Complainant Exhibits
Docketed per ALJ Request

Liza Mousios	:	
	:	C-2019-3007989
v.	:	
	:	
Metropolitan Edison Company	:	
	:	
Roy Cumming	:	
	:	
v.	:	C-2019-3007995
	:	
Metropolitan Edison Company	:	

a. Complainant Exhibit 1- CNX Effects-Enzymes Article
b. Complainant Exhibit 2 – Millimeter Waves Power Active Control Weapon Flyer
c. Complainant Exhibit 3 – Letter – Woodlands Healing Research Center
d. Complainants Exhibit 4 – Resume William Bathgate
e. Complainant Exhibit 5 – Self-Reporting of Symptom Development From Exposure to Radiofrequency Fields of Wireless Smart Meters in Victoria, Australia: A Case Series Article
f. Complainant Exhibit 6 -Document "Cell Phone Tower Tinnitus"
g. Complainant Exhibit 7 - Electrohypersensitivity as a Newly Identified and Characterized Neurologic Pathological Disorder: How to Diagnose, Treat, and Prevent It Article

Complaint Exhibit 1

From: **PA SafