequency (RF) radiation exposure.

Health Implications Of Long-Term Exposure To Electrosmog

By Prof. Dr. med. habil. Karl Hecht

Approaches to assessing long-term risks of electrosmog



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For the past 20 years, his major research areas have included: stress, sleep, chronomedicine, environmental medicine, space medicine, as well as health sciences and holistic naturopathy.

He is the author of 48 specialist and nonfiction books and has also published more than 800 scientific papers in national and international journals.

What the findings of our long-term review tell us
How ignorance or denial of such findings impact those affected

Summary

Why claims of safety do not do justice to the currently available evidence

At the very latest since the findings of Dr. Erwin Schliephake in 1932, do we know that radio-frequency radiation of longer exposure duration can cause illness in humans, especially affecting the central nervous system and its control functions. And as early as 1971, observations of pathogenic effects of electromagnetic radiation have been included in the U.S. government report with the title Program for Control of Electromagnetic Pollution of the Environment, which urgently warns of the associated risks. The authors of the report are convinced that "*in the decades ahead, man may enter an era of energy pollution of the environment comparable to the chemical pollution of today.*" They predict, "*The consequences of undervaluing or mis-judging the biological effects of long-term [author's emphasis], low-level exposure could become a critical problem for public health.*"

Even though research independent of industry has constantly produced new evidence that proves the above prediction right, the public is regularly told how safe wireless radiation is — and nowhere else have these messages become more frequent than in Germany over the last years. The authorities call on studies that investigate neither long-term EMF exposures nor biological effects of low-level exposure as has already been demanded by the authors of the above-discussed government report. The current exposure limits, which are supposed to protect the public, only consider possible thermal effects.

The information provided in this brochure makes clear that short-term studies cannot answer any questions regarding long-term health risks. The current exposure limits, which we mostly owe to the physicists' way of thinking, are a scientific anachronism. Furthermore, by using the concrete example of a research review, it has been shown how the authorities have ignored and continue to ignore that which is important for public health and a sustainable future, but would be contrary to economic interests.

What the findings of our long-term review tell us

In 1996, the author and his associate Balzer had been commissioned by the German Federal Agency of Telecommunications (today the Federal Network Agency) to carry out a review of the Russian scientific literature between 1960 and 1997 [Hecht, Balzer 1997]. Under the title Biologische Wirkungen elektromagnetischer Felder im Frequenzbereich 0 bis 3 GHz auf den Menschen [Biological Effects of Electromagnetic Fields on Humans in the Frequency Range of 0 to 3 GHz], they submited their review in 1997. Those who had commissioned the review, however, were eager to suppress the results of this 120-page research report.

The report revealed which central role the time factor plays for the biological effects of electromagnetic fields: In healthy persons, symptoms, especially those that affect the functions of the central nervous system (brain), will appear at the earliest after three to five years of EMF exposure (2–8 h/day). Only after five years of EMF exposure, and even more pronounced after ten years of EMF exposure, did the number and severity of the diseases increase.

Furthermore, these findings on long-term effects of electromagnetic fields have been obtained from a broad range of research. Out of more than 1500 Russian scientific papers, the authors selected 878 for the government-commissioned review. The selected papers were based on annual occupational health and industrial hygiene assessments legally required for those occupationally exposed to electromagnetic fields and most of these assessments had been carried out on thousands of workers over long periods. It was of particular interest to see that cases of illness clearly increased even though the Russian exposure limits of electromagnetic fields are three orders of magnitude lower than in Western Europe.

Beyond the great importance of exposure duration, it could be demonstrated that the effect of electromagnetic fields in humans is also dependent on other factors, especially the simultaneous exposure to other environmental factors as well as an individual's state of health and age.

How ignorance or denial of such findings impact those affected

As a scientist, physician, and expert witness, the author has been involved in numerous cases of persons with electromagnetic hypersensitivity as well as radar victims of the German Armed Forces and the

National People's Army of the former GDR. He describes the helplessness official agencies and ignorant physicians cause in those affected by electromagnetic hypersensitivity, the microwave syndrome, and radar exposure. He shows how the continuous experience of helplessness turns into a great stressor itself that exacerbates the disease-causing long-term effects of electromagnetic field exposure.

He also criticizes the loss of democratic culture, which makes the implications of the telecommunications policy for the public even worse. The brochure concludes with an appeal that sees the human right to health violated on several levels. He calls on the government and the political parties of the Federal Republic of Germany to put suitable protective measures into place that protect our living environment from increasing levels of EMF and that guarantee the public's right to health. We will probably never know how many radar victims there are because some have already died before applying and others have been unable to file an application. According to the information available to me, there still seemed to be almost 1500 applications outstanding in 2010, waiting to have their disability recognized based on military service injuries. The number of those already deceased cannot be determined either. According to my knowledge, the majority of radar victims, at least untill 2010, had the recognition of their disability declined, even with a documented diagnosis of skin cancer or other types of cancer. In most cases, the recognition was declined through court proceedings. After that, radar victims felt ridiculed, deceived, and helpless.

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Case-Control Study Of The Association Between Malignant Brain Tumours Diagnosed Between 2007 And 2009 And Mobile And Cordless Phone Use

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Previous studies have shown a consistent association between long-term use of mobile and cordless phones and glioma and acoustic neuroma, but not for meningioma. When used these phones emit radiofrequency electromagnetic fields (RF-EMFs) and the brain is the main target organ for the hand-held phone. The International Agency for Research on Cancer (IARC) classified in May, 2011 RF-EMF as a group 2B, i.e. a 'possible' human carcinogen. The aim of this study was to further explore the relationship between especially long-term (>10 years) use of wireless phones and the development of malignant brain tumours. We conducted a new case-control study of brain tumour cases of both genders aged 18-75 years and diagnosed during 2007-2009. One population-based control matched on gender and age (within 5 years) was used to each case. Here, we report on malignant cases including all available controls. Exposures on e.g. use of mobile phones and cordless phones were assessed by a self-administered questionnaire. Unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index using the whole control sample. Of the cases with a malignant brain tumour, 87% (n=593) participated, and 85% (n=1,368) of controls in the whole study answered the questionnaire. The odds ratio (OR) for mobile phone use of the analogue type was 1.8, 95% confidence interval (CI)=1.04-3.3, increasing with >25 years of latency (time since first exposure) to an OR=3.3, 95% CI=1.6-6.9. Digital 2G mobile phone use rendered an OR=1.6, 95% CI=0.996-2.7, increasing with latency >15-20 years to an OR=2.1, 95% CI=1.2-3.6. The results for cordless phone use were OR=1.7, 95% CI=1.1-2.9, and, for latency of 15-20 years, the OR=2.1, 95% CI=1.2-3.8. Few participants had used a cordless phone for >20-25 years. Digital type of wireless phones (2G and 3G mobile phones, cordless phones) gave increased risk with latency >1-5 years, then a lower risk in the following latency groups, but again increasing risk with latency >15-20 years. Ipsilateral use resulted in a higher risk than contralateral mobile and cordless phone use. Higher ORs were calculated for tumours in the temporal and overlapping lobes. Using the meningioma cases in the same study as reference entity gave somewhat higher ORs indicating that the results were unlikely to be explained by recall or observational bias. This study confirmed previous results of an association between mobile and cordless phone use and malignant brain tumours. These findings provide support for the hypothesis that RF-EMFs play a role both in the initiation and promotion stages of carcinogenesis.

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

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Key words:
National Toxicology Program study, carcinogenesis,
radiofrequency radiation, glioma, acoustic neuroma, cancer

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for Independent Research, Berlin, Germany
Availability of data and materials

The datasets generated and analyzed during the current study
are available from the corresponding author on reasonable request.

Authors' contributions:
Both LH and MC participated in the conception, design and writing of the manuscript.
LH supervised the study. MC made all statistical calculations.
Both authors have read and approved the final version.

Competing interests:
The authors declare that they have no competing interests.

"Based on the Preamble to the IARC Monographs, RF radiation should be classified as carcinogenic to humans, Group 1."

During the use of handheld mobile and cordless phones, the brain is the main target of radiofrequency (RF) radiation. An increased risk of developing glioma and acoustic neuroma has been found in human epidemiological studies. Primarily based on these findings, the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) classified in May, 2011 RF radiation at the frequency range of 30 kHz-300 GHz as a 'possible' human carcinogen, Group 2B. A carcinogenic potential for RF radiation in animal studies was already published in 1982. This has been confirmed over the years, more recently in the Ramazzini Institute rat study. An increased incidence of glioma in the brain and malignant schwannoma in the heart was found in the US National Toxicology Program (NTP) study on rats and mice. The NTP final report is to be published; however, the extended reports are published on the internet for evaluation and are reviewed herein in more detail in relation to human epidemiological studies. Thus, the main aim of this study was to compare earlier human epidemiological studies with NTP findings, including a short review of animal studies. We conclude that there is clear evidence that RF radiation is a human carcinogen, causing glioma and vestibular schwannoma (acoustic neuroma). There is some evidence of an increased risk of developing thyroid cancer, and clear evidence that RF radiation is a multi-site carcinogen. Based on the Preamble to the IARC Monographs, RF radiation should be classified as carcinogenic to humans, Group 1.

Recently, the US National Toxicology Program (NTP) released results on the toxicology and carcinogenicity of radiofrequency (RF) radiation in rats and mice, as further discussed below. This initiated this article for the comparison of earlier human epidemiological studies with the NTP the findings, including a short review of animal studies.

NTP is an interagency program established in 1978 to coordinate toxicology research and testing across the Department of Health and Human Services. The program was also created to strengthen the science base in toxicology, develop and validate improved testing methods, and provide information about potentially toxic chemicals to health regulatory and research agencies, scientific and medical communities, and the public. NTP is headquartered at the National Institute of Environmental Health Sciences (NIEHS) (https://ntp.niehs.nih.gov/about/org/index.html).

The brain is the main target of the exposure to RF radiation during the use of handheld wireless phones; both mobile and cordless phones (1,2). Thus, an increased risk of developing brain tumors has long been a cause for concern.

Our study group has since the end of the 1990s published results from case-control studies on use of wireless phones and brain tumor risk (3). A statistically significant increased risk for ipsilateral use of mobile phones, the same side of the brain as the phone was used, was published for malignant brain tumors (4) and vestibular schwannoma (5). Further scientific evidence on the association has more recently been discussed by Carlberg and Hardell (6).

In May, 2011 the International Agency for Research on Cancer (IARC) concluded that radiofrequency (RF) radiation in the frequency range 30 kHz-300 GHz is a 'possible' human carcinogen Group 2B (7,8). The classification was based primarily on evidence that long-term users of wireless phones (mobile and cordless phones) have an increased risk for glioma and acoustic neuroma. One major reason that the rating was not a 'probable' or a 'known' risk was the lack of clear evidence from animal studies. IARC at the World Health Organization (WHO) is independently financed and has its own governing and scientific councils, which WHO staff only attend as observers.
(http://www.who.int/ionizing_radiation/research/iarc/en/).

Unfortunately, WHO itself has constantly refused to acknowledge the carcinogenicity of RF radiation. In fact, WHO seems to rely on the conclusion of the non-governmental organization International Commission on Non-ionizing Radiation Protection (ICNIRP) instead of the IARC evaluation. That organization is even declared to be their in-house experts (9,10). ICNIRP is a private non-governmental organisation (NGO) based in Germany. New expert members can only be elected by members of the organization. Many of the ICNIRP members have ties to the industry that are dependent on the ICNIRP guidelines (11). This creates a conflict of interest, since the former leader of the WHO International Electromagnetic Field (EMF) Project is also the founder and honorary member of the ICNIRP (11). The guidelines are of huge economic and strategic importance to the military, telecom/IT and power industry. These circumstances are further discussed in a recent publication (12).

Table I. Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for glioma in case-control studies in the highest category of cumulative use in hours for mobile phone use.

	All			Ipsilateral		
Study (ref.)	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone, 2010 (40)						
Cumulative use ≥1,640 h	210/154	1.40	1.03-1.89	100/62	1.96	1.22-3.16
Coureau *et al*, 2014 (41)						
Cumulative use >896 h	24/22	2.89	1.41-5.93	9/7	2.11	0.73-6.08
Hardell and Carlberg, 2015 (43)						
Cumulative use ≥1,640 h	211/301	2.13	1.61-2.82	138/133	3.11	2.18-4.44
Meta-analysis (40,41,43)						
Cumulative use ≥1,640 h[a]	445/477	1.90	1.31-2.76	247/202	2.54	1.83-3.52

[a]≥896 h used for Coureau *et al*.

The IARC cancer classification includes all sources of RF radiation. The exposure from mobile phone base stations, DECT base stations, Wi-Fi access points, smart phones, laptops and tablets can be long-term, sometimes around the clock, at home, at the work place, at school and in the environment. For children, this risk may be accentuated due to a cumulative effect during a long lifetime use (13).

The exposure guidelines used by many agencies and countries were established in 1998 by the ICNIRP and were based only on established short-term thermal (heating) effects from RF radiation neglecting non-thermal biological effects (14). ICNIRP provides the guideline of 2 to 10 W/m2 for RF radiation, depending on the frequency. The ICNIRP guidelines were updated in 2009; however, they still do not cover cancer and other long-term or non-thermal effects (15) [see also Hardell (10)].

In contrast to the ICNIRP, the BioInitiative Reports from 2007 and 2012 based the evaluation also on the non-thermal health effects from RF radiation (16,17). The scientific benchmark for possible health risks was defined to be 30 to 60 μW/m2. In 2012, the Bioinitiative Working Group proposed a precautionary target level of 3-6 μW/m2, using a safety factor of 10. Using the significantly higher guideline by ICNIRP gives a 'green card' to roll out the wireless digital technology, thereby not considering non-thermal health effects from RF radiation.

The evidence of RF radiation as a carcinogen was confirmed when NTP released preliminary results of a study of long-term exposure of rats and mice to cell phone radiation (18). An increased incidence of glioma in the brain and malignant schwannoma in the heart was found. The NTP study has now been published online for public consultations (19,20) and is discussed below in relation to human epidemiological studies.

Background: Evidence from previous animal studies

There are several earlier animal studies that demonstrate the carcinogenic potential of RF radiation. Szmigielski et al already in 1982 published a study on the co-carcinogenic effects of RF radiation exposure and benzopyrene in mice (21). Cancer promotion was found for 2,450 MHz RF radiation at either 50 or 150 W/m2. The results revealed an acceleration of spontaneous and chemically-induced cancers.

Non-thermal 2,450 MHz continuous-wave RF radiation has been shown to cause a biphasic effect on glioma cells (22) and lymphocytes (23). Cell proliferation was found at a specific absorption rate (SAR) of ≤50 W/kg, whereas a higher SAR suppressed DNA and RNA synthesis.

SAR ranged from 0.144 to 0.4 W/kg depending on the rats' weight in a study from 1992 on 200 rats exposed to 2,450 MHz pulsed RF radiation 21.5 h per day for 25 months (24). Compared with 200 sham-exposed rats, a statistically significant increased incidence of primary malignant diseases was found in exposed animals. Among the malignancies found in the exposed rats were malignant lymphoma and thyroid cancer. These findings are of interest since SAR values in the study were rather low compared to the ICNIRP guideline on SAR 2 W/kg to the brain for use of mobile phones (14).

Table II. Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for meningioma in case-control studies in the highest category of cumulative use in hours for mobile phone use.

	All			Ipsilateral		
Study (ref.)	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone, 2010 (40)						
Cumulative use ≥1,640 h	130/107	1.15	0.81-1.62	46/35	1.45	0.80-2.61
Coureau *et al*, 2014 (41)						
Cumulative use >896 h	13/9	2.57	1.02-6.44	6/4	2.29	0.58-8.97
Carlberg and Hardell, 2015 (56)						
Cumulative use ≥1,640 h	141/301	1.24	0.93-1.66	67/133	1.46	0.98-2.17
Meta-analysis (40,41,56)						
Cumulative use ≥1,640 h[a]	284/417	1.27	0.98-1.66	119/172	1.49	1.08-2.06

[a]≥896 h used for Coureau *et al*.

A total of 100 mice were sham-exposed and 101 were exposed for two 30-min periods per day for up to 18 months to 900 MHz pulsed RF radiation with power densities 2.6-13 W/m2 (SAR 0.008-4.2 W/kg, averaging 0.13-1.4 W/kg). The mice carried a lymphomagenic oncogene and their risk of developing lymphoma was found to be statistically significantly higher in the exposed mice than in the controls (25).

The same results were not found in the study by Utteridge et al (26) that has been criticized as it was not a replication study. However, the findings on lymphoma risk by Repacholi et al (25) and Chou et al (24) are of relevance in relation to the indications of an increased risk of non-Hodgkin lymphoma (NHL) in human epidemiological

studies on the use of wireless phones. Thus, a statistically significant increased risk of T-Cell NHL was found in one study (27). In another study, NHL not otherwise specified was statistically signifi- cantly increased among subjects with ≥6 years duration [odds ratio (OR) =4.4 in men] for mobile phone use (28), although based on low numbers (n=7).

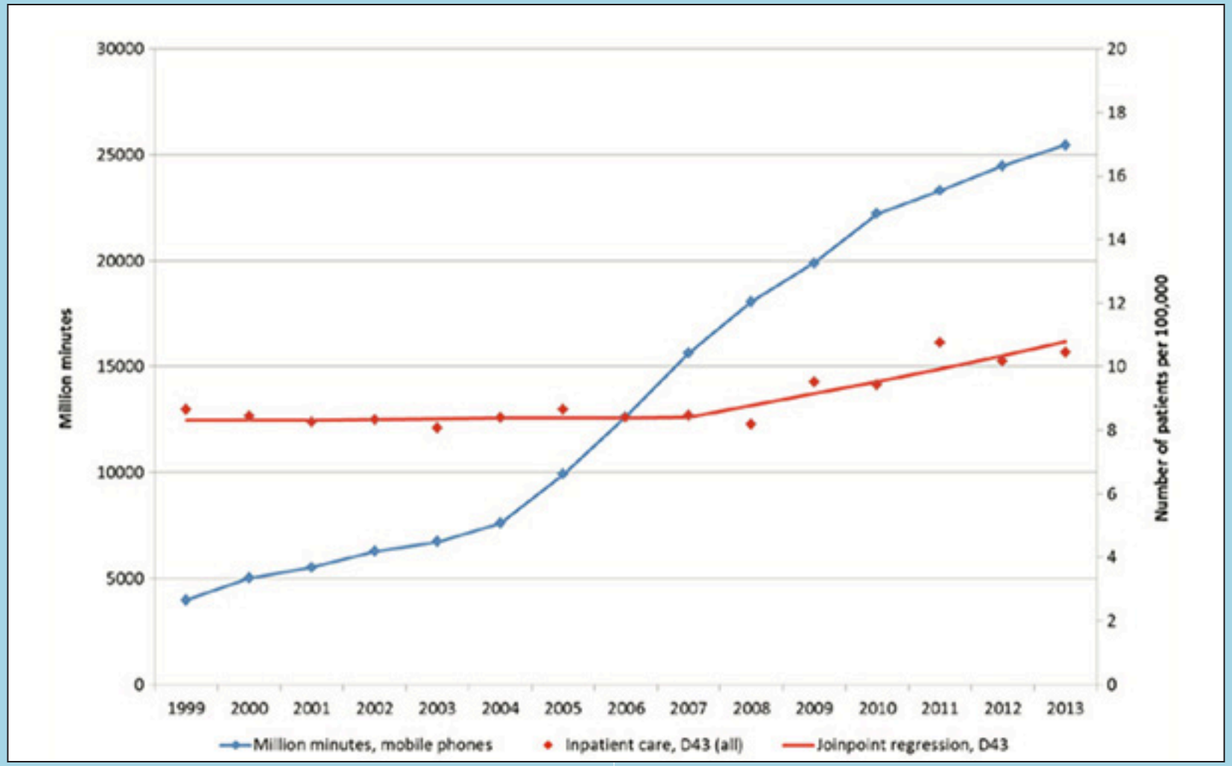
The thyroid gland is among the organs with the highest exposure to RF radiation during the use of the handheld wireless phone, particularly smartphones (29,30). The finding of thyroid cancer risk in the study by Chou et al (24), and the sharp increase in the incidence of thyroid cancer in humans during recent years (31) are of interest in that context.

In another study, mice were exposed to universal mobile telecommunications system (UMTS) fields with intensities of 0 (sham), 4.8 and 48 W/m2 up to 24 months (32). The low-dose group, exposed to 4.8 W/m2, was subjected to additional prenatal ethylnitrosourea (ENU) treatment. That group showed an increased lung tumor rate and an increased incidence of lung carcinomas as compared to the controls treated with ENU only. This indicated a co-carcinogenic effect of a lifelong UMTS exposure in female mice pretreated with ENU (32).

In a follow-up study, mice were exposed to RF radiation: 0 (sham), 0.04, 0.4 and 2 W/kg SAR (33). The numbers of tumors of the lungs and livers in exposed animals were statistically significantly higher than in sham-exposed controls, and the numbers of malignant lymphoma were also higher. A tumor-promoting effect of RF radiation was found at low to moderate levels (0.04 and 0.4 W/kg SAR), well below the ICNIRP exposure limits for users of mobile phones (33).

The study by the Ramazzini Institute is the largest long-term study ever performed on the health effects of RF radiation, including 2,448 rats (34). Male and female Sprague-Dawley rats were exposed from prenatal life until natural death to a 1.8 GHz global system for mobile communication (GSM) far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day. A statistically significant increase in the incidence of malignant Schwannoma in the heart was found in male rats at the highest dose, 50 V/m, corresponding to 0.66 mW/cm2 and whole-body SAR of 0.1 W/Kg. An increased incidence of heart Schwann cell hyperplasia was observed in treated male and female rats at the highest dose (50 V/m), but was not statistically significant. In treated female rats at the highest dose (50 V/m), the incidence of malignant glial tumors was increased, although this was not statistically significant. The study revealed an increased incidence of tumor types similar to those associated with the use of wireless phones, glioma and acoustic neuroma, in human epidemiological studies.

The NTP study provides additional confirmation of the carcinogenicity of RF radiation (19,20). They showed an increased incidence of malignant schwannoma in the heart and brain glioma in male rats exposed either to GSM-modulated or code division multiple access (CDMA)-modulated cell phone RF radiation for two years. There are also increased incidences of some other tumor types and diseases. Below we discuss some of the major findings.



The results on schwannoma and glioma are of particular concern since they corroborate human epidemiological findings. Thus, it is noteworthy that similar tumors were found in the NTP study as in epidemiological studies on the human use of wireless phones; mobile phones or cordless phones (DECT). Malignant schwannoma in the heart is a similar type of tumor as vestibular schwannoma in humans, also known as acoustic neuroma, although acoustic neuroma is usually benign and rarely undergoes malignant transformation. Below, we provide an updated evaluation of the scientific evidence of an increased risk of developing glioma and vestibular schwannoma (acoustic neuroma) associated with the use of wireless phones. It is pertinent to provide an updated presentation of the NTP reports on current evidence on cancer risks associated with the use of wireless phones.

Since the IARC evaluation in 2011, more human epidemiological studies have been published that support a causal association between RF radiation and brain and head tumors. A Danish cohort study on 'mobile phone users' (35,36) is not included herein due to serious methodological shortcomings in the study design [see Söderqvist et al (37)]. The study by Benson et al (38) is of limited value since the use of cordless phones was not included, mobile phone use was assessed only at baseline and no information on tumor laterality, including ipsilateral versus contralateral use was given. In spite of the many shortcomings, an increased risk of developing acoustic neuroma was reported. The study will not be further discussed below.

In the following, first, human epidemiological studies on specific tumor types are discussed. The NTP study findings are then presented and finally, an evaluation of the combined evidence from human and animal studies is presented.

Glioma:

Human Studies: Glioma is the most common malignant brain tumor and represents approximately 60% of all central nervous system (CNS) tumors. Most of these are astrocytic tumors divided into low-grade (WHO grades I-II) and high-grade (WHO grades III-IV). The most common glioma type is glioblastoma multiforme (WHO grade IV) with a peak incidence in the age group of 45-75 years and a median survival

less than one year (39). No substantial increasing survival has been obtained in recent years. Three research groups have provided results in case-control studies on glioma, Interphone (40), Coureau et al (41) and the Hardell group in Sweden (42-46).

The random effects model was used for a meta-analyses of published studies, based on the test for heterogeneity in the overall group ('all mobile'). Note that only our group also assessed the use of cordless phones. Thus, the reference category in our studies included cases and controls with no use of wireless phones, in contrast to the other studies investigating only mobile phone use. Including cordless phone use in the 'unexposed' group would bias the risk estimates towards unity (45).

In Table I, results of the highest cumulative use in hours of mobile phones are presented. All studies reported a statistically significantly increased risk of developing glioma and the meta-analysis yielded OR =1.90 and 95% confidence interval (CI) =1.31-2.76. For ipsilateral mobile phone use, the risk increased further to OR =2.54, 95% CI =1.83-3.52 in the meta-analysis based on 247 exposed cases and 202 exposed controls. Further support of the increased risk of glioma associated with mobile phone use has been obtained in additional analyses of parts of the Interphone study (47-49).

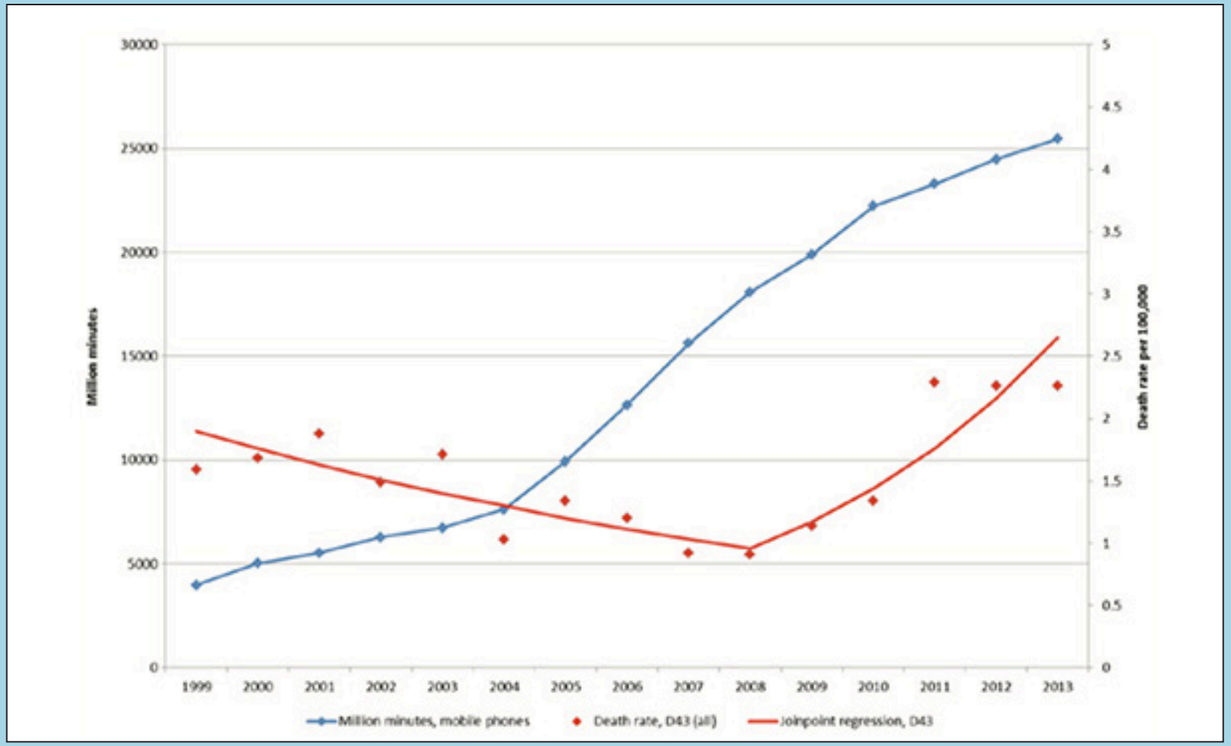
We previously analyzed the survival of the patients in our studies and found a shorter survival in patients with glioblastoma multiforme associated with the use of wireless phones compared with patients with no use (50). Interestingly, the mutation of the p53 gene involved in disease progression has been reported in glioblastoma multiforme in patients using mobile phones for ≥3 h per day. The mutation was statistically significantly associated with a shorter overall survival time (51).

NTP study:

No increased incidence of glioma was reported in the mouse study (20).

In male rats (19), malignant glioma and glia cell hyperplasia occurred in all groups exposed to GSM-modulated cell phone RF radiation for two years. No lesions were observed in the sham controls. In female rats, glial cell hyperplasia occurred in one rat (3 W/kg), but none in the sham controls. One malignant glioma occurred in one rat in the 6 W/kg group but none in the sham controls.

In male rats exposed to CDMA-modulated cell phone RF radiation for two years, there was an increased incidence of malignant glioma with a statistically significant trend, P=0.044. In females, three malignant glioma occurred in the 1.5 W/kg group, but none in the other exposed groups or the sham control (P-value for trend =0.384). Glial cell hyperplasia was observed in most exposed groups, although this was not statistically significant (noted in text; P-value for trend not presented in NTP table).



See also
http://www.bioinitiative.org/report/ wp-content/uploads/2017/11/Hardell-2017-Sec11-Update-Use_ of_Wireless_Phones.pdf.

Evaluation:

Based on human epidemiological studies supported by the NTP animal study, there is clear evidence that RF radiation causes glioma in humans. There is also evidence of an increased glioma risk in occupational studies on exposure to EMF (52-54).

Meningioma:

Human Studies: Meningioma is an encapsulated well-demarked and rarely malignant tumor. It is the most common non-malignant brain tumor that accounts for approximately 30% of intracranial neoplasms. It develops from the pia and arachnoid membranes that cover the CNS. It is slow-growing and presents neurological symptoms by the compression of adjacent structures. Most common are headaches and seizures. The incidence is greater than two-fold higher in women than in men and meningioma develops mostly among middle-aged and older individuals (55). The same research groups as for glioma also included meningioma in their case-control studies with a separate publication on meningioma by Carlberg and Hardell (56). The results of the meta-analyses for cumulative exposure in highest exposure category are presented in Table II. A statistically significant increased risk was obtained for ipsilateral mobile phone use with OR =1.49, 95% CI =1.08-2.06.

NTP study:

No increased incidence of meningioma was reported in rats or mice (19,20).

Granular cell tumors (GCTs):

Human Studies: GCTs are uncommon tumors. They are believed to be of neuronal origin (57). They are soft tissue tumors, which are thought to be derived from Schwann cells (58). The immunoprofile of granular cell tumors has revealed nerve sheath differentiation, lending support to their neuronal origin (59). GCTs can affect any organ in the body, although approximately 50% are found in the head and neck region (60). In our case-control studies on brain tumors, all diagnoses were based on a histopathological examination; no one was diagnosed with a granular cell tumor (42-46).

NTP study:

In the rat study (19), increased incidence of malignant or non-malignant granular cell tumors in the meninges, likely derived from Schwann cells, occurred in the males exposed to GSM-modulated cell phone RF radiation for two years. This was not statistically significant (P-value for trend =0.343). In female rats, granular cell tumors, either malignant or non-malignant were not associated with RF radiation (P-value for trend =0.594). Since GCT is neuronal in origin, the NTP study findings in male rats add to the evidence that exposure to RF radiation damage nerve sheaths.

Evaluation:

Based on human epidemiological studies and the NTP animal study, there is equivocal evidence that RF radiation causes meningeal tumors in humans (may be related to exposure).

Rate/incidence of brain tumors:

The Swedish Cancer Register has not shown increasing incidence of brain tumors in a study for the time period between 1979-2008, and has been used to dismissing epidemiological evidence on risk associated with use of wireless phones (61). We have previously demonstrated that descriptive studies cannot be used to dismiss results in analytical epidemiology with individual exposure histories, such as in case-control studies. We have also published the deficiencies in the reporting of brain tumors to the Swedish Cancer Register (62). The results for more recent time periods have now been published. These articles also discuss results from studies in other countries.

We used the Swedish National Inpatient Register (IPR) and Causes of Death Register (CDR) to study the incidence of brain tumors comparing with the Swedish Cancer Register data for the time period between 1998-2013 using joinpoint regression analysis (62). In the IPR, we found a joinpoint in 2007 with Annual Percentage Change (APC) +4.25%, 95% CI +1.98, +6.57% during the period between 2007-2013 for tumors of unknown type in the brain or CNS. Fig. 1 shows time trends in IPR for brain tumors of unknown type (D43), red line, and mobile phone communication; number of out-going mobile phone minutes in millions per year (blue line). The figure shows increasing rates of brain tumors with some latency in relation to the increasing use of mobile phones. In the CDR joinpoint regression, we found one joinpoint in 2008 with APC during the period between 2008-2013, +22.60%, 95% CI +9.68, +37.03%. These tumor diagnoses would be based on clinical examination, mainly CT and/or MRI, but without histopathology or cytology. No statistically significant increasing incidence was found in the Swedish Cancer Register during these years. We postulated that a large part of brain tumors of unknown type are never reported in the Cancer Register. Furthermore, the frequency of diagnoses based on autopsy has declined substantially due to a general decline of autopsies in Sweden, further adding to missing cases. We concluded that the Swedish Cancer Register is not reliable to be used to dismiss results in epidemiological studies on the use of wireless phones and brain tumor risk.

In Fig. 2, we present the rates per 100,000 of deaths in unknown type of brain tumor (D43), red line, and number of out-going mobile phone minutes in millions (blue line) during the period between 1999-2013. We postulate that the increasing rate of patients deceased with brain tumor may be associated with the increasing use of mobile phones.

Table III. Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for acoustic neuroma in case-control studies in the highest category of cumulative use in hours for mobile phone use.

	All			Ipsilateral		
Study (ref.)	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone, 2011 (65)						
Cumulative use ≥1,640 h	77/107	1.32	0.88-1.97	47/46	2.33	1.23-4.40
Hardell *et al*, 2013 (66)						
Cumulative use ≥1,640 h	27/301	2.40	1.39-4.16	19/133	3.18	1.65-6.12
Meta-analysis (65,66)						
Cumulative use ≥1,640 h	104/408	1.73	0.96-3.09	66/179	2.71	1.72-4.28

In an updated further analysis, we used the Swedish IPR to analyze rates of brain tumors of unknown type (D43) during the period between 1998-2015 in different age groups (63). The Average Annual Percentage Change (AAPC) per 100,000 increased with +2.06%, 95% CI +1.27, +2.86% in both sexes combined. A joinpoint was found in 2007 with APC 1998-2007 of +0.16%, 95% CI -0.94, +1.28%, and 2007-2015 of +4.24%, 95% CI +2.87, +5.63%. The highest AAPC was found in the age group of 20-39 years.

In the Swedish Cancer Register, the age-standardized incidence rate per 100,000 increased for brain tumors, ICD-code 193.0, during 1998-2015 with AAPC in men +0.49%, 95% CI +0.05, +0.94%, and in women +0.33%, 95% CI -0.29, +0.45% (63). The cases with brain tumor of unknown type lack morphological examination. Brain tumor diagnoses in the Cancer Register were based on cytology/histopathology in 83% for men and in 87% for women in 1980. This frequency increased to 90% in men and 88% in women in 2015. During the same time period, CT and MRI imaging techniques were introduced and morphology is not always necessary for diagnosis. If all brain tumors based on clinical diagnosis with CT or MRI had been reported to the Cancer Register the frequency of diagnoses based on cytology/histology would have decreased in the register. The results indicate underreporting of brain tumor cases to the Cancer Register. The real incidence would be higher. Thus, incidence trends based on the Cancer Register should be used with caution. Our results support mobile and cordless phones as risk factors for brain tumors with a reasonable latency period.

Fig. 3 shows joinpoint regression analyses of age-standardized incidence rates per 100,000 in men aged 60-79 years with astrocytoma grade III or IV in the Swedish Cancer Register during the period between 1998-2015, and Fig. 4 shows results in women (63).

Interestingly, a recent study demonstrated a similar increase in glioblastoma multiforme in England as in Sweden (64), '*We report a sustained and highly statistically significant ASR [age-standardized incidence rates] rise in glioblastoma multiforme (GBM) across all ages. The ASR for GBM more than doubled from 2.4 to 5.0, with annual case numbers rising from 983 to 2531. Overall, this rise is mostly hidden in the overall data by a reduced incidence of lower-grade tumours.*'

Evaluation:

Increasing rates/incidences of brain tumors in Sweden, a country with among the earliest use of wireless phones in the world, have been published. Similar findings have been reported from other countries, see above and reviewed by us (62). The results have strengthened the evidence that RF radiation causes brain tumors in humans.

Acoustic neuroma (vestibular schwannoma):

Human Studie: Acoustic neuroma, also known as vestibular schwannoma, is a non-malignant tumor located on the eight cranial nerve from the inner ear to the brain. It is usually encapsulated and grows in relation to the auditory and vestibular portions of the nerve. It grows slowly and due to the narrow anatomical space, may lead to the compression of vital brain stem structures. The first symptoms of acoustic neuroma are usually tinnitus and hearing problems. The results for the use of mobile phones in the Interphone (65) and Hardell et al (66) studies are presented in Table III. A statistically significant increased risk was found for cumulative ipsilateral use >1,640 h yielding an OR of 2.71, 95% CI of 1.72-4.28.

The study by Moon et al (67) was not included in the meta-analysis, since the data on cumulative mobile phone use with numbers of cases and controls were not given. Support of an increased risk was found in the case-case part of the study (67), as also reported by Sato et al (68) in their case-case analysis. Pettersson et al made a case-control study on acoustic neuroma in Sweden not overlapping our study (69). An increased risk for the highest category of cumulative use of both mobile phone (≥680 h OR =1.46, 95% CI =0.98-2.17) and cordless phone (≥900 h OR =1.67, 95% CI =1.13-2.49) was found. We did not include that study in our meta-analysis due to the many scientific shortcomings in the study, e.g., laterality analysis was not made for cordless phone and the numbers in the laterality analysis for mobile phone are not consistent in text and tables and obviously not correct, and the 'unexposed' reference category included subjects using either mobile or cordless phone (70).

The Danish part of the Interphone study reported a mean tumor volume of 1.66 cm3 among regular mobile phone users and 1.39 cm3 for non-users (P=0.03) (71). We analyzed the percentage change in tumor volume per year of latency and 100 hours of cumulative use (66). For all types of wireless phones, the percentage of tumor volume increased, and was statistically significant for analogue mobile phones per year of latency (P=0.02) and per 100 h of cumulative use (P=0.01). Moon et al (67) reported a statistically significant larger mean tumor volume for heavy users (11.32±15.43 cm3) compared with light users (4.88±5.60 cm3) based on the daily amount of mobile phone use (P=0.026). Similar results were found for cumulative hours of use. Taken together, these results support tumor promotion by RF radiation.

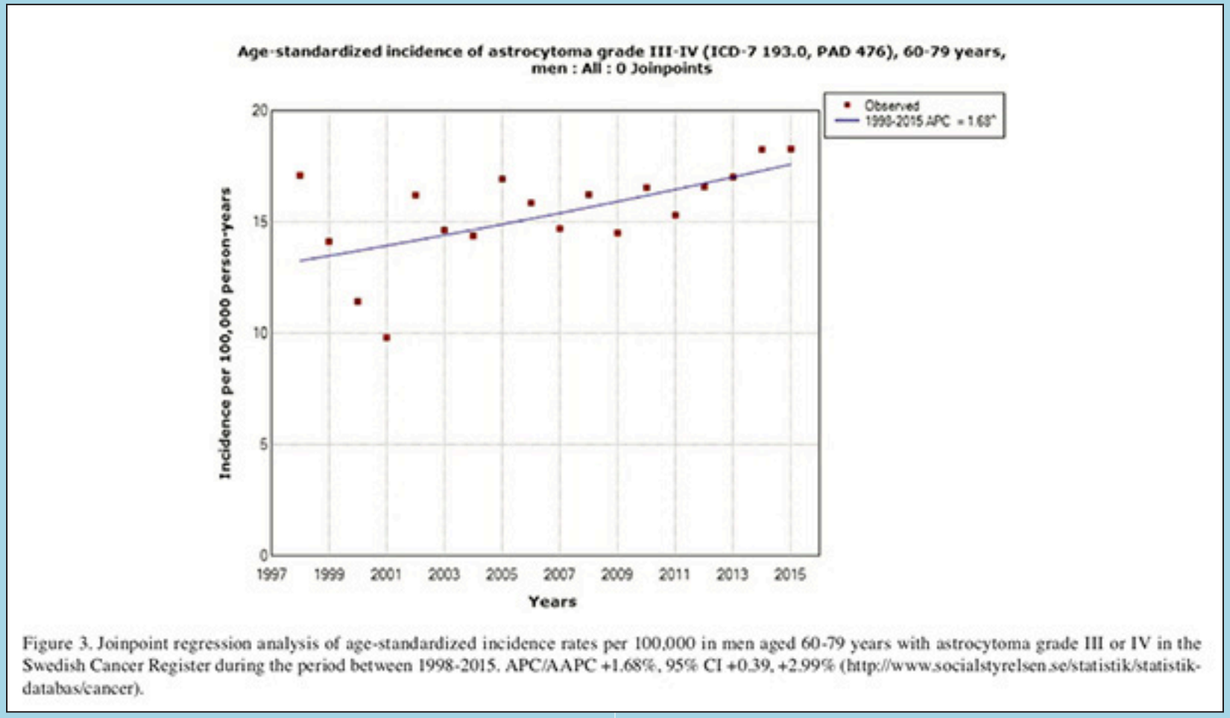


Figure 3. Joinpoint regression analysis of age-standardized incidence rates per 100,000 in men aged 60-79 years with astrocytoma grade III or IV in the Swedish Cancer Register during the period between 1998-2015. APC/AAPC +1.68%, 95% CI +0.39, +2.99% (http://www.socialstyrelsen.se/statistik/statistikdatabas/cancer).

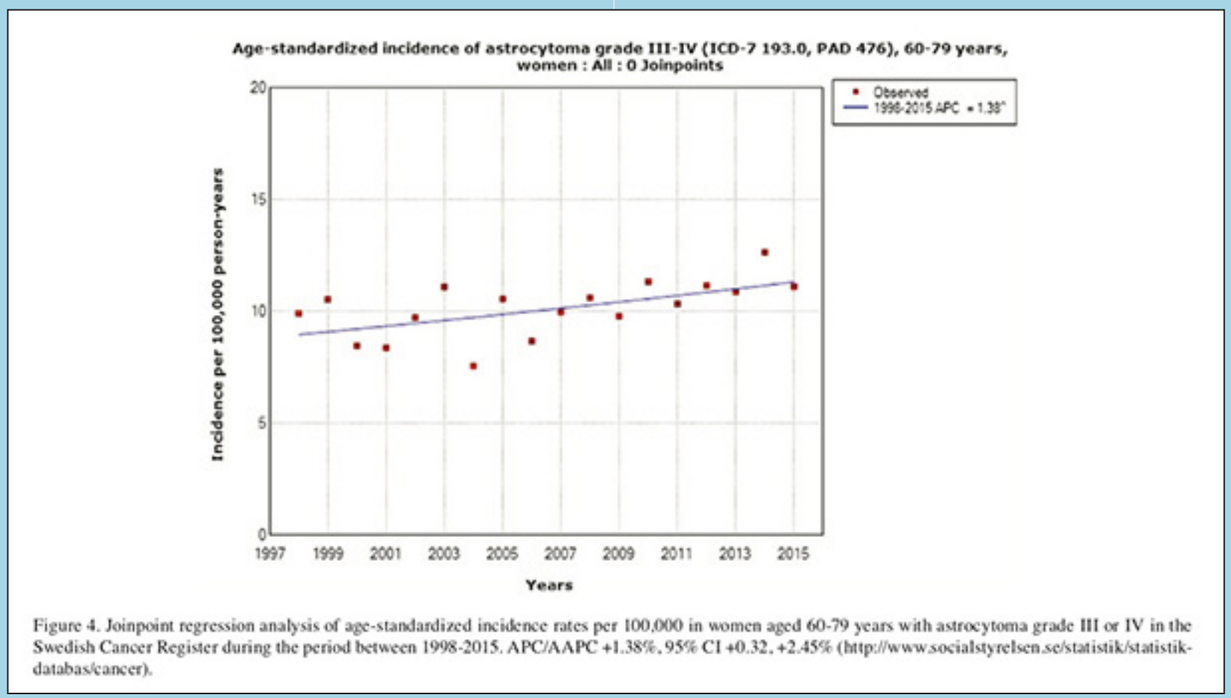


Figure 4. Joinpoint regression analysis of age-standardized incidence rates per 100,000 in women aged 60-79 years with astrocytoma grade III or IV in the Swedish Cancer Register during the period between 1998-2015. APC/AAPC +1.38%, 95% CI +0.32, +2.45% (http://www.socialstyrelsen.se/statistik/statistikdatabas/cancer).

NTP study:

No malignant schwannoma was reported in the mouse study (20).

In the rat study (19), there was a statistically significant increased incidence of malignant schwannoma in the heart of males exposed to GSM modulated cell phone RF radiation for 2 years; P-value for trend =0.041. The tumor was found in all exposure categories for male rats, whereas no malignant schwannoma was found in the sham controls. Endocardial hyperplastic Schwann cell lesions, that are preneoplastic, were found in one 1.5 W/kg and in two 6 W/kg males, but not in the sham control. A statistically significant trend was found in CDMA-modulated exposed males, P=0.011. Two female rats were diagnosed with malignant schwannoma in the heart in the 3 W/kg group, but no malignant schwannomas were found in the two other exposure groups or in the sham control, P-value for trend =0.640.

Evaluation:

Based on human epidemiological studies and the NTP animal study, there is clear evidence that RF radiation causes vestibular schwannoma (acoustic neuroma) in humans.

Pituitary Tumors:

Human Studies: In a case-control study from Japan, no statistically significant increased risks were found for the use of mobile phone (72). A somewhat increased risk was found in the highest cumulative call time in hours, OR =1.33, 95% CI =0.58-3.09. The cases were aged

30-69 years and diagnosed during the period between 2000-2004.

In a UK case-control study with patients diagnosed during the period between 2001-2005, overall no statistically significant increased risks were found (73). In the group with ≥10 years of use a somewhat increased risk was found for analog mobile phone use: OR =1.2, 95% CI =0.6-2.4, and digital mobile phone use with OR =2.5, 95% CI =0.7-9.1.

In a case-control study from China with cases diagnosed between 2006-2010, mobile phone use yielded an increased risk for pituitary tumor: OR =7.6, 95% CI =2.6-21.4 and a duration of use yielded OR =8.5, 95% CI =2.8-24.4 (74). However, no more data were provided.

The incidence of pituitary tumors increased during the time period between 2004-2009 in the USA (75). The incidence is increasing in Sweden, particularly since 2000, as shown in Fig. 5. There seems to be a decrease during the latest year, but this may be explained by a time lag in the reporting to the Swedish Cancer Register.

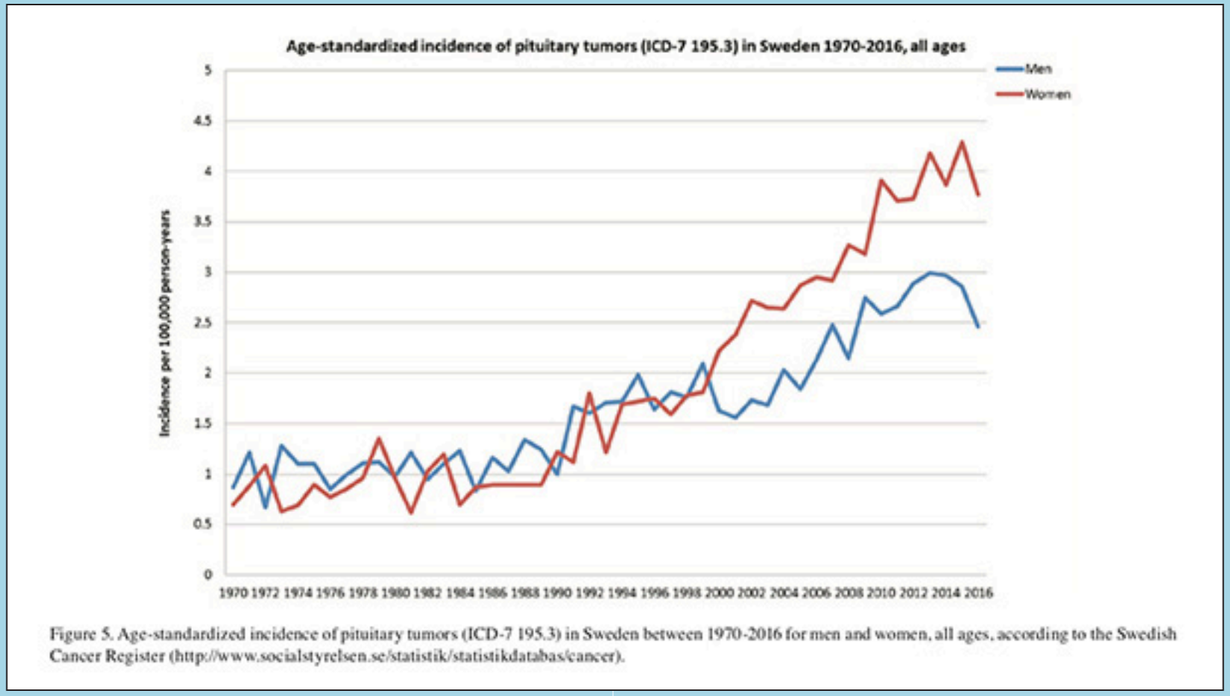


Figure 5. Age-standardized incidence of pituitary tumors (ICD-7 195.3) in Sweden between 1970-2016 for men and women, all ages, according to the Swedish Cancer Register (http://www.socialstyrelsen.se/statistik/statistikdatabas/cancer).

NTP study:

In male mice (20) exposed to CDMA-modulated RF radiation for two years, two adenoma and one carcinoma occurred in the pars distalis of the pituitary gland. No carcinoma or adenoma occurred in the sham control or the other two exposure groups. No increased incidence was found in female mice.

In male rats exposed to GSM-modulated cell phone RF radiation for two years (19), an increased incidence of pituitary adenoma was found in all exposed groups, although no statistically significance was found (P-value for trend =0.301). In females, the incidence of adenoma in 1.5 and 6 W/kg was statistically significantly decreased (1.5 W/kg P=0.049; 6 W/kg P=0.038).

In male rats exposed to CDMA-modulated RF radiation for two years, an increased incidence of pituitary adenoma was found in the 1.5 W/kg (P=0.208) and 3 W/kg (P=0.030). In females there was a statistically significantly decreased incidence of adenoma or carcinoma in the 3 W/kg group (P = 0. 0 3 0).

Evaluation:

Based on human epidemiological studies and the NTP animal study, there is equivocal evidence that RF radiation causes pituitary tumors in humans (may be related to exposure).

Thyroid Cancer:

Human Studies: The incidence of thyroid cancer is increasing in many countries, particularly the papillary type that is the most radiosensitive type. We used the Swedish Cancer Register to study the incidence of thyroid cancer during the period between 1970-2013 using joinpoint regression analysis (31). In women, the incidence increased statistically significantly during the whole study period; AAPC +1.19% (95% CI +0.56, +1.83%). Two joinpoints were detected, 1979 and 2001, with a high increase of the incidence during the last period between 2001-2013 with an APC of +5.34% (95% CI +3.93, +6.77%).

In the age group of 20-39 years, joinpoint regression analysis of age-standardized incidence of thyroid cancer in women, aged 20-39 years, APC increased with +10.77% (95% CI +5.75, +16.04%) during the time period between 2006-2013 (Fig. 6).

Analyses based on data from the Cancer Register indicated that the increasing trend in Sweden was mainly caused by thyroid cancer of the papillary type. The incidence increased statistically significantly in women with an AAPC of +4.38% (95% CI +2.95, +5.84%) during the period between 1993-2013 (Fig. 7). One joinpoint was detected in 2006; 1993-2006 APC +1.69% (95% CI +0.32, +3.08%), 2006-2013 APC +9.58% (95% CI +5.85, +13.44%). The incidence of papillary cancer increased in men during the period between 1993-2013 with an AAPC of +3.95% (95% CI +2.20, +5.73%).

AAPC for thyroid cancer in all men during the period between 1970-2013 was +0.77% (95% CI -0.03, +1.58%). One joinpoint was detected in 2005 with a statistically significant increase in incidence during the period between 2005-2013; APC +7.56% (95% CI +3.34, +11.96%). Based on the NORDCAN data, there was a statistically significant increase in the incidence of thyroid cancer in the Nordic countries during the same time period. In both women and men a joinpoint was detected in 2006. The incidence increased during 2006-2013 in women; APC +6.16% (95% CI +3.94, +8.42%) and in men; APC +6.84% (95% CI +3.69, +10.08%), thus showing similar results as in the Swedish Cancer Register (31).

We postulate that the whole increase cannot be attributed to better diagnostic procedures. In Fig. 8 data from the Nordic countries are shown on number of out-going mobile phone minutes during the period between 2001-2013 and the incidence of thyroid cancer in men (green line) and in women (red line). Clearly, with a lag time of some years after the increasing number of out-going calls, the thyroid cancer incidence is increasing.

Increasing exposure to ionizing radiation, e.g., medical CT scans [and others], and to RF radiation should be further studied as causative factors to this emerging thyroid cancer health problem.

Fig. 9 presents three developments in the antenna design in mobile phones that may be of relevance

in thyroid carcinogenesis. The second generation (2G) mobile phones appeared in the 1990s with the external retractable monopole or helical antennas. The 2G GSM band operated at a 800/900 MHz frequency band, later accompanied by a 1,800 MHz band. Around the turn of the millennium, the external antennas began to disappear, replaced with new phone models with internal planar or microstrip antennas. The first internal antenna was introduced in 1998 and the first dual-band mobile phone, with the internal antenna, was introduced on the market in 1999 (76). The internal antennas were positioned at the top of the telephone. With the emergence of the smartphones in the mid- and late 2000s, the internal antenna location started to shift from the top of the phone to the bottom. Currently, the majority of smartphone models have their antenna positioned at the bottom of the phone, thus closer to the thyroid gland (shown by grey color in Fig. 9). This would have a major impact on increasing radiation to the thyroid gland from smartphones.

Some published laboratory studies are of interest, Radiofrequency radiation at 2.45 GHz at a non-thermal level modified the morphology of the thyroid gland in a study on rats. The central and peripheral follicles presented increased in size and the thickness of peripheral septa decreased. Peripheral follicles increased in size with repeated exposure at 3 W power (77).

In another study on rats, whole body exposure to 900 MHz pulse-modulated RF radiation that was similar to that emitted by the global system for mobile communications (GSM) mobile phones caused pathological changes in the thyroid gland. The gland structure was altered and caspase-dependent pathways of apoptosis were enhanced (78).

NTP study:

In mice (20) no increased incidence was reported.

In female rats (19) a statistically significant increased incidence of C-cell hyperplasia was found in the two years of GSM-exposed groups (1.5, 3 and 6 W/kg, respectively). In males, a statistically non-significant increased incidence was observed in the 1.5 W/kg exposure group (noted in text; P-value not given in NTP table).

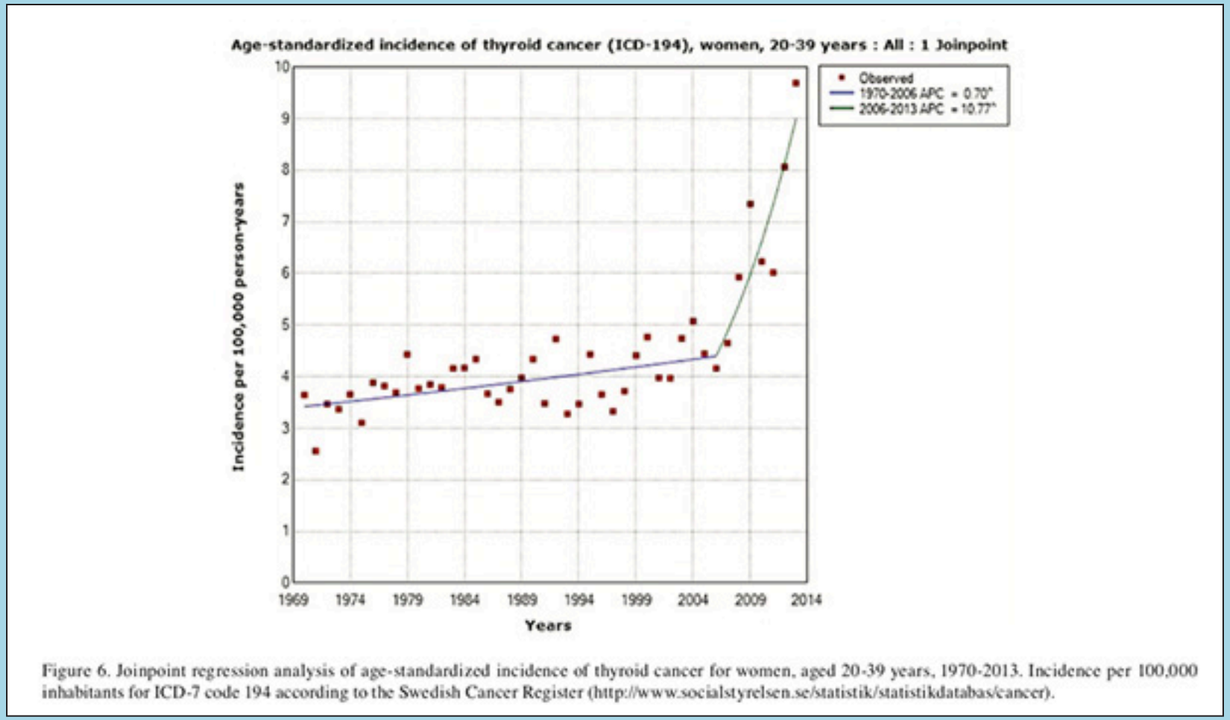


Figure 6. Joinpoint regression analysis of age-standardized incidence of thyroid cancer for women, aged 20-39 years, 1970-2013. Incidence per 100,000 inhabitants for ICD-7 code 194 according to the Swedish Cancer Register (http://www.socialstyrelsen.se/statistik/statistikdatabas/cancer).

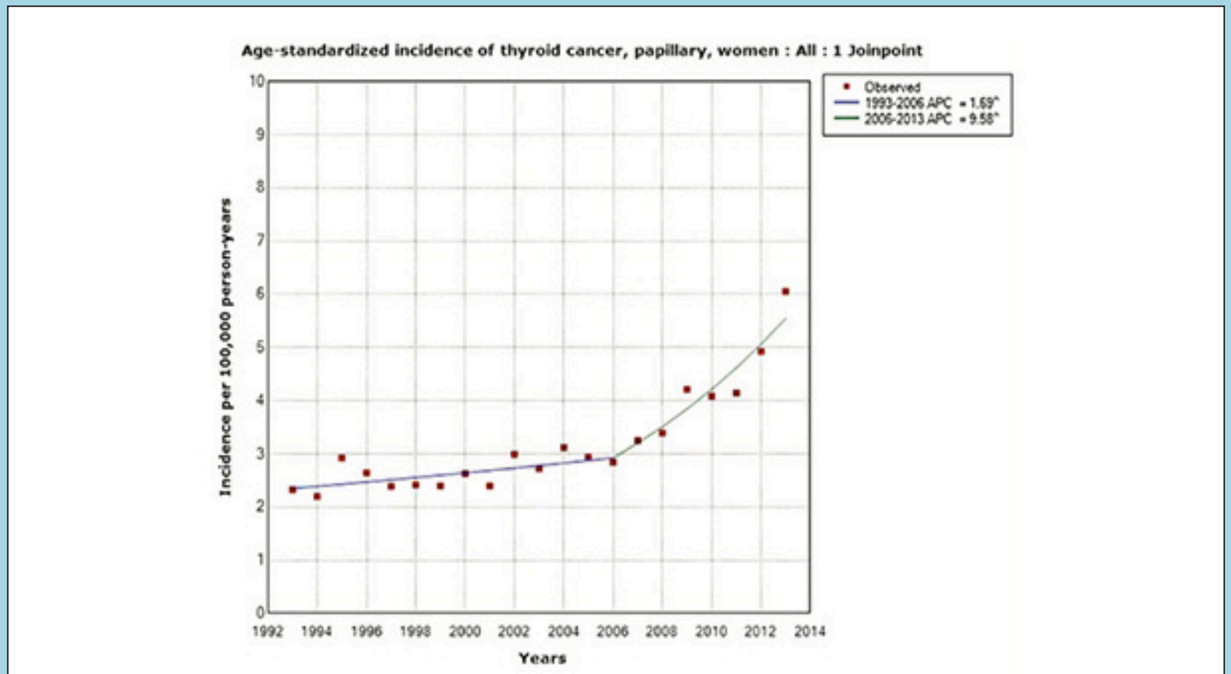


Figure 7. Joinpoint regression analysis of age-standardized incidence of papillary thyroid cancer for women, all ages, 1993-2013. Incidence per 100,000 inhabitants for ICD-7 code 194; data obtained from the Swedish Cancer Register.

Evaluation:

C-cell hyperplasia as a precursor to familial medullary thyroid cancer in humans is well established. C-cell hyperplasia may be a precursor to other types of thyroid cancer but its role is not well established. Based on human cancer statistics and the NTP animal study, there is some evidence that thyroid cancer is caused by RF radiation in humans.

Malignant Lymphoma The use of cellular or cordless telephones:

As regards T-cell NHL and the >5 year latency period, the use of analogue cellular phones yielded: OR =1.46, 95% CI =0.58 -3.70; digital: OR =1.92, 95% CI =0.77-4.80; and cordless phones: OR =2.47; 95% CI =1.09-5.60. The corresponding results for certain lymphoma, e.g., of the cutaneous and leukemia types, were for analogue phones: OR =3.41, 95% CI =0.78-15.0; digital: OR =6.12, 95% CI =1.26-29.7; and cordless phones: OR =5.48, 95% CI =1.26-23.9. The results indicate an association between T-cell NHL and the use of cellular and cordless telephones; however, the study was based on low numbers and must be interpreted with caution. As regards B-cell NHL, no association was found.

Human Studies: Few studies exist on malignant lymphoma and exposure to RF radiation. In a case-control study male and female subjects aged 18-74 years living in Sweden were included during a period from December 1, 1999 to April 30, 2002 (27). Controls were selected from the national population registry. Exposure to different agents was assessed by a questionnaire. In total, 910 (91%) cases and 1,016 (92%) controls participated. NHL of the B-cell type was not associated

RF radiation. A case-control study in USA used a questionnaire to assess cellular telephone use in 551 NHL cases and 462 frequency-matched population controls (28). Compared to persons who had never used cellular telephones, risks were not increased among individuals whose lifetime use was >100 times (e.g., regular users, OR =0.9, 95% CI =0.6-1.4). Among regular users compared to those who had never used hand-held cellular telephones, risks of NHL were not statistically significantly associated with minutes per week, duration, cumulative lifetime or year of first use, although NHL was non-significantly higher in men who used cellular telephones for >8 years; OR =2.4, 95% CI =0.8-7.0. NHL not otherwise specified was statistically significantly increased in men for mobile phone use among subjects with ≥6 years duration, OR =4.4, 95% CI =1.3-14.6. There was little evidence to link the use of cellular telephones with total, diffuse large B-cell lymphoma or follicular NHL. No results were presented for T-cell lymphoma.

In the USA, primary central nervous system lymphoma (PCNSL) rates in immunocompetent men and women aged 65+ years increased statistically significantly (1.7 and 1.6% per year, respectively), but remained stable in other age groups during the period between 1992-2011 (79). Thus, the increasing rates could not be related to HIV or immune suppression in organ transplant patients.

In Sweden, the increasing incidence of PCNSL was reported for the time period between 2000-2013 in immunocompetent persons (80). With 359 identified PCNSL cases (median age, 66 years), the overall incidence was 0.26 (95% CI =0.24-0.29) per 100,000 person-years and the average annual increase 4% (P=0.002). The increasing trend was primarily observed among elderly individuals (70+ years). Similarly, an increase in incidence of all brain tumors was noted only among the elderly. No etiological factor has clearly been defined to explain the increasing incidence of brain lymphoma. However, it has occurred during a time period when RF radiation to the brain from wireless phones has increased.

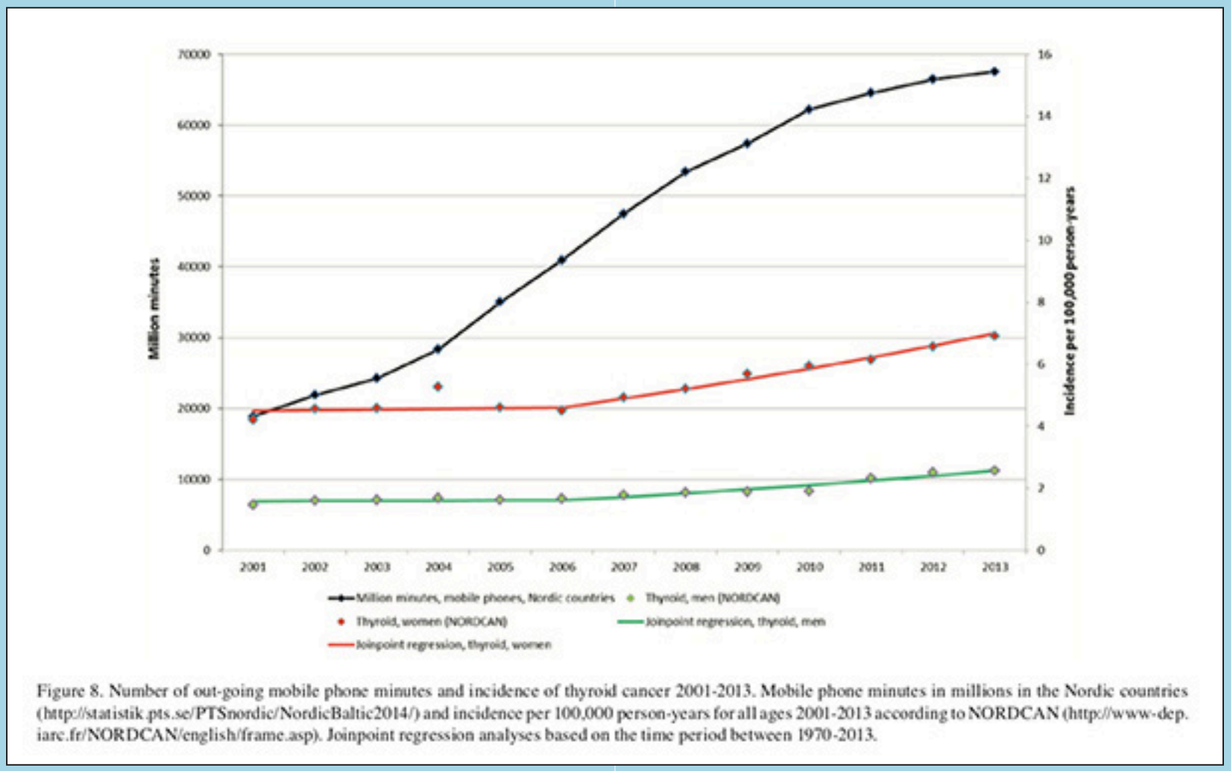


Figure 8. Number of out-going mobile phone minutes and incidence of thyroid cancer 2001-2013. Mobile phone minutes in millions in the Nordic countries (http://statistik.pts.se/PTSnordic/NordicBaltic2014/) and incidence per 100,000 person-years for all ages 2001-2013 according to NORDCAN (http://www-dep.iarc.fr/NORDCAN/english/frame.asp). Joinpoint regression analyses based on the time period between 1970-2013.

It should be noted that in transgenic mice, an increased incidence of lymphoma exposed to 900 MHz GSM RF radiation was reported; P=0.006 versus the sham group (25). No increased risk of malignant lymphoma was found in mice exposed to GSM 900 MHz in another study (26). However, the incidence in the sham exposed group was higher in the study by Utteridge et al (26) compared with the study by Repacholi et al (25) which might have influenced the results.

NTP study:

In female mice exposed to GSM-modulated cell phone RF radiation for two years, there were increased incidences of malignant lymphoma in all exposed groups compared to the controls (20). The increase was statistically significant in the 2.5 W/kg (P=0.004) and 5 W/kg groups (P=0.035). In the CDMA-modulated cell phone RF radiation for two years, the incidence increased in female mice in all exposed groups compared to the controls, and was statistically significant in the 2.5 W/kg group (P=0.035).

No conclusive evidence of increased incidence of malignant lymphoma was reported in female rats (19); P-value for trend =0.537 for GSM-modulated cell phone RF radiation and P-value for trend =0.339 for CDMA-modulated cell phone RF radiation.

Evaluation:

Based on human epidemiological studies and the NTP study, there is equivocal evidence that malignant lymphoma is caused by RF radiation in humans (may be related to exposure).

Skin (cutaneous tissue):

Human Studies: Few studies exist on RF radiation and the risk of developing skin tumors. In a Danish cohort on mobile phone subscribers from the period between 1987-1995 followed to 2007, no increased risks of skin cancer were observed (81). The same cohort has also been used for studying brain tumor risk. Due to serious methodological problems, including the misclassification of exposure the study has been evaluated to be uninformative (8,37).

In a Swedish study on cutaneous malignant melanoma diagnosed during the period between 2000-2003, no increased risk was observed overall (82). In the shortest latency period of >1-5 years and highest cumulative use of >365 h, wireless phone use (mobile phone and/or cordless phone) yielded OR =1.6, 95% CI =0.96-2.9. For melanoma in the most exposed anatomical area during use of the handheld phone, temporal, ear, cheek, the risk increased to OR =2.1, 95% CI =1.1-3.8. The risk was overall highest for cases with first use of a wireless phone before 20 years of age, OR =2.7, 95% CI =0.6-12, although based on low numbers. No interaction was observed with known risk factors for malignant melanoma, such as hair and eye color, skin type or sunburns as a teenager.

Fig. 10 displays the rapidly increasing incidence of malignant melanoma in Sweden in both sexes. The increase is most marked from early 2000.

NTP study:

The incidences of malignant fibrous histiocytoma in the skin were higher in 5 and 10 W/kg male mice

exposed to GSM-modulated cell phone RF radiation for two years (20). The results were not statistically significant (5 W/kg P= 0.124; 10 W/kg P= 0.321). The incidences of fibrosarcoma, sarcoma or malignant fibrous histiocytoma were higher in exposed male mice compared with sham control, although border-line significant, P-value for trend =0.093. No increased incidence was observed in female mice.

Male rats exposed to GSM-modulated cell phone RF radiation for two years (19) exhibited higher incidences of fibroma, fibrosarcoma, myxosarcoma, or malignant fibrous histiocytoma in the skin (subcutaneous tissue) in all exposed groups. The increased rates were not statistically significant (P-value for =0.428). No statistically significant results were found in female rats (P-value for trend =0.551).

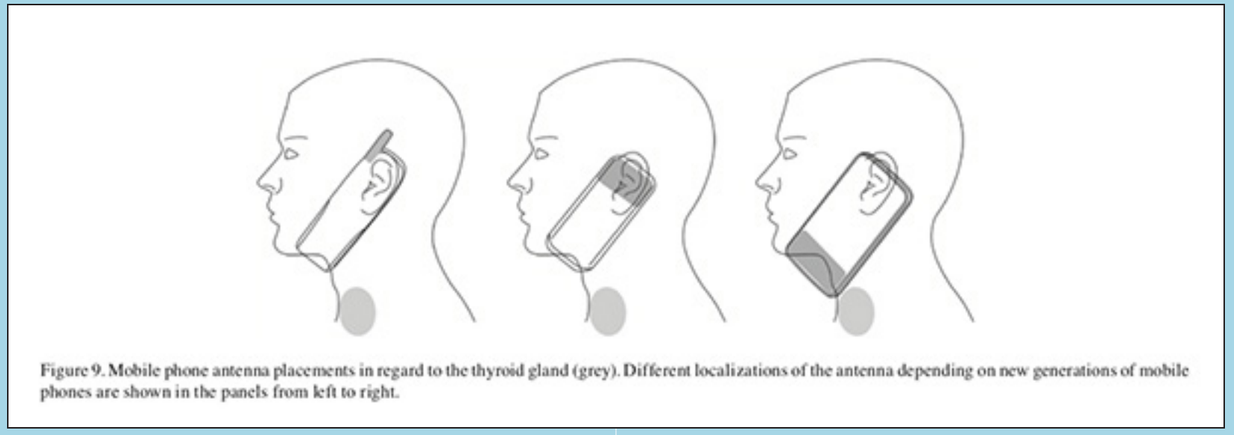


Figure 9. Mobile phone antenna placements in regard to the thyroid gland (grey). Different localizations of the antenna depending on new generations of mobile phones are shown in the panels from left to right.

Evaluation:

Based on human epidemiological studies and NTP animal studies there is equivocal evidence that RF radiation causes skin cancer in humans (may be related to exposure).

Concluding Remarks: Based on case-control studies, as discussed above, there is a consistent finding of an increased risk of developing glioma and acoustic neuroma associated with the use of mobile phones. Similar results are found for cordless phones in the Hardell group studies. These results are supported by the results of the NTP animal studies (19,20). Malignant vestibular schwannoma is a similar tumor type as acoustic neuroma, also known as vestibular schwannoma.

The findings are less consistent for meningioma although somewhat an increased risk was observed in the meta-analysis of ipsilateral mobile phone use. A longer follow-up time is necessary for this type of slow-growing tumor.

The results on glioma and acoustic neuroma are supported by results from other animal studies showing carcinogenic and/or tumor promoting effects from RF radiation (21-25,32-34). The NTP study showed genotoxicity of RF radiation in rats and mice exposed to RF radiation (83). That result supports previous findings of DNA strand breaks in rat brain cells exposed to RF radiation (84). One mechanism in carcinogenesis may be oxidative stress with the production of reactive oxygen species (ROS), as summarized by Yakymenko et al (85). This could be an indirect mechanism for the increased brain and head tumor risk since ROS may lead to DNA damage (86).

By now carcinogenicity has been shown in human epidemiological studies, which has been replicated in animal studies. Laboratory studies on RF radiation have shown increased ROS production that can cause DNA damage. In 2013, we published the conclusion that RF radiation should be regarded as a human carcinogen, Group 1 according to the IARC definition, fulfilling Bradford Hill causality criteria (87). This was further supported in our updated article (6). That conclusion is reinforced by the current evaluation. The evidence that RF radiation exposure is a risk factor for cancer is particularly worrying, taking the present deployment of the fifth generation (5G) for wireless communication. More than 200 scientists and medical doctors have asked for a moratorium until studies have been performed by independent researchers on hazards to human health and the environment (88). These millimeter waves have primarily effects on the skin and eye (89). Sweat ducts in the skin may act as helical antennas and boost RF radiation exposure (90). These findings are worrying, taking the present evaluation that present RF radiation may increase the risk of developing skin cancer.

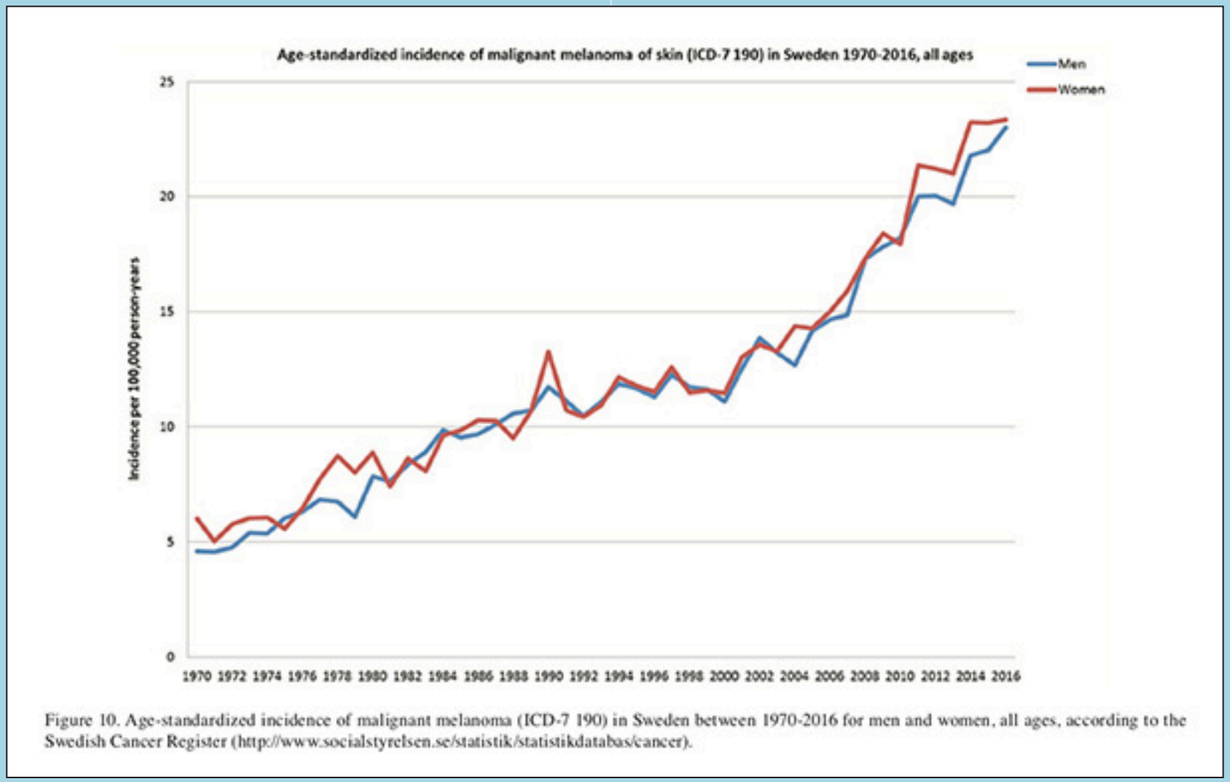


Figure 10. Age-standardized incidence of malignant melanoma (ICD-7 190) in Sweden between 1970-2016 for men and women, all ages, according to the Swedish Cancer Register (http://www.socialstyrelsen.se/statistik/statistikdatabas/cancer).

Discussion:

The NTP report uses five categories for the evaluation of RF radiation carcinogenicity as follows:

Clear Evidence: Clear evidence of carcinogenic activity is demonstrated by studies that are interpreted as showing a dose-related i) increase of malignant neoplasms; ii) increase of a combination of malignant and benign neoplasms; or iii) marked increase of benign neoplasms if there is an indication from this or other studies of the ability of such tumors to progress to malignancy.

Some Evidence: Some evidence of carcinogenic activity is demonstrated by studies that are interpreted as showing a test agent-related increased incidence of neoplasms (malignant, benign, or combined) in which the strength of the response is less than that required for clear evidence.

Equivocal Evidence: Equivocal evidence of car-

cinogenic activity is demonstrated by studies that are interpreted as showing a marginal increase of neoplasms that may be test agent related.

No Evidence: No evidence of carcinogenic activity is demonstrated by studies that are interpreted as showing no test agent-related increases in malignant or benign neoplasms.

Inadequate Study: Inadequate evidence of carcinogenic activity is demonstrated by studies that, due to major qualitative or quantitative limitations, cannot be interpreted as valid for showing either the presence or absence of carcinogenic activity.

They conclude that *'ICNIRP considers that the NTP (2018a, b) and Falcioni et al (2018) studies do not provide a consistent, reliable and generalizable body of evidence that can be used as a basis for revising current human exposure guidelines.'* That conclusion is not based on scientific evidence, but is rather an ad hoc statement.

On March 26-28, 2018, a panel of 11 external scientific experts met to evaluate carcinogenicity of the NTP carcinogenicity studies (https://factor.niehs.nih.gov/2018/4/ feature/feature-2-cell-phone/index.htm). As shown in Table IV, the carcinogenicity was upgraded for seven tumor types and/or location. Thus for glioma the vote was 'some evidence' in male rats exposed to GSM or CDMA cell modulation. Evidence for heart Schwannoma was found in male rats and was equivocal in female rats, as shown in Table IV. Note that we have herein discussed carcinogenesis only for tumor types with human epidemiological data. It is of interest that animal data indicate also increased incidence for other tumor types and/or locations such as prostate gland, adrenal medulla, pancreas, liver and lung, see also: https://ntp.niehs.nih.gov/ntp/about_ntp/ trpanel/2018/march/actions20180328_508.pdf

A recent commentary discussed 'several unfounded criticisms about the design and results of the NTP study that have been promoted to minimize the utility of the experimental data on RFR for assessing human health risks. In contrast to those criticisms, an expert peer-review panel recently concluded that the NTP studies were well designed, and that the results demonstrated that both GSM- and CDMA-modulated RFR were carcinogenic to the heart (schwannomas) and brain (gliomas) of male rats.' (91).

In contrast to the NTP panel, ICNIRP has made its own evaluation (https://www.icnirp.org/cms/upload/publications/ICNIRPnote2018.pdf). They discuss mainly the Schwannoma findings and ignore glial tumors. ICNIRP does not recognize the pattern of increased risk for Schwannoma and glioma in both animal studies and human epidemiology on RF radiation. Our conclusion on RF radiation carcinogenicity is the following based on human epidemiology and supported by animal results in the NTP reports: Glioma, clear evidence; meningioma, equivocal evidence; vestibular schwannoma (acoustic neuroma), clear evidence; pituitary tumor (adenoma), equivocal evidence; thyroid cancer, some evidence; malignant lymphoma, equivocal evidence; skin (cutaneous tissue), equivocal evidence; multi-site carcinogen, clear evidence.

There is clear evidence that RF radiation causes cancer/tumor at multiple sites, primarily in the brain (glioma) and head (acoustic neuroma). There is also evidence of an increased risk of developing other tumor types. The results are similar in both the NTP studies (19,20) and

Table IV. National Toxicology Program (NTP) Cell Phone Radiation 2-Year Study Evaluation of Carcinogenicity of Cell Phone Radiation: NTP Draft Technical Reports (TR 595, TR 596) vs. Expert Panel Vote.[a]

				Evidence of carcinogenicity	
Animal	Sex	Cell phone modulation	Tumor types and/or location	NTP draft report	Expert panel (vote yes-no-abstention)
Rat	Male	GSMb	Heart: Schwannoma	Some evidence	Clear evidence (8-3)
Rat	Male	CDMAc	Heart: Schwannoma	Some evidence	Clear evidence (8-3)
Rat	Male	GSM	Brain: Glioma	Equivocal	Some evidence (7-4)
Rat	Male	CDMA	Brain: Glioma	Equivocal	Some evidence (6-4-1)
Rat	Male	GSM	Brain: Granular cell	Equivocal	Equivocal (11-0)
Rat	Male	GSM	Prostate gland	Equivocal	Equivocal (11-0)
Rat	Male	GSM	Pituitary gland	Equivocal	Equivocal (10-1)
Rat	Male	CDMA	Pituitary gland	Equivocal	Equivocal (11-0)
Rat	Male	GSM	Adrenal medulla	Equivocal	Some evidence (6-4-1)
Rat	Male	GSM	Pancreas	Equivocal	Equivocal (11-0)
Rat	Male	CDMA	Liver	Equivocal	Equivocal (11-0)
Rat	Female	GSM	Heart: Schwannoma	No evidence	Equivocal (9-2)
Rat	Female	CDMA	Heart: Schwannoma	No evidence	Equivocal (9-2)
Rat	Female	CDMA	Brain: Glioma	Equivocal	Equivocal (8-3) (4 voted earlier for 'some evidence')
Rat	Female	CDMA	Adrenal medulla	Equivocal	Equivocal (10-0-1)
Mouse	Male	GSM	Skin	Equivocal	Equivocal (8-3)
Mouse	Male	GSM	Lung	Equivocal	Equivocal (11-0)
Mouse	Male	CDMA	Liver	Equivocal	Equivocal (10-1)
Mouse	Female	GSM	Lymphoma	Equivocal	Equivocal (9-2)
Mouse	Female	CDMA	Lymphoma	Equivocal	Equivocal (11-0)

[a]Joel M. Moskowitz, School of Public Health, University of California, Berkeley, March 30, 2018 Electromagnetic Radiation Safety (https://www.saferemr.com/2018/01/national-toxicology-program-peer-public.html) with courtesy; [b]GSM, global system for mobile communications; [c]CDMA, code-division multiple access.

the Ramazzini Institute findings (34). Based on the IARC preamble to the monographs, RF radiation should be classified as Group 1: The agent is carcinogenic to humans.

'This category is used when there is sufficient evidence of carcinogenicity in humans. Exceptionally, an agent may be placed in this category when evidence of carcinogenicity in humans is less than sufficient but there is sufficient evidence of carcinogenicity in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity.'

(http://monographs. iarc.fr/ENG/Preamble/currentb6evalrationale0706.php)

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Why Children Absorb More Microwave Radiation Than Adults: The Consequences

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Abbreviations:
MRI, magnetic resonance imaging; MWR, microwave radiation;
CNS, central nervous system, FDTD, finite-difference, time-domain; GBM, glioblastoma multiforme (also called glioblastoma); cm, centimeter.

Keywords:
Tumors, Myelin, Carcinogen, Fetus, Children, Latency

Computer simulation using MRI scans of children is the only possible way to determine the microwave radiation (MWR) absorbed in specific tissues in children. Children absorb more MWR than adults because their brain tissues are more absorbent, their skulls are thinner and their relative size is smaller. MWR from wireless devices has been declared a possible human carcinogen. Children are at greater risk than adults when exposed to any carcinogen. Because the average latency time between first exposure and diagnosis of a tumor can be decades, tumors induced in children may not be diagnosed until well into adulthood. The fetus is particularly vulnerable to MWR. MWR exposure can result in degeneration of the protective myelin sheath that surrounds brain neurons. MWR-emitting toys are being sold for use by young infants and toddlers. Digital dementia has been reported in school age children. A case study has shown when cellphones are placed in teenage girls' bras multiple primary breast cancer develop beneath where the phones are placed. MWR exposure limits have remained unchanged for 19 years. All manufacturers of smartphones have warnings which describe the minimum distance at which phone must be kept away from users in order to not exceed the present legal limits for exposure to MWR. The exposure limit for laptop computers and tablets is set when devices are tested 20 cm away from the body. Belgium, France, India and other technologically sophisticated governments are passing laws and/or issuing warnings about children's use of wireless devices.

Children's Greater Absorption Of Non-Ionizing Microwave Radiation

There are multiple studies showing that children absorb more MWR than adults. In 1996 a study reported that the absorbed MWR penetrated proportionally deeper into the brain of children age 5 and 10 compared to adults' brains [2].

In 2008 Joe Wiart, a senior researcher for French telecom and Orange reported that the brain tissue of children absorbed about two times more MWR than adults' brain tissue [3].

A 2009 study reported the CNS absorption by children is "*significantly larger (~2×) because the RF [MWR] source is closer and skin and bone layers are thinner*", and "*bone marrow exposure strongly varies with age and is significantly larger for children (~10×)*" [4].

In 2010, Andreas Christ and team reported children's hippocampus and hypothalamus absorbs 1.6–3.1 times higher and the cerebellum absorbs 2.5 times higher MWR compared to adults'; children's bone marrow absorbs 10 times higher MWR radiation than in adults, and children's eyes absorb higher MWR than adults [5]. These calculations were based on porcine measurements taken from sacrificed animals.

Microwave Radiation Is A Class 2B (Possible) Carcinogen

After 30 experts from 14 countries reviewed the science, the World Health Organization's (WHO's) International Agency for Research on Cancer (IARC) declared that RF-EMF [MWR] is a Class 2B (possible) carcinogen [6]. It was a near unanimous declaration (one dissenter).

Including MWR, there are 285 agents listed by WHO's IARC as Class 2B carcinogens [7]. Exposures to almost all of these agents are regulated. Some of the commonly recognized agents are: carbon black, carbon tetrachloride, chloroform, DDT, lead, nickel, phenobarbital, styrene, diesel fuel, and gasoline.

Like these other Class 2B Carcinogens, should anyone, particularly children, be exposed to MWR?

Children Are At Increased Risk When Exposed To Carcinogens

Children are at greater risk from exposure to carcinogens than adults, and the younger the child, the higher the risk [8–10].

Exposure Limits

In 1996, the FCC adopted the IEEE 1991[11] standard with some details from the 1986 NCRP Report [12] as exposure limits in the United States. Nineteen years after the FCC exposure limits were published, based on documents published 24 and 29 years previously, the legal exposure limit has remained unchanged. Yet during these decades an enormous body of scientific studies was published reporting risk well below the legal exposure limit.

The Institute of Electrical and Electronic Engineers (IEEE) is an industry professional organization, as is the National Council on Radiation Protection (NCRP). Neither organization had medical or public health expertise.

In European countries and a few other countries, the exposure limits are based on the 1998 "*Guidelines*" of the International Commission for Non-Ionizing Radiation Protection (ICNIRP) [13]. These "*Guidelines*" were based on publications from 1984, 1987, 1991, and 1993 [page 494]. **That is the** "*Guidelines*" **were based on publications up to 31 years ago**, Similar to the IEEE and NCRP, ICNIRP is an organization without medical or public health expertise. ***It is accountable to no government and its funding sources are not transparent.***

The 19 Year Old IEEE And 17 Year Old ICNIRP Exposure Limits Are Based On A False Premise

The exposure limits are premised on an assumption that the only biological effect from MWR exposure is acute (short-term) heating sufficient to cause tissue damage. There is no consideration of the effects from chronic (long-term) exposures. There are many scientific papers that report biological impacts tied with non-thermal (no measurable temperature change) effects. Indeed, the 480-page IARC Monograph 102 that documents the science that led to the declaration that MWR is a Class 2B (possible) carcinogen is a virtual compendium of such papers [14].

FCC Compliance Requirements Do Not Comport With Current Testing Systems

The FCC requires "*For purposes of evaluating compliance with localized SAR guidelines, portable devices should be tested or evaluated based on normal operating positions or conditions*" [15]. But phones are not tested in pants or shirt pockets. As a result every cellphone manual has warnings that the phone should be kept at various distances from the body otherwise the human exposure limits can be exceeded [**No one pays attention to these warnings. They'e virtuallt impossible to adhere to when using a cell phone].**

Here Are Two Of Many Examples:

(1) The BlackBerry Torch 9800 Smart Phone warns, "*keep the BlackBerry device at least 0.98in. (25mm) from your body (including the abdomen of pregnant women and the lower abdomen of teenagers).*" "*Lower abdomen*" is an oblique reference to testicles and "*abdomen of pregnant women*" is an oblique reference to the fetus.

(2) The iPhone 5's manual is embedded within the phone: Users must go to "*Settings*," and scroll down to "*General,*" then scroll to the bottom to "*About,*" go to "*Legal,*" scroll down to "*RF [MWR] Exposure*" where it reads, "*To reduce exposure to RF energy, use a hands-free option, such as the built-in speakerphone, the supplied head- phones, or other similar accessories. Carry iPhone at least 10 mm away from your body to ensure exposure levels remain at or below the as-tested [exposure limit] levels.*" [You read that, right?]

There Is A 20 cm Distance Rule For Tablets And Laptop Computers

"*For purposes of these requirements mobile1 devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 cm is normally maintained between radiating structures and the body of the user or nearby persons*" [16].

Clearly, this 20 cm rule contradicts the "*normal operating position*" regulation in the description "*a separation distance of at least 20 cm is normally maintained.*" Indeed, "*laptop*" computer directly implies that it is to be placed on a lap which is not 20 cm distant from the user.

The growing use of tablets by young children in schools contradicts these normal tested conditions as well, as these children have shorter arms that do not allow them to hold devices 20 cm from their bodies.

Early Development

Here we present evidence of harmful effects from exposure to MWR during early developmental stages both in animals and in humans.

Fetal Exposures

A study from Yale University School of Medicine exposed mice in utero to MWR [18]. The study reported that these mice were hyperactive and had impaired memory "*due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex.*" During pregnancy the mice were irradiated by a cellphone positioned above each cage positioned over the feeding bottle at a distance of 4.5–22.3 cm from each mouse depending on the location of the mouse within the cage. Controls were under the same condition but the phone was not active. The observed effects were similar to attention deficit hyperactivity disorder (ADHD) in children.

A Turkish study reported on a 900 MHz in utero exposure of rats [19]. "*The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats ($p<0.01$). This suggests that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus.*"

A Chinese study investigated effects of MWR emitted by cellphones on rat CNS, in vitro (cortical neuronal cells) and in vivo (rat's brain) [20]. Neuronal cells had a significantly higher death rate at power densities of 0.05 mW/cm2 and above. In vivo results show increased apoptosis with DNA fragmentation.

Myelination

A myelin sheath covering neurons acts as an insulation of the electrical activity of neurons. In human embryos, the first layer develops from mid-gestation to 2 years of age and continues into adolescence [21]. Myelination of the brain is not complete until early adulthood.

There Are Two Studies With Reported Degeneration Of The Myelin Sheath After MWR Exposure:

A 1972 study from Poland reported myelin degeneration and glial cell proliferation in guinea pigs and rabbits from a 3 GHz exposure [22].

In 1977 Switzer & Mitchell reported a 2.45 GHz exposure in rats increased myelin degeneration in rat brains at 6 weeks after exposure. They concluded "*The results of our study and related investigations by others indicated that exposures to low-intensity MW irradiation can result both in transient and in long-term structural anomalies in CNS tissue and may result in various hematologic irregularities*" [23].

Breast Cancers Resulting From Placement Of Cellphones In Bras

A case study reported 4 women who placed cellphones in their bras. Two were diagnosed at age 21,

with one who had begun placing her cellphone in her bra at age 15. This resulted in multiple primary breast cancers immediately beneath where the cellphones were placed [29].

Parotid Gland Tumors

The parotid gland is a large salivary gland in the cheek immediately next to where a cellphone is held to the ear.

A Chinese study reported statistically significant increased risks of 10- to 30-fold [30]. With more than 10 years since first use of a cellphone, the risk of epithelial parotid gland cancer, OR = 10.631, CI = 5.306–21.300, p < 10−10 ; similarly the risk for mucoepidermoid carcinoma, OR = 20.72, CI = 9.379–45.821, p < 10−13 , and for average daily use of >3.5 h, OR = 30.255, CI = 10.799–90.456, p<10−10.

An Israeli Interphone study found significant risk of parotid gland tumors [31]. "*For ipsilateral use, the odds ratios in the highest category of cumulative number of calls and call time without use of hands-free devices were 1.58 (95% confidence interval: 1.11, 2.24) and 1.49 (95% confidence interval: 1.05, 2.13), respectively.*"

Another Israeli study showed that among the 3 salivary glands, the only increase was the parotid gland [32]. "***The total number of parotid gland cancers in Israel increased 4-fold from 1970 to 2006*** *. . . whereas two other salivary gland cancers remained stable.*" Fig. 1 illustrates the enormous increase in parotid gland tumors relative to other salivary gland tumors.

An Israeli reported "***[S]alivary gland cancer, which researchers suspect to be linked to cellphone use, was disproportionately common among young patients. One fifth of those patients were under 20***" [33].

Sperm Damage

Perhaps more than any other adverse health effect from exposure to MWR, damage to sperm is the most documented including in vitro, in vivo and human epidemiological studies.

A 2005 study with data collection from November 2002 to March 2004 examined the motility of sperm. "*The proportion of slow progressive motile sperm increased with increase of the duration of the daily transmission time p < 0.01*" [34].

A study of cellphone usage among men who attended an infertility clinic concluded, "***Use of cell phones decrease the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality***" [35].

A Japanese study reported "***This study has indicated significant decrease in sperm count*** *[p=0.004]* ***and motility*** *[p = 0.003] . . .* ***because of exposure to MP [Mobile Phone] emission, respectively***" [36].

An Australian study investigated how sperm cells are damaged by cellphone MWR. Its conclusions stated "***RF- EMR [Radio Frequency Electro Magnetic Radiation] in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and well-being of their offspring***" [37]. Professor Stanton A. Glantz is a Professor of Medicine at the University of California, San Francisco Medical School. He is also author of a renowned graduate level statistics textbook, Primer of Biostatistics, Seventh Edition [38]. Referring to the above four studies on sperm damage from MWR he concludes:

"***Taking all the information we have discussed on cell phones and sperm allows us to confidently conclude that exposure to cell phones adversely effects sperm.***"

A study of temperature controlled human sperm placed 3cm beneath a laptop computer connected to Wi-Fi for 4 h [39] reported, "***Donor sperm samples, mostly normo-zoospermic [normal sperm], exposed ex vivo during 4 h to a wireless internet-connected laptop showed a significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation.***" The study concluded "***Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility.***"

Tumor Latency Times

The average time between exposure to a carcinogen and the diagnosis of a resultant solid tumor is 3 or more decades. Brain tumors, like lung cancer and many other solid tumors have, on average, long latency times [8,40]. Therefore, it may be several decades before tumors induced by current MWR exposures in children are diagnosed. For example, the Israeli study showing brain tumor risk was inverse with age had long latency times [8]. In contrast the Aydin et al. study had relatively short latency times [24].

Discussion

Wireless Device Exposure Limit Certification:

The FCC has approved two processes to certify that a wireless device meets the required exposure limit:

(1) The computer simulation process, and

(2) The Specific Anthropomorphic Mannequin (SAM) process.

The computer simulation process is discussed above.

The SAM process is based on a plastic mannequin representing the top 10% largest U.S. military recruits in 1989. Any head smaller than SAM will absorb more MWR (~97% of the U.S. population) [17]. A liquid with the average adult absorption properties of the 40 tissues of the head is poured into a hole at the top of this head. A robotic arm with an electric field probe is positioned within the mannequin such that the location of the highest electric field is located within any one cubic centimeter volume.

A cellphone to be certified is clamped to either side of SAM (see Fig. 2). The electric fields values are used to calculate the maximum spatial peak Specific Absorption Rate (SAR) for any 1 g of tissue (equivalent to 1 cm3 volume). If the maximum SAR is at or below the U.S. exposure limit of 1.6 W/kg the phone is certified for sale without regard to the ±30% tolerance of the SAM certification process [41].

Cellphone Manual Warnings And 20 cm Distance Rule

In spite of an FCC regulation "*For purposes of evaluating compliance with localized SAR guidelines, portable devices should be tested or evaluated based on normal operating positions or conditions*" [15], this regulation is ignored by the FCC. Holding a cellphone at a defined distance from your body is not "*based on normal operating positions*"!

For laptop computers, tablets and similar devices, an exposure limit that begins at a distance of 20cm is not "*based on normal operating positions.*" Indeed the very term "*laptop*" computer defines the normal operating position, which when placed on the lap is not 20 cm distant.

Increasing Brain Cancer Incidence

There are studies showing an increased risk of brain cancer from wireless phone use. It is a current problem. The worst brain cancer, glioblastoma, has increased in the United States, and Denmark. Brain cancer incidence has increased in Australia in recent years. These results are based on brain cancer incidence from each country's cancer registries.

A United States study examined 3 cancer registries (Los Angeles County, California and SEER 122) [42]. It examined incidence rates between years 1992–2006 and reported the Average Percent Change (APC) during those years. "*RESULTS: Increased AAIRs [Age-Adjusted Incidence Rates] of frontal (APC +2.4–3.0%, p≤0.001) and temporal (APC +1.3–2.3%, p ≤ 0.027) lobe glioblastoma multiforme (GBM) tumors were observed across all registries . . . The AAIR of cerebellar GBMs increased according to CCR (APC +11.9%, p < 0.001).*"

The Danish Cancer Registry issued a press release that stated, "***The number of men who are diagnosed with the most malignant form of brain cancer (glioblastoma), has almost doubled over the past ten years***" [43].

The Australian study reported, "***an overall significant increase in primary malignant brain tumors was observed over the study period from 2000 to 2008*** *(APC, 3.9; 95%CI, 2.4–5.4),* ***particularly since 2004*** *(overall AAPC, 3.9; 95% CI, 2.6–5.2)*" [44].

Selling Toys For Infants And Toddlers

The iPad, tablets, laptop computers and cellphones are not children's toys. Within 20cm of the device, the exposure limit can be exceeded with iPads and laptop computers. Figs. 3–5 are examples of toys for sale (there are many more similar toys).

Digital Dementia

Digital dementia also referred to as FOMO (Fear Of Missing Out) is a real concern. A science publication's review article describes the problem in great depth [45]. An empirical study of the problem was published in 2013 [46].

Governmental Warnings

Many countries have issue warning about children's cellphone use. Some examples are:

Turkey 2013:
Governor Aksoy Huseyin, of the Samsun province announced he would launch a cellphone campaign to bring awareness of their hazards.

Belgium 2013:
The Public Health Minister bans cellphone sales for children under 7 years old. Advertisements are also banned during children's TV programs.

Australia 2013:
The federal government created a fact sheet providing citizens ways to reduce exposure from wireless devices. The agency advises parents to limit children's exposure to cellphones.

France, 2010
Laws make advertising cellphones to children under the age of 12 illegal.

Conclusions

The risk to children and adolescent from exposure to microwave radiating devices is considerable. Adults have a smaller but very real risk, as well.

(1) Children absorb greater amount of microwave radiation (MWR) than adults;

(2) MWR is a Class 2B (possible) carcinogen as is carbon black, carbon tetrachloride, chloroform, DDT, lead, nickel, phenobarbital, styrene, diesel fuel, and gasoline. It seems clear that we would not expose children to these other agents, so why would we expose children to microwave radiation?

(3) Fetuses are even more vulnerable than children. Therefore pregnant women should avoid exposing their fetus to microwave radiation.

(4) Adolescent girls and women should not place cellphones in their bras or in hijabs.

(5) Cellphone manual warnings make clear an overexposure problem exists.

(6) Wireless devices are radio transmitters, not toys. Selling toys that use them should be banned.

(7) Government warnings have been issued but most of the public are unaware of such warnings [Right?].

(8) Exposure limits are inadequate and should be revised such that they are adequate.

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Commentary On The Utility Of The National Toxicology Program Study On Cell Phone Radiofrequency Radiation Data For Assessing Human Health Risks Despite Unfounded Criticisms Aimed At Minimizing The Findings Of Adverse Health Effects

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Declaration Of Interest:
The author has consulted on the design and utility of the NTP study on cell phone radiation.
Keywords:
Radiofrequency, Radiation, Carcinogenicity,
Glioma, Schwannoma, Rats, National Toxicology Program

The National Toxicology Program (NTP) conducted two-year studies of cell phone radiation in rats and mice exposed to CDMA- or GSM-modulated radiofrequency radiation (RFR) at exposure intensities in the brain of rats that were similar to or only slightly higher than potential, localized human exposures from cell phones held next to the head. This study was designed to test the (null) hypothesis that cell phone radiation at non-thermal exposure intensities could not cause adverse health effects, and to provide dose-response data for any detected toxic or carcinogenic effects. Partial findings released from that study showed significantly increased incidences and/or trends for gliomas and glial cell hyperplasias in the brain and schwannomas and Schwann cell hyperplasias in the heart of exposed male rats. These results, as well as the findings of significantly increased DNA damage (strand breaks) in the brains of exposed rats and mice, reduced pup birth weights when pregnant dams were exposed to GSM- or CDMA-modulated RFR, and the induction of cardiomyopathy of the right ventricle in male and female rats clearly demonstrate that the null hypothesis has been disproved. The NTP findings are most important because the International Agency for Research on Cancer (IARC) classified RFR as a "*possible human carcinogen*" based largely on increased risks of gliomas and acoustic neuromas (which are Schwann cell tumors on the acoustic nerve) among long term users of cell phones. The concordance between rats and humans in cell type affected by RFR strengthens the animal-to-human association. This commentary addresses several unfounded criticisms about the design and results of the NTP study that have been promoted to minimize the utility of the experimental data on RFR for assessing human health risks. In contrast to those criticisms, an expert peer- review panel recently concluded that the NTP studies were well designed, and that the results demonstrated that both GSM- and CDMA-modulated RFR were carcinogenic to the heart (schwannomas) and brain (gliomas) of male rats.

Addendum

After this paper was submitted to Environmental Research, the NTP released drafts of the full technical reports on GSM- and CDMA- modulated cell phone RFR in rats and mice. Those reports were peer-reviewed by an external panel of scientists who had expertise in studying biological effects of electromagnetic fields and expertise in interpreting results from experimental carcinogenicity studies (NTP, 2016). The peer-review panel concluded that there was clear evidence of carcinogenic activity for heart schwannomas in male rats exposed to GSM- or CDMA-modulated RFR, some evidence of carcinogenic activity for brain gliomas in male rats (both GSM and CDMA), and equivocal evidence of carcinogenic activity for heart schwannomas in female rats (both GSM and CDMA). These categories of evidence are defined in all NTP technical reports: some evidence of carcinogenic activity means that the test agent caused an increased incidence in neoplasms, but "*the strength of the response was less than that required for clear evidence.*" Equivocal evidence of carcinogenicity means that there was "*a marginal increase in neoplasms that may be test-agent related.*" In addition, the studies in rats showed that the prostate gland was a target organ of proliferative lesions (neoplasms and/or preneoplastic epithelial hyperplasias) induced by GSM- and CDMA-modulated cell phone RFR. The peer review panel also concluded that there was some evidence of carcinogenic activity in the adrenal gland of male rats exposed to GSM-modulated RFR. The peer review panel concurred with NTP that there was equivocal evidence of carcinogenic activity of RFR in the prostate gland, pituitary gland, liver, meninges of the brain, and pancreas in rats, and for lymphoma and neoplasms in the lung, skin, and liver of mice. The expert peer-review panel clearly recognized the validity and biological significance of the adverse health effects produced in the NTP's studies of cell phone RFR. The overall results from the NTP studies indicate that cell phone RFR is potentially carcinogenic to multiple organs of exposed people.

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Evidence Of Oxidative Stress After Continuous Exposure To Wi-Fi Radiation In Rat Model

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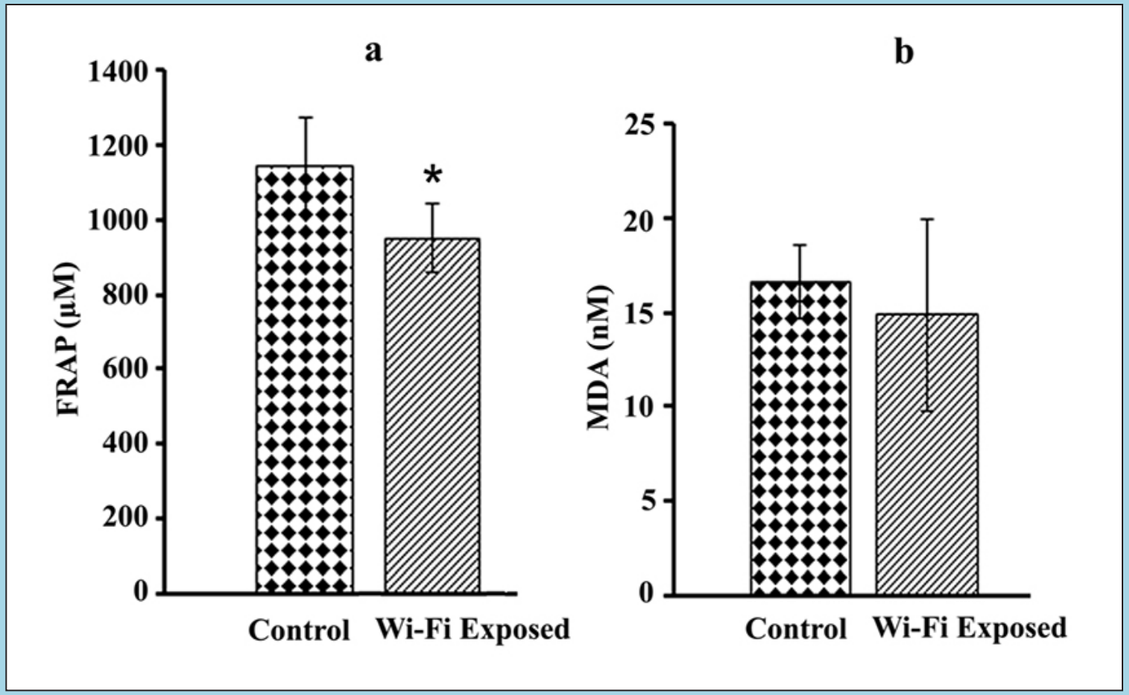
Keywords:
Wi-Fi device, Oxidative stress, Antioxidant capacity

Exposure to electromagnetic radiation (EMR) is rapidly increasing in everyday environment, consequently conferring potential health effects. Oxidative stress is emerging as a mechanism implicated in pathophysiology and progression of various diseases. To our knowledge, no report has been made on the status of antioxidant redox systems after continuous exposure to radiofrequency radiation emitted from a Wi-Fi access point in animal model so far. Therefore, we aimed to continuously subject rats in the experimental group to radiofrequency (RF) radiation emitted from a commercially available Wi-Fi device. Male Wister rats were exposed to 2.45 GHz RF radiation emitted from a Wi-Fi for 24 h/day for 10 consecutive weeks. In order to assess the change in antioxidant redox system of plasma after continuous exposure to a Wi-Fi device, the total antioxidant capacity of plasma, level of thiobarbituric acid reactive substances, concentration of reduced glutathione (GSH), and activity of different enzymatic antioxidants, e.g., superoxide dismutase [SOD], catalase [CAT], glutathione peroxidase [GSH-Px], and glutathione S-transferase [GST], were measured. In the Wi-Fi exposed group, a significant decrease was detected in total antioxidant capacity of plasma and the activities of several antioxidant enzymes, including CAT, GSH-Px, and SOD ($P < 0.05$). Meanwhile, the GST activity was significantly increased in this group ($P < 0.05$). However, no significant changes were found in GSH and TBARS levels following exposure to RF radiation. According to the results, oxidative defense system in rats exposed to Wi-Fi signal was significantly affected compared to the control group. Further studies are needed to better understand the possible biological mechanisms of EMR emitted from Wi-Fi device and relevant outcomes.



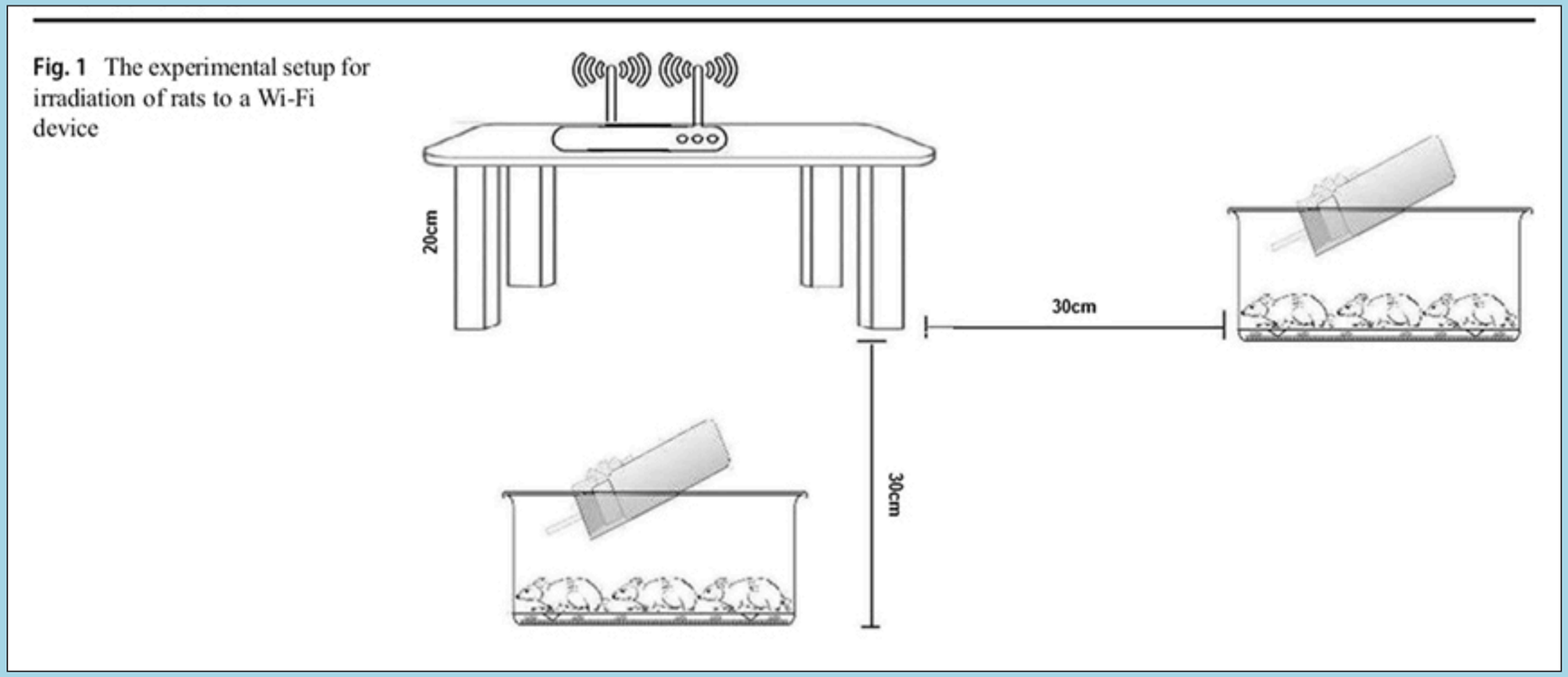
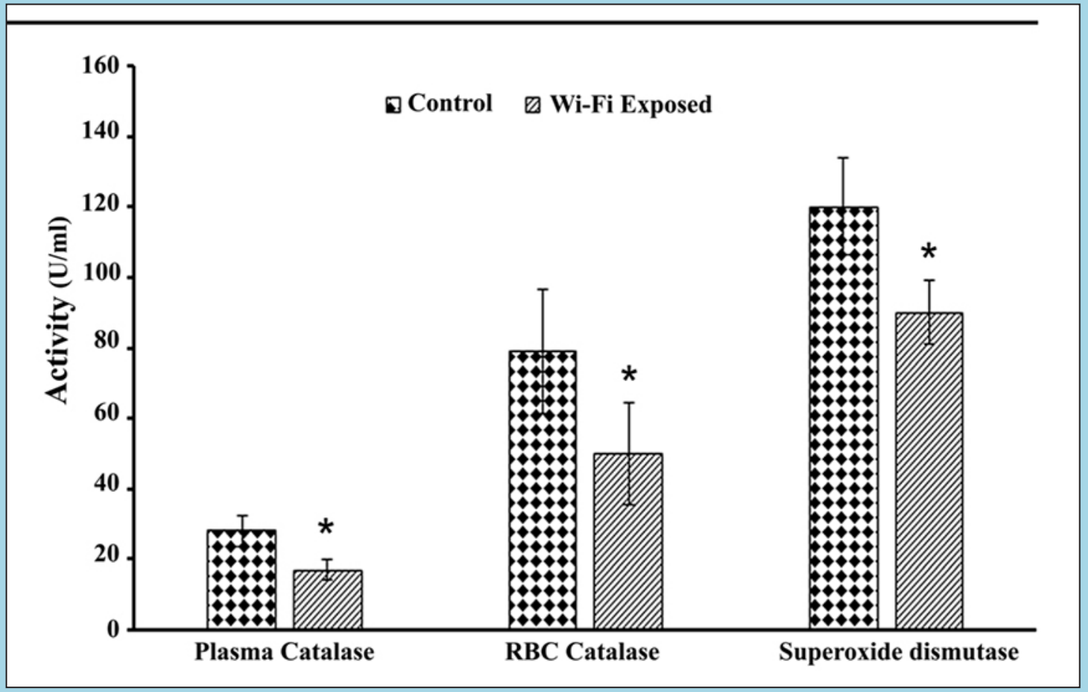
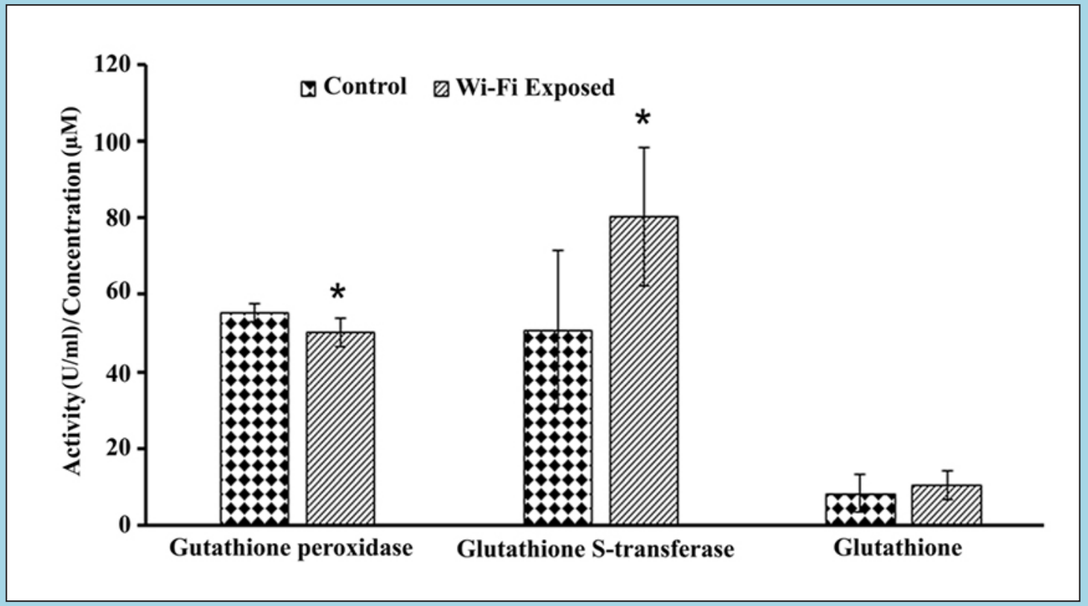


Fig. 1 The experimental setup for irradiation of rats to a Wi-Fi device

Conclusion:

According to the results of the current research, long-term exposure to EMR emitted from wireless devices had adverse effects on the antioxidant potential of blood. Therefore, to protect individuals from harmful effects of Wi-Fi signals, it is advised to limit the use of such devices for household and occupational activities, if possible. This study may stimulate future helpful research in the development of new protective or therapeutic approaches. In addition, it is recommended that the target tissues of EMR emitted from wireless devices and the level of other mediators be investigated to understand the exact molecular mechanism and site of action upon continuous exposure to such radiations.





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Mobile Phone Radiation Causes Brain Tumors And Should Be Classified As A Probable Human Carcinogen: Review

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Quickly changing technologies and intensive uses of radiofrequency electromagnetic field (RF-EMF)-emitting phones pose a challenge to public health. Mobile phone users and uses and exposures to other wireless transmitting devices (WTDs) have increased in the past few years. We consider that CERENAT, a French national study, provides an important addition to the literature evaluating the use of mobile phones and risk of brain tumors. The CERENAT finding of increased risk of glioma is consistent with studies that evaluated use of mobile phones for a decade or longer and corroborate those that have shown a risk of meningioma from mobile phone use. In CERENAT, exposure to RF-EMF from digitally enhanced cordless telephones (DECTs), used by over half the population of France during the period of this study, was not evaluated. If exposures to DECT phones could have been taken into account, the risks of glioma from mobile phone use in CERENAT are likely to be higher than published. We conclude that radiofrequency fields should be classified as a Group 2A "probable" human carcinogen under the criteria used by the International Agency for Research on Cancer (Lyon, France). Additional data should be gathered on exposures to mobile and cordless phones, other WTDs, mobile phone base stations and Wi-Fi routers to evaluate their impact on public health. We advise that the as low as reasonable achievable (ALARA) principle be adopted for uses of this technology, while a major cross-disciplinary effort is generated to train researchers in bioelectromagnetics and provide monitoring of potential health impacts of RF-EMF.

Introduction

In a world where the growth of mobile phone use and other wireless transmitting devices (WTDs) is without precedence, the issue of brain cancer and radiation from mobile phones has received considerable attention in the research community and by the general public. Occupational studies and studies of atomic bomb survivors indicate that the latency for brain cancer could be as long as three decades or more. The first reports on case-control studies published on this association in the 1990s lacked sufficient power to find an effect, because they studied persons who had used early technology (1 and 2G) phones for relatively limited periods of time (1-4). The definition of "regular use" (at least once a week, for 6 months or more) during a period of rapidly increasing mobile phone use resulted in an average use time of ~6 years. Both the INTERPHONE Study Group (5), and Coureau et al (6) used this definition of "regular use."

In the past few years a number of investigations have included those who have used phones for a decade or longer. In this report we identify and evaluate all case-control studies that incorporate decade-long use of mobile phones to provide a more complete picture of their potential impacts on public health.

The highest cumulative hours of exposure for brain cancer, glioma and acoustic neuroma are doubled or greater (range, 1.82-2.89) (Table I). Of particular interest are studies from Sweden and Korea. In the Korean study, significant increases for acoustic neuroma occurred with >2,000 cumulative hours of use when compared to less (7), and in the Swedish study for >2,300 hours of cumulative use (8). In three studies, increased risks for meningioma were also found at the highest cumulative hours of use (5,6,9).

At the highest years of use there were significant risks for glioma (5,10), brain cancer (8) and acoustic neuroma (11,12). For studies with greater years of use, acoustic neuroma tumor volume increased compared to less years of use (7,12).

This French case-control study of cases ≥16 years of age diagnosed between June 2004 and May 2006 included 253 glioma and 194 meningioma cases with two age- and gender-matched controls per case selected between 2005 and 2008 (6).

Potential confounders considered were the level of education, smoking, alcohol consumption, and occupational exposures to pesticides, extremely low frequency electromagnetic fields (ELF-EMF), radiofrequency electromagnetic fields (RF-EMFs), and ionizing radiation. In spite of listing RF-EMF as a potential confounder, separate analyses of exposures to digitally enhanced cordless telephones (DECTs) were not included, because questions about DECT use were not asked in the questionnaire.

During the period when cases were selected, the prevalence of French mobile phone use in 2004, 2005, and 2006 was 73, 78, and 84% respectively, while the use of cordless phones is likely to have mirrored similar patterns of increasing use (13).

Underestimation Of Risk Of Glioma In CERENAT And INTERPHONE

Risks of glioma were reported for "*heavy mobile phone use*" (≥896 cumulative hours of use) (Fig. 1). When "*heavy mobile phone use*" was examined by years since first use, glioma risk increased from >1 year since first use, to >2 years, and to >5 years, OR 2.89, [95% confidence interval (CI) 1.41-5.93], OR 3.03, (95% CI 1.47-6.26), and OR 5.30, (95% CI 2.12-13.23), respectively (6).

There are two principal reasons why the cerenat findings as well as those of interPHone are likely to have underestimated the risks of glioma from mobile phone use. First, exposures to RF-EMF radiation from conventional DECT can be substantial (15). Neither in INTERPHONE nor in CERENAT were these exposures evaluated. However Hardell et al (8,12) reported risks of brain tumors from these devices

similar to those from mobile phones. While in the CERENAT study RF-EMF exposures from other sources were listed as a potential confounder, questions were not asked about DECT use. Thus, the reference category "*no regular use*" included subjects who used a DECT. This misclassification of exposure biases the findings towards the null.

Risks were also reported by anatomical region.There was a borderline significant risk for glioma in the temporal lobe, OR 3.94 (95% CI 0.81-19.08), which when combined with at least 5 years of use increased to a significantly elevated 5.3-fold risk; for frontal lobe tumors there was a non-significant increased risk, OR 1.87 (95% CI 0.62-5.64), and for other regions a significant increased risk, OR 3.61 (95% CI 1.00-12.96). Of the total mobile phone radiation absorbed by the brain, the temporal lobe absorbs 50-60% and the frontal lobe absorbs 14-18% (14).

Industry records reveal that the estimated prevalence of DECT use in France (introduced into France in 1992) was well above 50% between 2004 and 2006.

The highest risk reported was among heavy mobile phone users from environments known to have multiple sources of WTDs at work and home in urban areas, OR 8.20 (95% CI 1.37-49.07).

A second factor that could contribute to an underestimation of risk is that the participation rate in CERENAT was relatively low: 66% for cases and 45% for controls (6). The 13-country interPHone study's average participation rate was 70% for glioma, 79% for meningioma, 56% for controls (5). the authors of the interPHone study acknowledged the possible selection bias from low participation rates and calculated that these resulted in a 10% underestimation of risk and the overall underestimation of glioma and meningioma risk was per "*the observed reductions below the null in the ORs in ever regular mobile phone users for meningioma* (21%, 95% CI 32-9) *and glioma* (19%, 95% CI 30-6)" (5).

Higher risks were found from reported ipsilateral use, or 2.11 (95% CI 0.73-6.08) compared to contralateral use, OR 0.66 (95% CI 0.23-1.89).

The OR for analogue mobile phone use was 3.75 (95% CI 0.97-14.43), that for digital mobile phone use was 2.71 (95% CI 1.03-7.10). This is consistent with mobile phone use constituting a risk factor for glioma, because analogue mobile phones always radiated maximum power while the digital mobile phone's adaptive power control circuitry reduces the radiated power consistent with an acceptable signal to noise ratio.

Hardell and Carlberg (16) suggested that the CERENAT method for analyzing laterality of risk was incorrect. In reply the CERENAT authors provided corrected calculations, showing that "*heavy*"users incurred greater ipsilateral risks (≥896 cumulative hours of use) (17) (Table II). By using the correction the OR for the highest cumulative hours of use for glioma doubled.

For several exposure categories there was an increased risk with increased number of hours or calls per day of exposure: "*average calling time per month (hours)*", p=0.02; average

Consistent with what is expected if there is a causal association between risks of glioma with different estimated exposure intensities, overall for ≥896 cumulative hours of use ("*heavy mobile phone use*"), there was a significant 2.9-fold increased risk.

for glioma, all ipsilateral ORs were greater than contralateral ORs. With two exceptions, this was also true for meningioma. Because ipsilateral use results in higher exposure than contralateral, this is consistent what is expected if mobile phone use is a risk for glioma and meningioma.

Meningioma Elevated Risk In CERENAT

"*Heavy mobile phone*" use was associated with increased risks of meningioma (but somewhat weaker than the risks for glioma): for >1 year, OR 2.57 (95% CI 1.02-6.44); for >2 years, OR 2.40 (95% CI 0.96-6.05), and for >5 years (5 cases), OR 1.44 (95% CI 0.43-4.80).

Risks were non-significantly elevated for temporal lobe (2 cases), OR 7.89 (95% CI 0.48-130.14) and for frontal lobe (5 cases), OR 4.82 (95% CI 0.78-29.63).

There was one significant and one borderline significant risk with increasing exposure: "*average calling time per month (hours)*", p=0.04; and "*cumulative duration of calls (hours)*", p=0.06 (6).

Evidence That Electromagnetic Radiation Can Act Both As An Initiator And A Promoter Of Tumors

Exposure indicated an early effect in glioma development, which is an increased risk with long latency. However, we also found an increased risk with short latency, indicating a late effect in tumor development...these results could be compatible with both tumor initiation and promotion. This is illustrated in fig. 2.

Discussion

In reviewing the epidemiological evidence on mobile phone use and brain tumors, The IARC Monograph Working Group (19) noted the limited data available from epidemiological studies at that time though noting that Hardell et al have conducted the most detailed and largest number of studies on the risks for glioma from wireless phone (mobile and/or cordless phone).

Morgan et al (20) suggested that the magnitude of the under-estimation of risk was 25% in the interPHone study. This is consistent with the INTERPHONE Study Group (5) conclusion that their under-estimation was at least 19% based on "*regular*" mobile phone use. Nevertheless, when minimal use was defined as the reference level, risks in the INTERPHONE study were significant: for 10+ years since first use compared to 1-1.9 years since first use, OR 2.18 (95% CI 1.43-3.31), for >1,640 cumulative hours of use compared to <5 h of use, or 1.82 (95% CI 1.15-2.80).

The IARC Monograph Working Group concluded that radiofrequency fields were possible human carcinogens, Group 2B (19). Since then, a number of studies have been published of experimental results showing that radiofrequency fields affect cellular repair and increase biomarkers associated with cancer risk. In our view these results and several epidemiology studies (8,21) are consistent with what is expected if radiofrequency fields from mobile phone use are a cause of brain cancer: the higher the cumulative hours of use, the higher the risk; the longer the time since first use, the higher the risk; the higher the radiated power, the higher the risk; ipsilateral risk is higher than contralateral risk.

Thus, evidence published since the IARC review provides additional support, based on IARC criteria,

for concluding that at the time of the IARC review it was known that when mobile phone use began as a teenager, the risks were higher than when use began as an adult (22,23). Since then, additional evidence has accrued of an increased risk to children. In the Cefalo study, using operator reported data, an OR of 2.15 (95% CI 1.06-4.29) was reported for children of median age 13 with >2.8 years since time from first subscription, combined with an increasing risk with increase in years since first use, radiofrequency fields are probable human carcinogens; radiofrequency fields should now be classified Group 2A. P-trend=0.001 (24). In addition, the CEFALO authors reported an ipsilateral risk with >4 years of cumulative duration of subscriptions, OR 3.74 (95% CI 1.19-11.77) in combination of an increasing risk with increasing years of use, P-trend=0.02.

As the young adult brain is not fully myelinated, and wireless radiation has been shown to induce demyelination experimentally, it is plausible that wireless radiation could have a stronger impact on the developing brain than on older adults.

1t has been suggested that if mobile phone use was causing brain cancer, with so many people using mobile phones there should be an increase in brain cancer, but there has been none (25,26). **This is not correct.**

Recently a significant annual percent change (APC) in age-adjusted rates of brain cancer between 1992 and 2006 was reported from the United States using data from three cancer registries: Los Angeles County (LAC), California Cancer Registry (CCR), and the SEER 12 cancer registry (27). Table III shows this increase in brain cancer for the three anatomical regions that absorb the greatest proportion of the absorbed mobile phone radiation in the brain (81% at 900 MHz and 86% at 1,800 MHz) (14).

Also showing incidence increases is an Australian study of regional hospital-based data for the years 2000-2008. Dobes et al (28) stated, "*a significant increasing incidence in glioblastoma multiforme (GBM) was observed in the study period* (APC 2.5; 95% CI 0.4%-4.6, n=2,275), *particularly after 2006*".

An increasing incidence of brain tumors during 2003-2012, 41.2% among men and 46.1% in women has been noted in Denmark, cases of GBM nearly doubled in the previous 10 years (29).

Fig. 2. SAM Phantom. The red devices are clamps to hold the cellphone in a specified location. "CTIA" is the Cellular Telecommunications Industry Association.
Source: Speag Phantom Product Flyer.

"An increasing incidence of brain tumors 2003-2012 (41.2% among men and 46.1% in women) has been noted in Denmark, cases nearly doubled in the previous 10 years"

The case-control design is generally considered the preferred methodology for studying brain cancer risk tied with mobile phone use, as with any relatively rare disease with extensive exposure. The latency reported between known causes of brain cancer and development of the disease appears to range from 10 to 50 years. Because brain cancer is a relatively rare disease with a relatively long latency, and the reported relative risk associated with mobile phone use thus far ranges from 1.5 to 8, in order to have sufficient power to detect a real increase in risk associated with mobile phone use, prospective cohort studies would have to include >3 million persons followed for 20 years to have 80% power. A retrospective cohort study of ~400,000 cell phone users in Denmark has been reported evaluating brain cancer risk in persons who began using cell phones in 1992-1994 compared to those who began to use cell phones later (30). The authors excluded business users from the exposed contending they were unable to know if a phone registered to a business user was solely used by that person, including these same business users in the unexposed category. This misclassification of exposure impairs the ability of the study to detect an increase in risk, while it lacks statistical power, as it involves a small cohort for which exposure information has not been updated for 20 years.

Conclusions

The CERENAT study corroborates the significant risks of glioma associated with exposure to radiofrequency fields reported by the Swedish team and by the 13-country interPHone study, and adds weight to the epidemiological evidence that radiofrequency fields, classified by the international agency for research on cancer as a group 2B (possible) carcinogen in 2011 should be reclassified as a Group 2A (probable) carcinogen.

In the CERENAT study, a significant increased risk of brain cancer was found from mobile phone use overall with an 8-fold increased risk for higher urban exposures. Three out of every four persons today live in mega-cities with populations of >10 million, many in the rapidly developing world where exposures to RF-EMF may be poorly controlled and access to medical treatment problematic. CERENAT also corroborates those few studies that have shown a risk of meningioma from mobile phone use.

The growth of mobile phone use worldwide has reached the level that in many nations there are more phones than adults. exposures today can occur simultaneously from a number of WTDs such as mobile phones, mobile phone base stations (as known as masts or cell towers), and tablets, with the latter often being held quite close to the bodies of users (ignoring that the exposure limit it is measured at 20 cm distance from tablets, laptop computer, and similar WTDs).

Until further evidence is available, it is prudent for policies about the use and development of WTDs rely on reducing exposures to the ALARA standard used in pediatric radiology. The ALARA approach would require hardware and software designers to create proximity sensors and embed flash notices regarding simple advisories about safer use within devices. In the meantime, we urge that serious national programs of training and research be established to train experts in evaluating this technology and establish appropriate monitoring and surveillance systems such as those in place for pharmaceuticals and other agents. This program could be funded by a fee of 2 cents/month to be paid equally from consumers, manufacturers, and providers into an independently operated research and training program.

100s of 1000s of antennaes will support 5G
The antennaes will be located across every street corner and neighborhood in America
generating a web of non-ionizing radiation across the surface of the planet

Andrologia • October 2017

Quantitative Changes In Testicular Structure And Function In Rat Exposed To Mobile Phone Radiation

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Keywords:
Cavalieri principle, electromagnetic field, mobile phone, stereology, testis morphology

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The possible effects of the electromagnetic fields (EMF) generated by mobile phones on reproductive functions have been discussed in recent years. The aim of this study was to evaluate the effects of EMF emitted from mobile phones on the rat testis morphology and histopathology using stereological techniques. We also investigated cortisol, testosterone, FSH and LH levels. A total of thirty-two (n = 32) male Wistar albino rats were used in this study. Animals were randomly divided into four groups as control (C, n = 8), sham (Sh, n = 8), mobile phone speech (Sp, n = 8) and mobile phone standby (ST by). Morphometric measurements were made with the help of a computer-assisted stereological analysis system.

The testis weight and volume were significantly lower in the EMF exposed groups.

The mean volume fraction of interstitial tissue was higher, but the volume fraction of tubular tissue was lower in the EMF-exposed groups. The mean tubular and germinal tissue volume, seminiferous tubule diameter and germinal epithelium height were also lower in EMF exposed groups. The cortisol levels in the EMF-exposed groups were significantly higher. In conclusion, the EMF created by mobile phones caused morphologic and histological changes by the affecting germinal epithelium tissue negatively.

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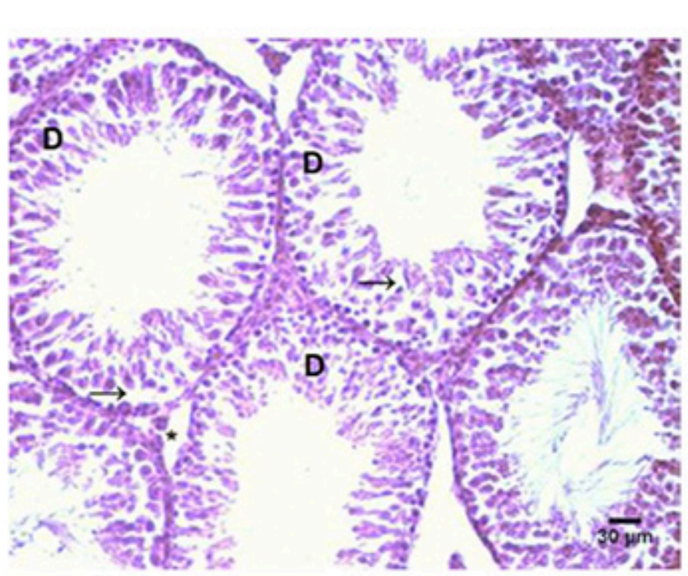

FIGURE 3 Showing the histopathological changes in the standby group (D: the degenerated seminiferous tubules, (*): the separated germinal epithelium from tunica propria, (→): the gaps were among series of spermatogenic cells); magnification: ×20

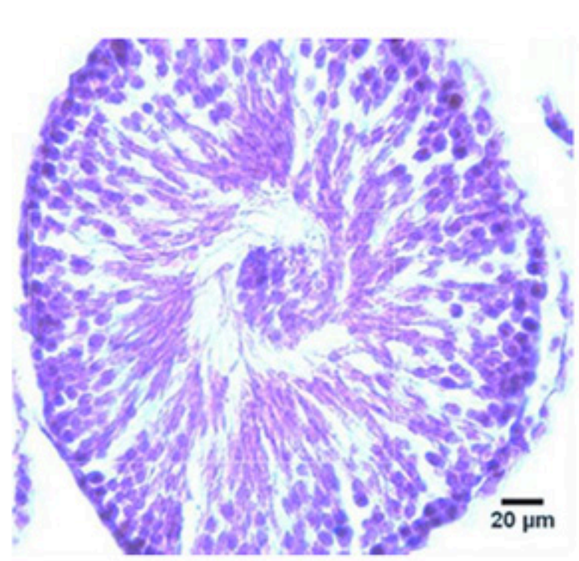

FIGURE 4 Showing the cellular masses were found in the seminiferous tubule lumen; magnification: ×40

BioMed Research International • June 2014

Extremely Low Frequency Magnetic Fields Induce Spermatogenic Germ Cell Apoptosis: Possible Mechanism

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The energy generated by an extremely low frequency electromagnetic field (ELF-EMF) is too weak to directly induce genotoxicity. However, it is reported that an extremely low frequency magnetic field (ELF-MF) is related to DNA strand breakage and apoptosis. The testes that conduct spermatogenesis through a dynamic cellular process involving meiosis and mitosis seem vulnerable to external stress such as heat, MF exposure, and chemical or physical agents. Nevertheless the results regarding adverse effects of ELF- EMF on human or animal reproductive functions are inconclusive. According to the guideline of the International Commission on Non-Ionizing Radiation Protection (ICNIRP; 2010) for limiting exposure to time-varying MF (1 Hz to 100 kHz), overall conclusion of epidemiologic studies has not consistently shown an association between human adverse reproductive outcomes and maternal or paternal exposure to low frequency fields. In animal studies there is no compelling evidence of causal relationship between prenatal development and ELF-MF exposure. However there is increasing evidence that EL-EMF exposure is involved with germ cell apoptosis in testes. Biophysical mechanism by which ELF-MF induces germ cell apoptosis has not been established. This review proposes the possible mechanism of germ cell apoptosis in testes induced by ELF-MF.

Summary And Conclusion

Germ cell apoptosis can be triggered by hormonal and nonhormonal factors, including gonadal toxin, heat stress, biochemical agents, and EMF exposure. The mechanism of germ cell apoptotic pathway of exposure to ELF-EMF is little understood. However, on the basis of serial biological response induced by ELF-EMF exposure from each of the results reported, we can comprehensively speculate regarding germ cell apoptotic pathway of ELF-MF exposure that initially mature spermatids degenerate due to direct cytotoxicity of high dose EMF. In addition, the production of testosterone transiently increases in the early phase of exposure to ELF- EMF due to the altered proliferation of the Leydig cells. Proliferation rate of spermatogonia and spermatocyte (germ cell transformation) subsequently increases. Proliferation of the Leydig cells is followed by DNA damage. Over time, the testosterone level shows a declining tendency. In the late phase, the Leydig cells get repaired, and accordingly HPG axis is adapted to chronic stimulation of MF. Consequently, the testosterone level partially recovers. On the other hand, germ cell apoptosis results in degeneration of differentiating spermatocyte and spermatogonia. It may be a dynamic compensatory mechanism of spermatogenesis during germ cell apoptosis responding to exposure to ELF-EMF according to intensity of EMF and exposure pattern, age, and duration. To understand the mechanism regulating ELM-MF induced germ cell apoptosis, molecular signaling pathway should be elucidated.

Conflict Of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

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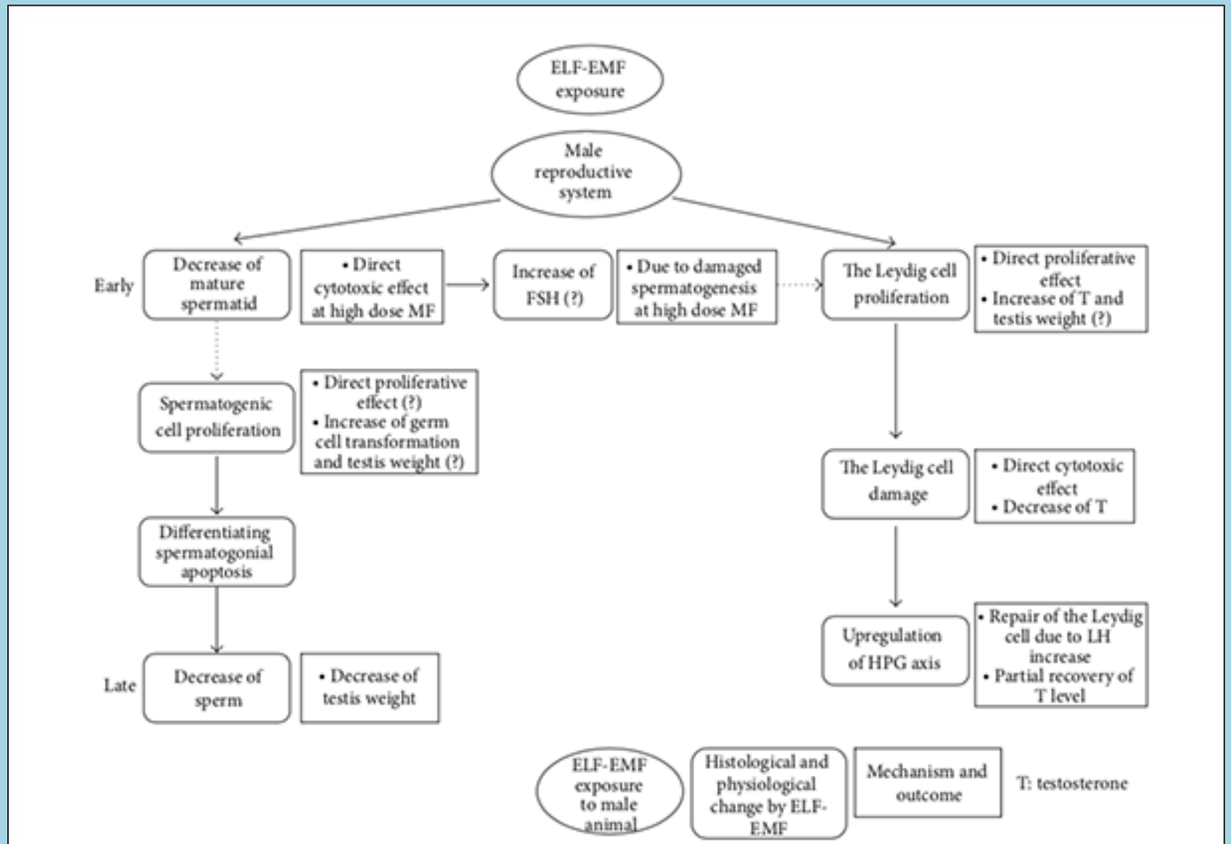

Figure 2: Proposed diagram of apoptotic process in testis exposed to ELF-EMF.

Electromagnetic Biology and Medicine • November 2018

Effects Of Exposure To Electromagnetic Field From Mobile Phone On Serum Hepcidin And Iron Status In Male Albino Rats

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Background: Electromagnetic fields (EMF) created by mobile phones during communication have harmful effects on different organs.
Objectives: To explore the effects of exposure to EMF of mobile phones for different durations on hematological parameters and serum hepcidin in male albino rats.
Methods: Three groups of eight rats:
Sham group: Rats were exposed to a mobile phone while it was switched off.
Experimental group I: Rats were exposed to microwave radiation from a mobile phone at 9 am for 30 min.
Experimental group II: Rats were exposed to microwave radiations from a mobile phone at 9 am for an hour. In all groups, the exposure was conducted daily for a total period of 5 months, followed by estimation of serum hepcidin, total leukocyte count (TLC), interleukin 6 (IL6), serum iron, serum ferritin, plasma hemoglobin (Hb), hematocrit value (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), unsaturated iron binding capacity (UIBC), total iron binding capacity (TIBC) and 1.25 dihydroxycholecalciferol levels.
Results: In Experimental group II, there was a significant increase in serum hepcidin, TLC, IL6 and serum ferritin; however, serum iron, TIBC, UIBC, 1.25 dihydroxycholecalciferol, plasma Hb, Hct, MCV and MCH were significantly lower in comparison to sham-exposed group. In Experimental group I, there was a significant increase in serum hepcidin, IL6 and TLC, along with non-significant changes in the remaining studied parameters in comparison to the sham-exposed group.
Conclusion: Chronic exposure to EMF from mobile phones increases hepcidin level with subsequent impairment of iron parameters, in addition to negatively affecting both UIBC and TIBC.

Discussion

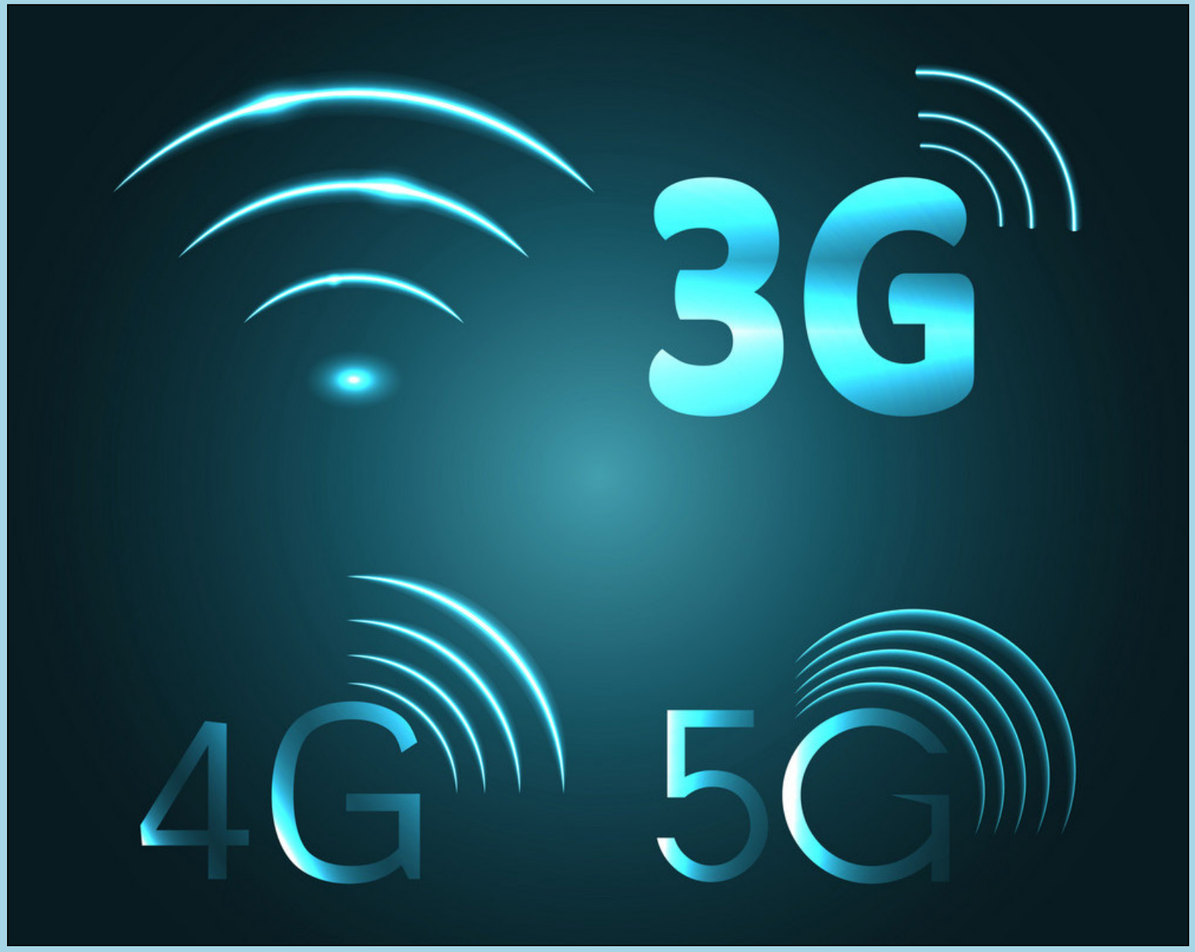
Widespread use of mobile phones has increased humans' exposure to EMFs, so it is of great importance to investigate their effects on the biological systems. In this study, the effect of mobile phone EMF on iron parameters and serum hepcidin level was investigated.

In the current study, exposure to EMF from a mobile phone for an hour per day for 5 months led to a significant increase in serum hepcidin, and it was reported that hepcidin synthesis and secretion by the liver is controlled by inflammation (Nemeth and Ganz, 2009). Interestingly, researchers demonstrated that electromagnetic waves from cell phones have an inflammatory effect (Koca et al., 2014). This was indicated in our study by a significant increase in the average number of WBCs on exposure to EMF from mobile for an hour per day for 5 months with significant positive correlation with hepcidin level, which was in line with the observations of Alghamdi and El- Ghazaly (2012) who reported an increase in white cells indicating an increase in the body's immune response on exposure to EMF.

Moreover, in the current study, upon exposure to EMF from a mobile phone for an hour per day for 5 months, there was a significant increase in serum IL6 when compared to controls, with significant positive correlation with hepcidin level. IL6 is a proinflammatory cytokine which is a potent stimulus of hepcidin production (Nemeth et al., 2004).

It is interesting that 1.25 dihydroxycholicalciferol has been shown to decrease hepcidin and optimal function of hepcidin may be predicated upon the adequate presence of vitamin D in the blood (Bacchetta et al. 2014). 1.25 dihydroxycholicalciferol was observed to decrease in our study on exposure to EMF from mobile phones for an hour per day, with significant negative correlation with hepcidin level. Many investigators stated presence of oxidative stress on exposure to EMF (Gharib, 2011; Guney et al., 2007), this finding is supported by the findings of Krivošíková et al. (2015) who noticed that 1.25 dihydroxycholicalciferol is decreased in any condition of oxidative stress.

It was clear from the current study that there was a significant decrease in serum iron on exposure to EMF from mobile phones for an hour per day when compared to sham with significant negative correlation with hepcidin level, this may be due to increased hepcidin level reported in this study, this is in line with Nourmohammadi et al. (2001) and Hachulla et al. (2000) who stated that iron values were affected negatively by long exposure to EMF.



The Effects Of Radiofrequency Electromagnetic Radiation On Sperm Function

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Mobile phone usage has become an integral part of our lives. However, the effects of the radiofrequency electromagnetic radiation (RF-EMR) emitted by these devices on biological systems and specifically the reproductive systems are currently under active debate. A fundamental hindrance to the current debate is that there is no clear mechanism of how such non-ionising radiation influences biological systems. Therefore, we explored the documented impacts of RF-EMR on the male reproductive system and considered any common observations that could provide insights on a potential mechanism. Among a total of 27 studies investigating the effects of RF-EMR on the male reproductive system, negative consequences of exposure were reported in 21. Within these 21 studies, 11 of the 15 that investigated sperm motility reported significant declines, 7 of 7 that measured the production of reactive oxygen species (ROS) documented elevated levels and 4 of 5 studies that probed for DNA damage highlighted increased damage due to RF-EMR exposure. Associated with this, RF-EMR treatment reduced the antioxidant levels in 6 of 6 studies that discussed this phenomenon, whereas consequences of RF-EMR were successfully ameliorated with the supplementation of antioxidants in all 3 studies that carried out these experiments. In light of this, we envisage a two-step mechanism whereby RF-EMR is able to induce mitochondrial dysfunction leading to elevated ROS production. A continued focus on research, which aims to shed light on the biological effects of RF-EMR will allow us to test and assess this proposed mechanism in a variety of cell types.

Over the past 20 years, the use of mobile phones has increased exponentially (Gorpinchenko et al. 2014), with a current estimate of more than one billion users worldwide (French et al. 2001, Meral et al. 2007). In the United States, there is approximately one device in use per person, and well above more than one person in European countries such as Germany, Denmark and Italy (U.S. Census Bureau, 2012). Furthermore, the number of devices in service is rising at an estimated rate of 3% annually (ACMA 2013). Accordingly, the exposure of humans to radiofrequency electromagnetic radiation (RF-EMR) emitted from these devices has also increased substantially, with an average talk time of 30 min per day spent talking on mobile phones (CTIA 2011). The effect of this radiation on human health remains to be fully elucidated with current literature detailing an array of apparently contradictory results. Indeed, although some studies have identified pronounced deleterious effects of RF-EMR on a variety of cell types (Balode 1996, d'Ambrosio et al. 2002, Bilgici et al. 2013, Furtado-Filho et al. 2014, Hou et al. 2015, Kahya et al. 2014, Dasdag et al. 2015), others have reported only very subtle or no significant effects (Marchionni et al. 2006, Masuda et al. 2006, Dasdag et al, 2009, Demirel et al. 2012, Khalil et al. 2014). A confounding factor in these studies involves the use of differing RF intensity, frequency, exposure length and method of administration, which discounts the possibility of direct and robust study-to-study comparisons. Such variation attempts to simulate elevated levels of exposure in certain studies and real-life mobile phone exposure in others, which is extremely hard to model given the variability that exists in each of these parameters of intensity and frequency (Lerchl 2013). For instance, the intensity of RF-EMR emitted from mobile phones varies from ~0.1–4W/kg (Fejes et al. 2005, Guney et al. 2007, La Vignera et al. 2012), whereas mechanistic studies have involved intensities as high as 27.5W/kg (De Iuliis et al. 2009a). Regardless of these differences, the balance of evidence supports the principle that RF-EMR has the ability to induce cellular damage (Adams et al. 2014). In light of this conclusion and to work towards identifying real clinical risks, it is imperative that we develop an understanding of the mechanism(s) by which this form of radiation affects different biological systems.

Conclusion

To date, contradictory studies surrounding the impacts of RF-EMR on biological systems maintain controversy over this subject. Nevertheless, research on the biological responses stimulated by RF-EMR is particularly important given our ever-increasing use of mobile phone technology. Although clinical studies are identifying possible detrimental effects of RF-EMR, it is imperative that mechanistic studies are conducted that elucidate the manner in which RF-EMR perturbs biological function, thus supplying a rational cause. A focus on the male reproductive system is justified given the potentially elevated levels of exposure this system may experience as consequences of the personal storage of mobile devices, the unique vulnerability of the highly specialised sperm cell, and the future health burden that may be created if conception proceeds with defective, DNA-damaged spermatozoa. Although this subject remains a topic of active debate, this review has considered the growing body of evidence suggesting a possible role for RF-EMR-induced damage of the male germline. In a majority of studies, this damage has been characterised by loss of sperm motility and viability as well as the induction of ROS generation and DNA damage. We have therefore given consideration to the potential mechanisms through which RF-EMR may elicit these effects on spermatozoa, which we used as a sensitive model system. We propose a mechanistic model in which RF-EMR exposure leads to defective mitochondrial function associated with elevated levels of ROS production and culminates in a state of oxidative stress that would account for the varying phenotypes observed in response to RF-EMR exposure. With further complementary data, this model will provide new impetus to the field and stimulate research that will allow us to confidently assess the reproductive hazards of mobile phone usage.

Declaration Of Interest

The authors declare no conflicts of interest that could be perceived as prejudicing the impartiality of the research reported.

Funding

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Journal Of Biomedical & Physical Engineering • March 2018

Electromagnetic Fields of Mobile Phone Jammer Exposure On Blood Factors In Rats

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Background: The increasing demand for using mobile phones has led to increasing mobile phone jammers as well. On the other hand, reports show that exposure to electromagnetic field causes an increase in the incidence of diseases such as leukemia, cancer, depression and failure in pregnancy outcomes; therefore, the aim of this study is to investigate the effects of exposure to electromagnetic fields of mobile phone jammers on blood factors.
Materials and Methods: Thirty male Wistar immature and thirty mature rats were selected randomly and each one was divided into three groups of ten. The control group did not receive any radiation; the sham group was exposed to a switched-off jammer device and the experimental group was exposed to electromagnetic fields (EMF) radiated by Mobile Phone Jammer daily eight hours for five days a week during forty days. Blood sample was taken from heart and blood factors including PLT, MCHC and RDW-CV were measured. The data were analyzed by ANOVA which was followed by Duncan's test.
Results: The data from mature rats revealed that jammer usage led to a significant difference in blood factors including RBC, platelet, hemoglobin, hematocrit, MCV and RDWCV ($P \leq 0.05$); however, the number of lymphocytes, WBC and MCVH in the blood was the same in all groups. In immature rats, the exposure to jammer did not change RBC, lymphocyte and WBC count, hemoglobin and hematocrit; while, the platelet count along with MCHC, MVC and RDWCV changed by jammer radiation.
Conclusion: The results exhibited that mobile phone jammer caused frequent changes in blood cell factors.

Keywords:
Electromagnetic Field (EMF), Radiation, Mobile Phone Jammer, Blood Cell Factors

Conclusion

Based on the results of the present study, it can be concluded that exposure of mature rats to mobile phone jammer radiation caused significant differences in platelets, hematocrit and hemoglobin, RBC, MCHC, MCV and RDWCV compared to the control group. In immature rats, the jammer exposure had no significant effects on hematocrit, hemoglobin as they change in the mature ones. It also modified blood parameters in mature and immature rats in different ways.

Acknowledgment

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Conflict of Interest

None Declared

Oxidative Medicine and Cellular Longevity • November 2018

Role Of Mitochondria In The Oxidative Stress Induced By Electromagnetic Fields: Focus On Reproductive Systems

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Modern technologies relying on wireless communication systems have brought increasing levels of electromagnetic field (EMF) exposure. This increased research interest in the effects of these radiations on human health. There is compelling evidence that EMFs affect cell physiology by altering redox-related processes. Considering the importance of redox milieu in the biological competence of oocyte and sperm, we reviewed the existing literature regarding the effects of EMFs on reproductive systems. Given the role of mitochondria as the main source of reactive oxygen species (ROS), we focused on the hypothesis of a mitochondrial basis of EMF-induced reproductive toxicity. MEDLINE, Web of Science, and Scopus database were examined for peer-reviewed original articles by searching for the following keywords: "extremely low frequency electromagnetic fields (ELF- EMFs)," "radiofrequency (RF)," "microwaves," "Wi-Fi," "mobile phone," "oxidative stress," "mitochondria," "fertility," "sperm," "testis," "oocyte," "ovarian follicle," and "embryo." These keywords were combined with other search phrases relevant to the topic. Although we reported contradictory data due to lack of uniformity in the experimental designs, a growing body of evidence suggests that EMF exposure during spermatogenesis induces increased ROS production associated with decreased ROS scavenging activity. Numerous studies revealed the detrimental effects of EMFs from mobile phones, laptops, and other electric devices on sperm quality and provide evidence for extensive electron leakage from the mitochondrial electron transport chain as the main cause of EMF damage. In female reproductive systems, the contribution of oxidative stress to EMF-induced damages and the evidence of mitochondrial origin of ROS overproduction are reported, as well. In conclusion, mitochondria seem to play an important role as source of ROS in both male and female reproductive systems under EMF exposure. Future and more standardized studies are required for a better understanding of molecular mechanisms underlying EMF potential challenge to our reproductive system in order to improve preventive strategies.

Conclusions and Final Remarks

Based on the current literature, the analysis of ELF-EMF and RF impact on the maintenance of male and female fertility potential reports contradictory results. The main reason for these discrepancies may be the lack of uniformity in the experimental design, including the use of different models and the extremely variable exposure sources and protocols. Moreover, since ROS levels can be influenced by temperature, a possible criticism to many of these works is the lack of control of this parameter during EMF exposure [188].

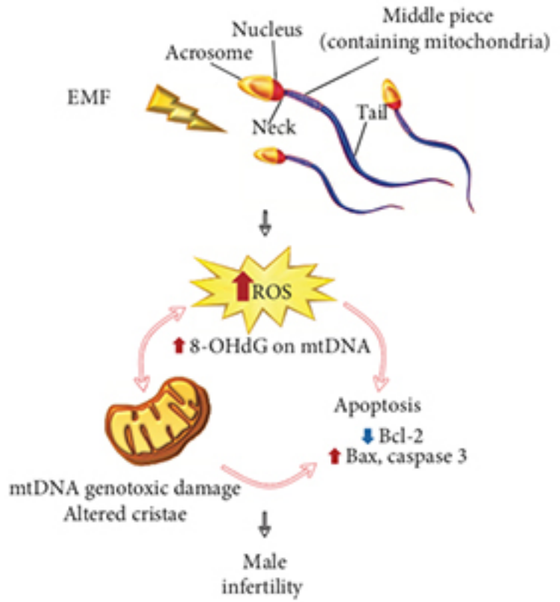

FIGURE 1: Involvement of oxidative stress and mitochondrial dysfunction after EMF exposure in the male reproductive system. EMF: electromagnetic fields; ROS: reactive oxygen species; 8-OHdG: 8-hydroxy-2′-deoxyguanosine; Bcl-2: apoptosis regulator Bcl-2; Bax: Bcl-2-associated X protein.

On the other hand, growing evidence suggests that the damage induced by EMFs to reproductive cells and organs is caused by deregulation of redox homeostasis [140, 144–146, 149, 168, 180, 186, 187].

Based on in vitro studies, there is a general consensus on the effects of EMFs from mobile phones, laptops, and other electric devices on human sperm quality with possible negative influence on fertility [67, 113, 131–135, 189–192].

The role of mitochondria as one of the main targets of ELF- and RF-EMF exposure has emerged, especially in the male reproductive system. Indeed, these radiations seem to directly target the electron transport chain thus establishing mitochondrial dysfunctions and ROS overproduction, self-reinforced in a vicious cycle [103, 133, 154, 156, 159, 187].

According to recent data reported here [122, 146, 148], the strict link between EMF-related damage of reproductive systems and oxidative stress is reinforced by the observations of protective effects of antioxidant supplementations that require to be confirmed in humans. This approach, although still unexplored in the female reproductive system, could represent an important preventive strategy. A further criticism emerging from the literature is the difficulty to understand whether EMF-induced fertility abnormalities are caused by direct gonadal damage or by disruption of the hypothalamic-pituitary-gonadal axis. Indeed, most studies rely on total body exposure of small animals within cages. In this regard, the application of EMF-emitting devices to abdominal regions [183] or the use of large animal models may help to elucidate the mechanisms underlying ELF-EMF and RF biological effects, as suggested by Bernabò and colleagues [193]. This kind of approach would aid to clarify the impact of ELF-EMF and RF on human health, also considering the entry in our lives of the new 5G standard that may increase environmental EMF pollution.

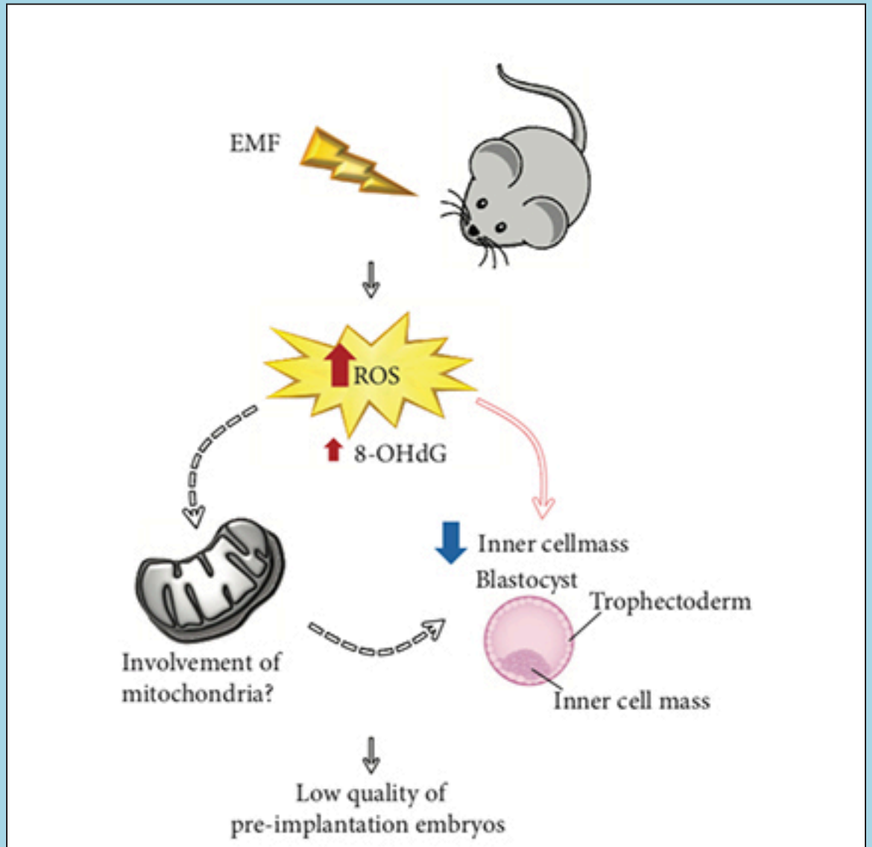

FIGURE 2: Involvement of oxidative stress and possible role of mitochondria-related pathways in embryos produced from females exposed to EMF. EMF: electromagnetic fields; ROS: reactive oxygen species; 8-OHdG: 8-hydroxy-2′-deoxyguanosine.

Finally, an interesting aspect of EMF-related biomedical research that has been poorly investigated regards what happens to reproductive cells and organs when the exposure to EMFs occurs in concomitance with other environmental pollutants. This issue would be of great interest since our everyday life is characterized by the continuous presence of some environmental agents (e.g., EMFs) and the sporadic or frequent occurrence of exposure to other chemicals and physical toxicants. In support to these concerns, Tenorio et al. [106] observed that the exposure to ELF-EMF after testis heat shock irreversibly damages the spermatogenic process. Thus, EMFs may represent a risk factor for fertility in males suffering from reversible testicular damage.

In conclusion, future and more standardized studies are needed in order to understand the molecular mechanisms underlying EMF challenge to reproductive systems and establish preventive strategies.

Conflicts Of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

NO ESCAPE


5G
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Andrologia • 2016

Radiofrequency Electromagnetic Radiation From Cell Phone Causes Defective Testicular Function In Male Wistar Rats

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Cell phones have become an integral part of everyday life. As cell phone usage has become more widespread, concerns have increased regarding the harmful effects of radiofrequency electromagnetic radiation from these devices. The current study was undertaken to investigate the effects of the emitted radiation by cell phones on testicular histomorphometry and biochemical analyses. Adult male Wistar rats weighing 180– 200 g were randomly allotted to control, group A (switched off mode exposure), group B (1-hr exposure), group C (2-hr exposure) and group D (3-hr exposure). The animals were exposed to radiofrequency electromagnetic radiation of cell phone for a period of 28 days. Histomorphometry, biochemical and histological investigations were carried out. The histomorphometric parameters showed no significant change ($p < .05$) in the levels of germinal epithelial diameter in all the experimental groups compared with the control group. There was no significant change ($p < .05$) in cross-sectional diameter of all the experimental groups compared with the control group. Group D rats showed a significant decrease ($p \sim .05$) in lumen diameter compared with group B rats. There was an uneven distribution of germinal epithelial cells in groups B, C and D. However, there was degeneration of the epithelia cells in group D when compared to the control and group B rats. Sera levels of malondialdehyde (MDA) and superoxide dismutase (SOD), which are markers of reactive oxygen species, significantly increased (MDA) and decreased (SOD), respectively, in all the experimental groups compared with the control group. Also sera levels of gonadotropic hormones (FSH, LH and testosterone) significantly decreased ($p < .05$) in groups C and D compared with the control group.

Conclusion

The study suggests that chronic exposure to radiofrequency electromagnetic radiation of cell phone leads to defective testicular function that is associated with increased oxidative stress and decreased gonadotropic hormonal profile.

"The study demonstrates that chronic exposure to radiofrequency electromagnetic radiation of cell phone leads to defective testicular function that is associated with increased oxidative stress and decreased gonadotropic hormonal profile."

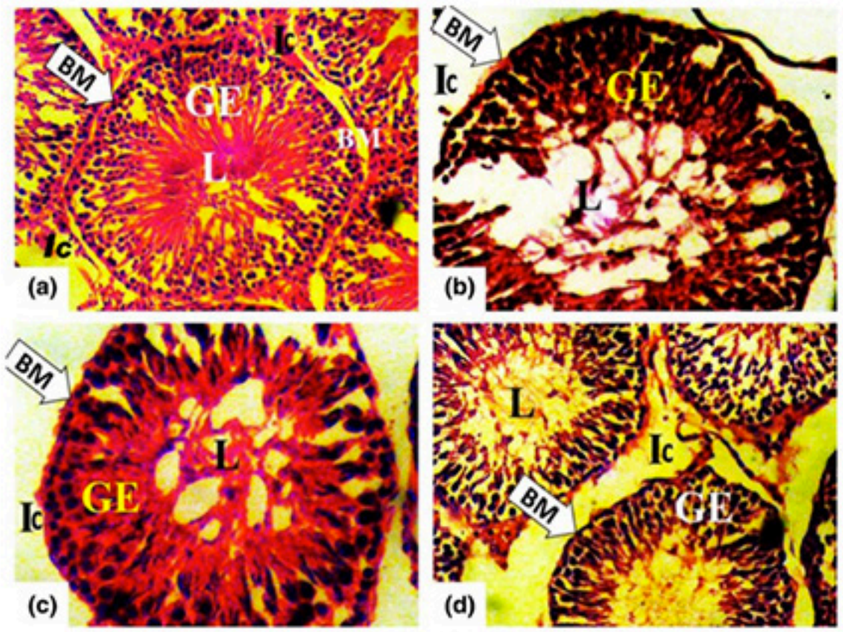

FIGURE 1 Effect of RF-EMR emitted from cell phone on the histology of testes of the male rats. Group a (Control rats) shows normal interstitium (IC), lumen (L), basement membrane (BM) and germinal epithelium (GE), group b (1-hr exposure) shows deleterious IC, L, BM and GE, group c (2-hr exposure) shows connective tissue degeneration, luminal vacuolation, distorted IC, L, BM and GE and group d (3-hr exposure) shows severe cellular necrosis, luminal vacuolation, deleterious IC, BM, GE and connective tissue degeneration. (H & E paraffin stain; ×400, Longitudinal section)

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Effects Of 1950 MHz Radiofrequency Electromagnetic Fields On Aβ Processing In Human Neuroblastoma And Mouse Hippocampal Neuronal Cells

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Alzheimer's disease (AD) is a neurodegenerative disease leading to progressive loss of memory and other cognitive functions. One of the well-known pathological markers of AD is the accumulation of amyloid-beta protein (Aβ), and its plaques, in the brain. Recent studies using Tg-5XFAD mice as a model of AD have reported that exposure to radiofrequency electromagnetic fields (RF-EMF) from cellular phones reduced Aβ plaques in the brain and showed beneficial effects on AD. In this study, we examined whether exposure to 1950 MHz RF-EMF affects Aβ processing in neural cells. We exposed HT22 mouse hippocampal neuronal cells and SH-SY5Y human neuroblastoma cells to RF-EMF (SAR 6 W/kg) for 2 h per day for 3 days, and analyzed the mRNA and protein expression of the key genes related to Aβ processing. When exposed to RF-EMF, mRNA levels of APP, BACE1, ADAM10 and PSEN1 were decreased in HT22, but the mRNA level of APP was not changed in SH-SY5Y cells. The protein expression of APP and BACE1, as well as the secreted Aβ peptide, was not significantly different between RF-EMF–exposed 7w-PSML, HT22 and SH-SY5Y cells and the unexposed controls. These observations suggest that RF-EMF exposure may not have a significant physiological effect on Aβ processing of neural cells in the short term. However, considering that we only exposed HT22 and SH-SY5Y cells to RF-EMF for 2 h per day for 3 days, we cannot exclude the possibility that 1950 MHz RF-EMF induces physiological change in Aβ processing with long-term and continuous exposure.

Keywords:
1950 MHz radiofrequency electromagnetic fields (RF-EMF), Alzheimer's disease
Aβ processing, mouse hippocampal neuronal cell line
human neuroblastoma cell line, CHO cell–based 7w-PSML cell line

Scientific Reports May 2014

Exposure To 1800 MHz Radiofrequency Radiation Impairs Neurite Outgrowth Of Embryonic Neural Stem Cells

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A radiofrequency electromagnetic field (RF-EMF) of 1800 MHz is widely used in mobile communications. However, the effects of RF-EMFs on cell biology are unclear. Embryonic neural stem cells (eNSCs) play a critical role in brain development. Thus, detecting the effects of RF-EMF on eNSCs is important for exploring the effects of RF-EMF on brain development. Here, we exposed eNSCs to 1800 MHz RF-EMF at specific absorption rate (SAR) values of 1, 2, and 4 W/kg for 1, 2, and 3 days. We found that 1800 MHz RF-EMF exposure did not influence eNSC apoptosis, proliferation, cell cycle or the mRNA expressions of related genes. RF-EMF exposure also did not alter the ratio of eNSC differentiated neurons and astrocytes. However, neurite outgrowth of eNSC differentiated neurons was inhibited after 4 W/kg RF-EMF exposure for 3 days. Additionally, the mRNA and protein expression of the proneural genes Ngn1 and NeuroD, which are crucial for neurite outgrowth, were decreased after RF-EMF exposure. The expression of their inhibitor Hes1 was upregulated by RF-EMF exposure. These results together suggested that 1800 MHz RF-EMF exposure impairs neurite outgrowth of eNSCs. More attention should be given to the potential adverse effects of RF-EMF exposure on brain development. Image on following page.

Acknowledgments
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Author contributions
Conceived and designed the experiments: C.C. and Z.Z. Performed the experiments: C.C., Q.M., C.L., P.D., G.Z., L.Z., M.H., Y.L., W.D., L.P. and M.L.; Analysed the data and performed the statistical analysis: C.C. and Q.M. Helped analysed the data and provided critical strategic advice Z.Y. and Z.Z. Wrote the paper: C.C.

Additional information

Supplementary information accompanies this paper at http://www.nature.com/ scientificreports

Competing financial interests: The authors declare no competing financial interests.

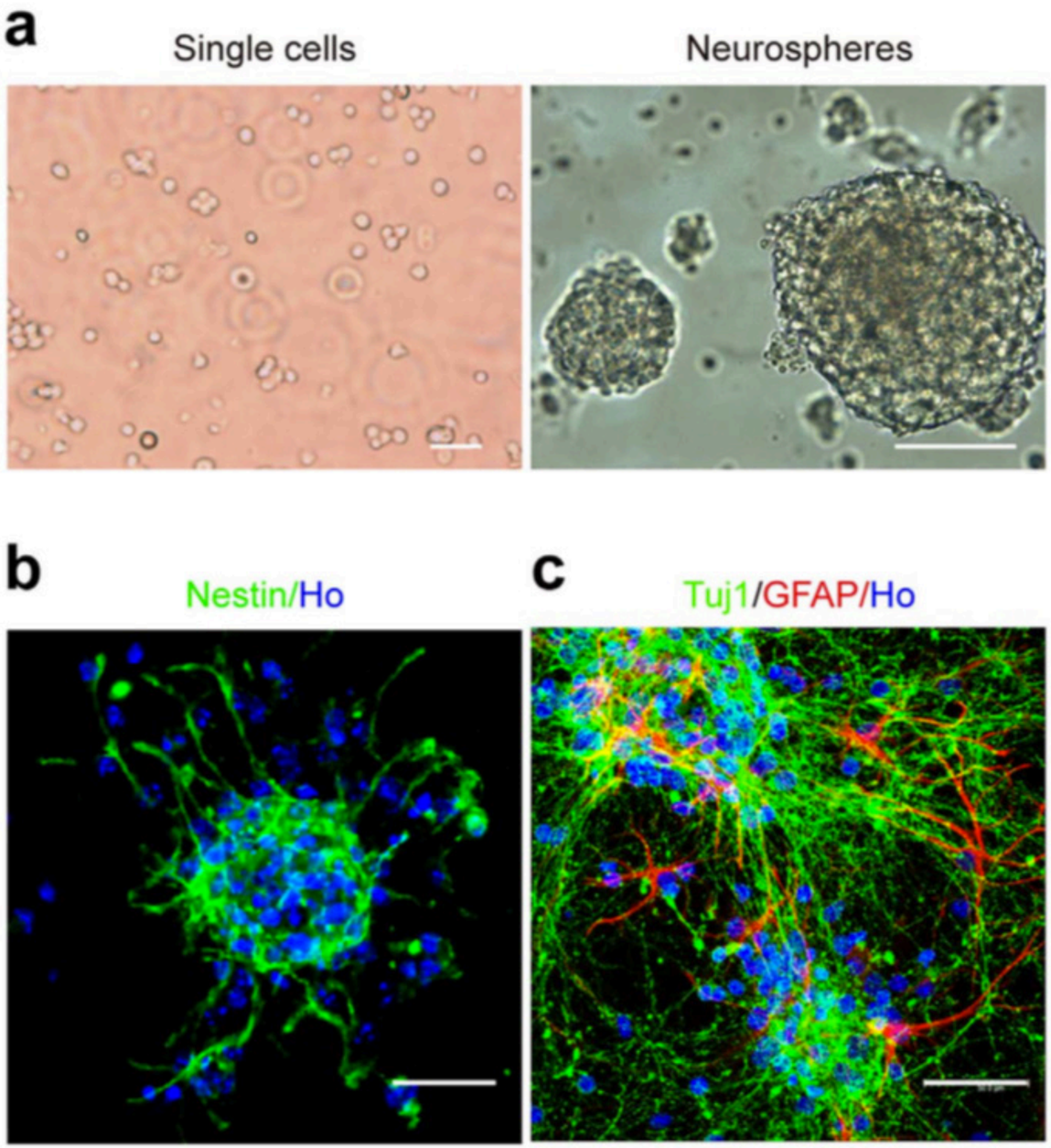
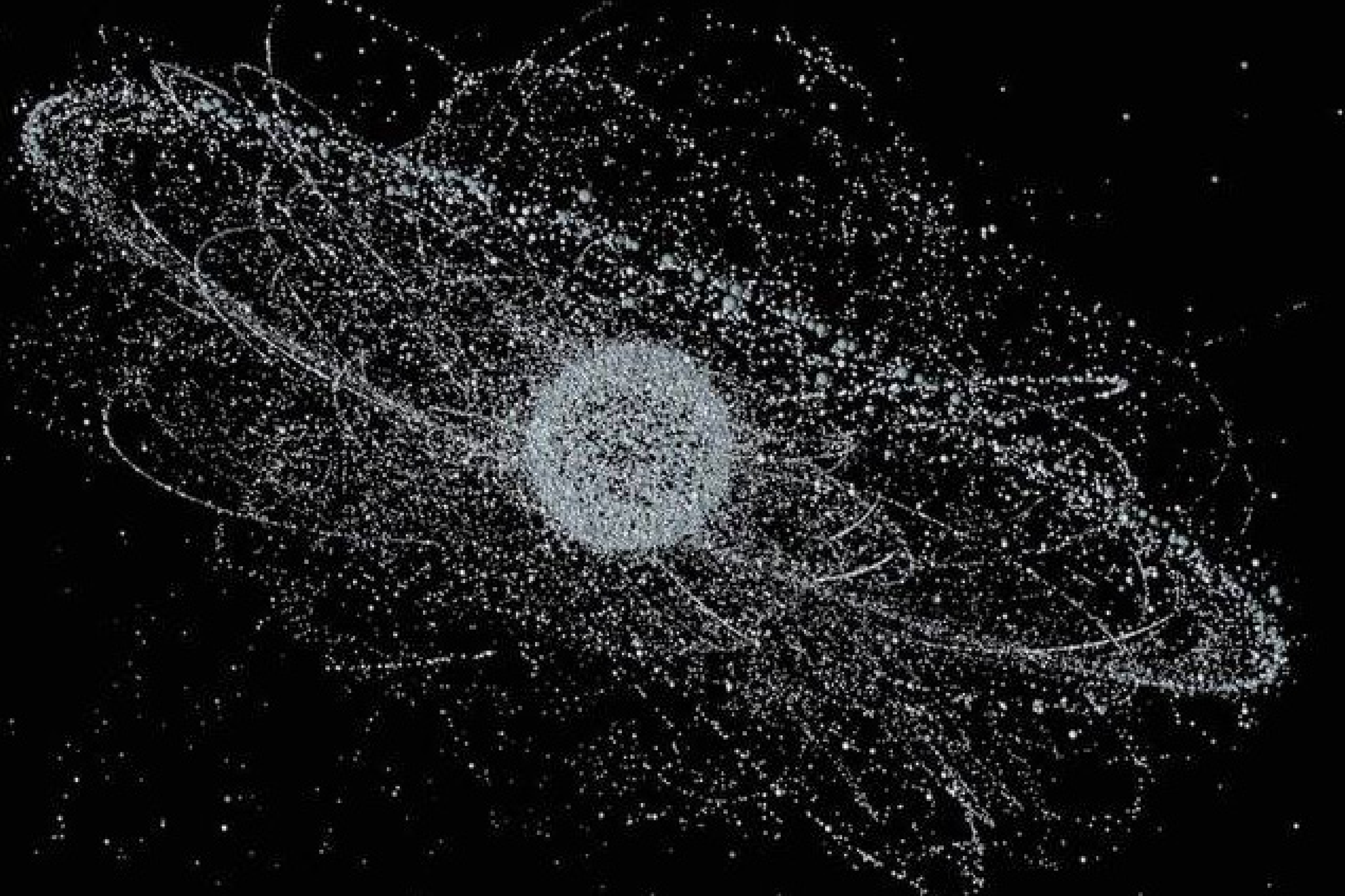


Figure 1 | eNSC culture and identification. (a) The isolated single cells from E13.5 mouse telencephalons. (b) The cultured cells formed neurospheres at 6 days *in vitro*. (c) The cultured cells were Nestin positive. (d) The cultured cells can differentiated into Tuj1+ and GFAP+ cells *in vitro*. Scale bar: 50 μm.

SPACE JUNK

FROM A CROWDED PLANET



Clean Spacecraft Operations
Explosions: 36

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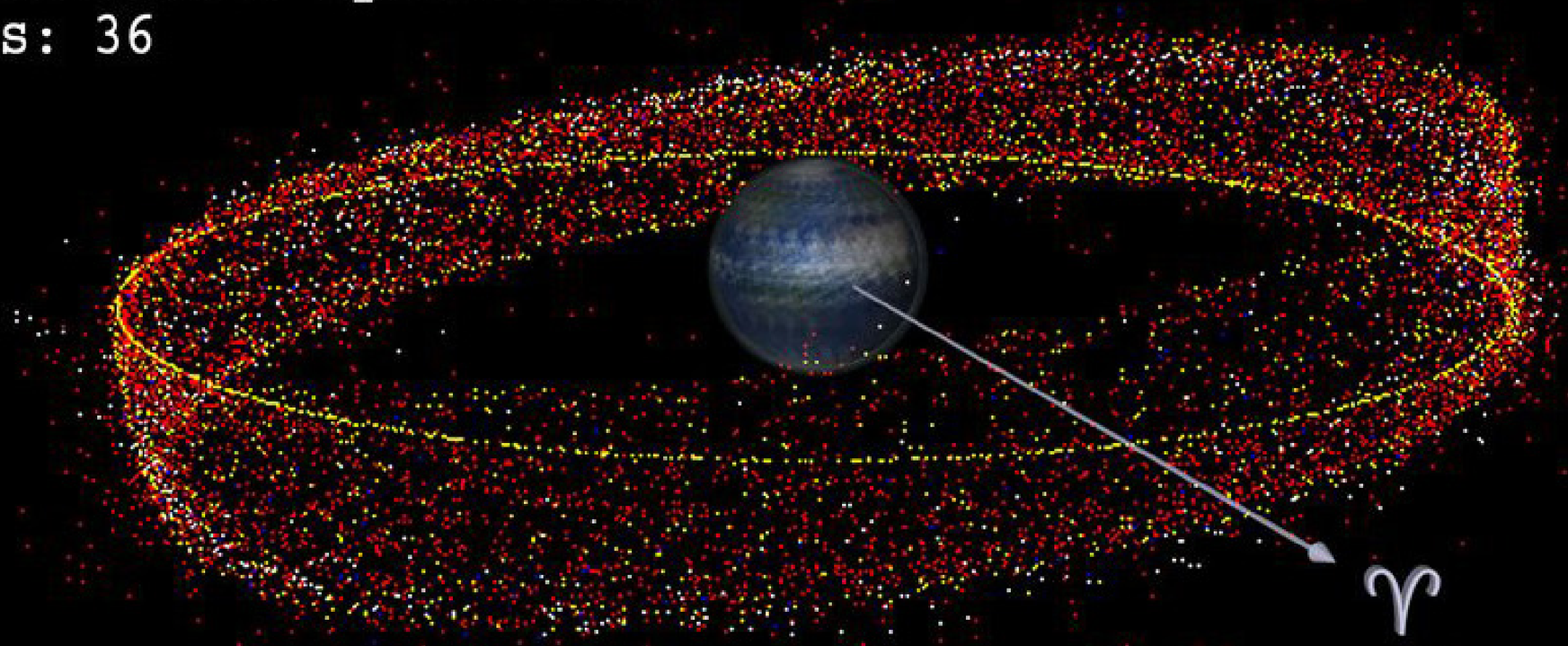
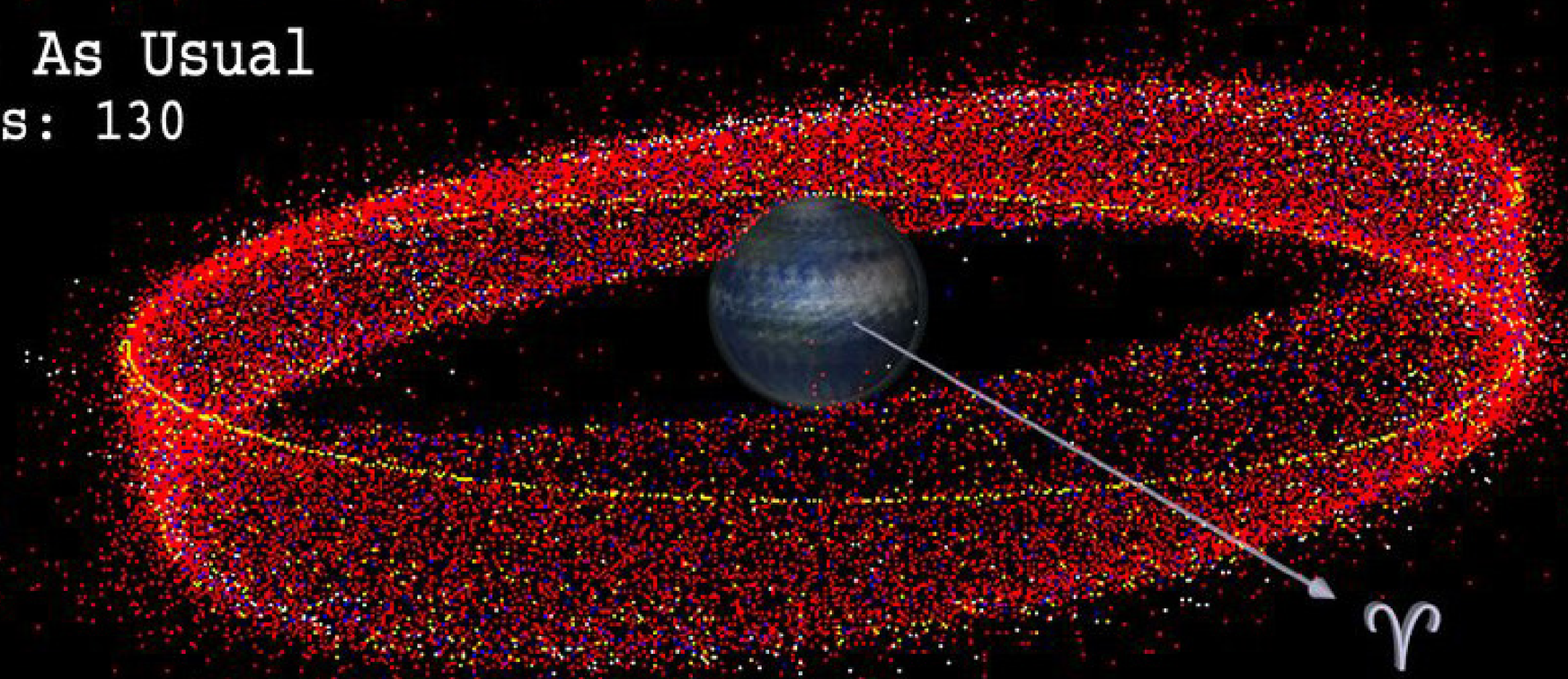
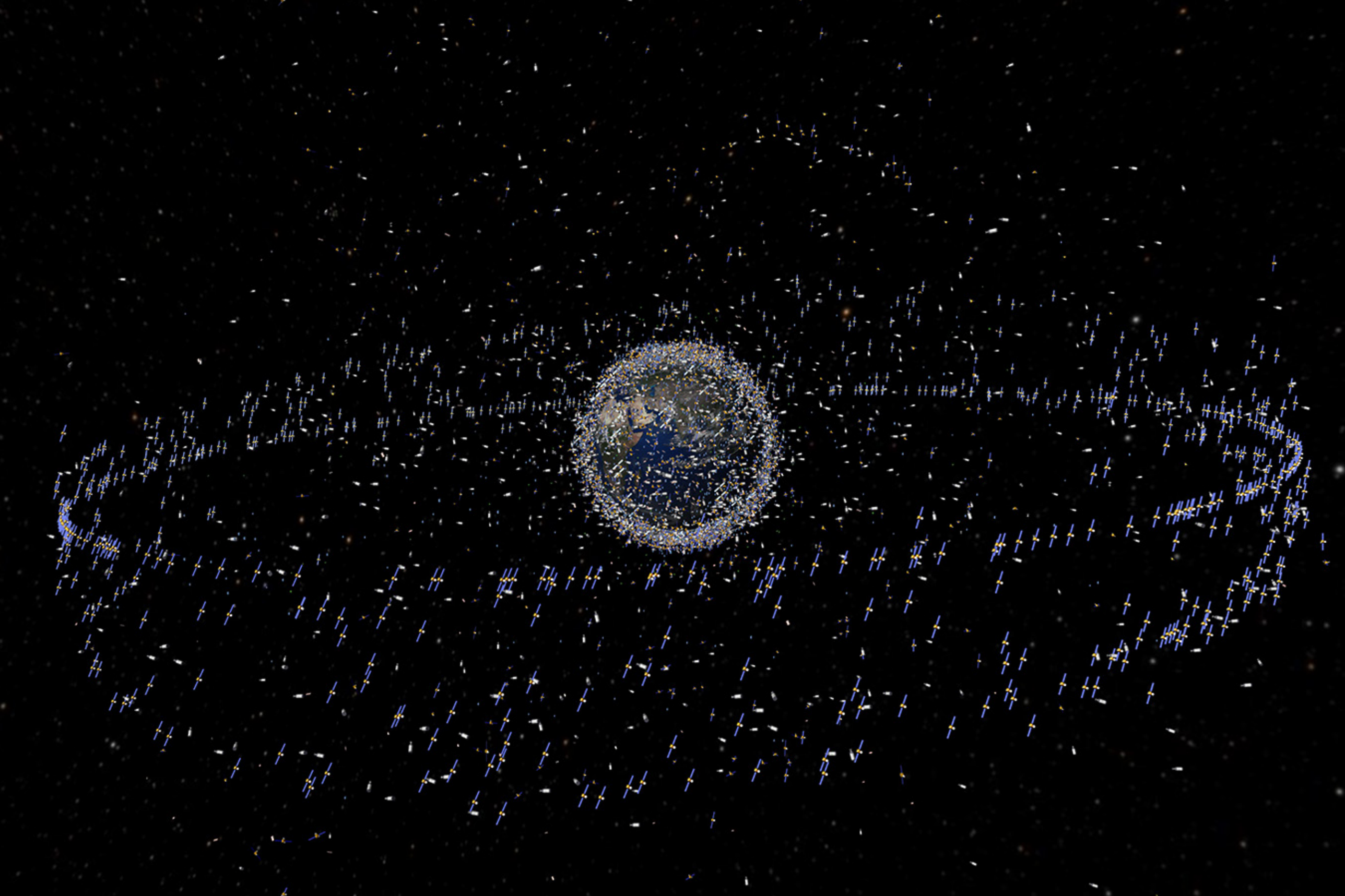
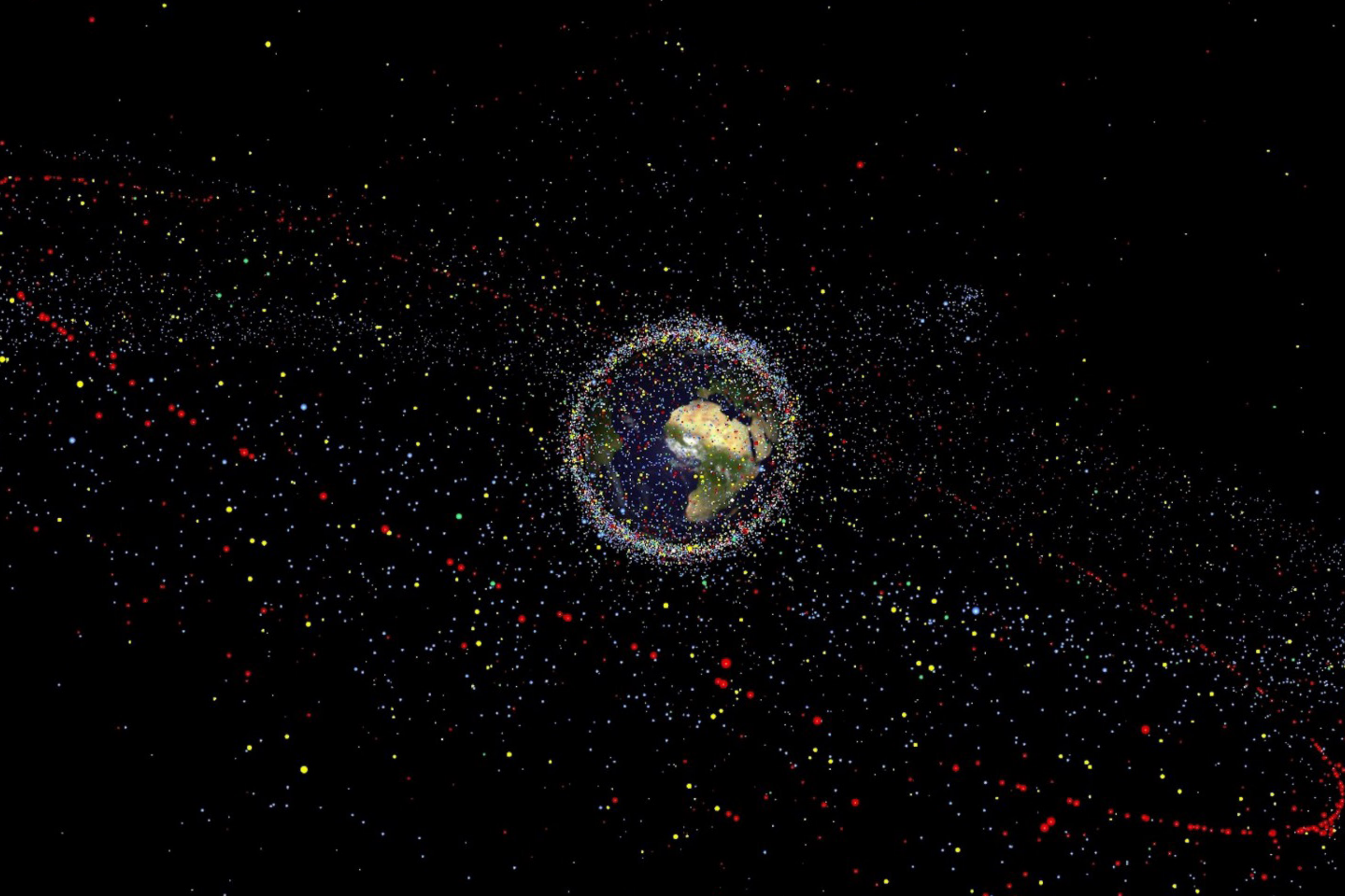


Business As Usual
Explosions: 130



Satellites Mission-related objects Explosion Fragments First Explosion





WITH OVER 20,000 MORE SATELLITES

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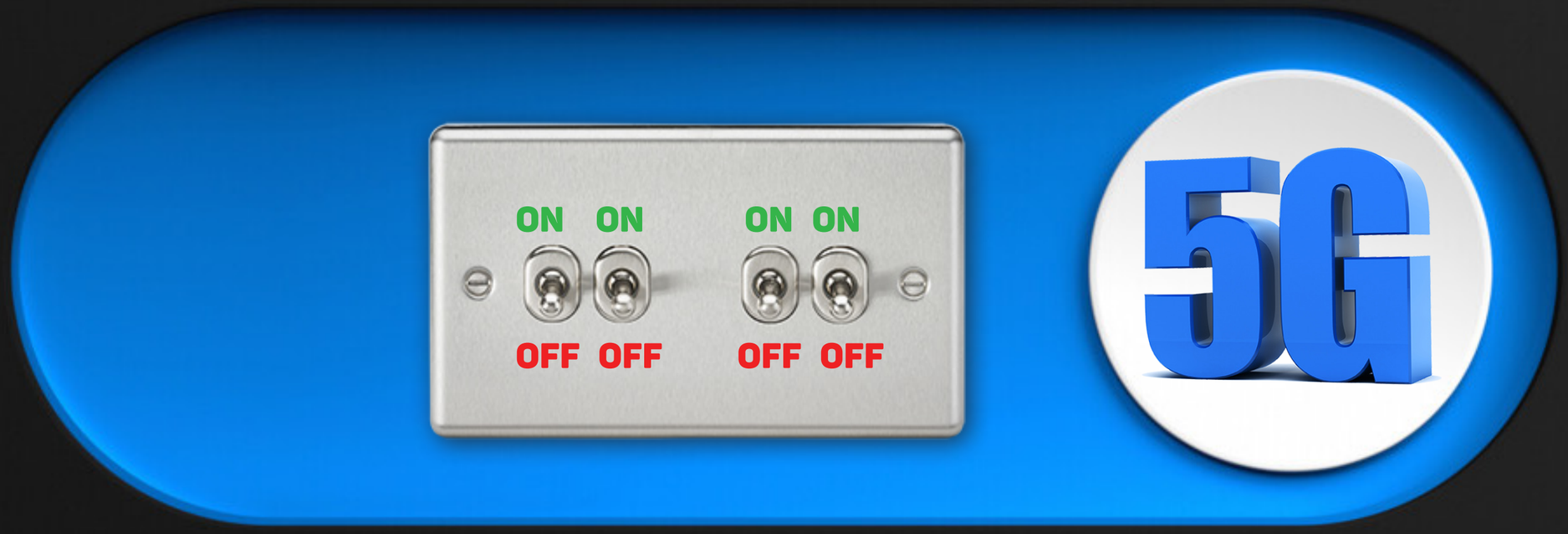
NEAR YOU ...

AND



MASS CIVIL ACTION REQUIRED

NO ESCAPE

A Radiation Inspired Jeff Prager Publication • April 2019 • For Camy, Syrena and Illiana

IMAGE: Japanese Housing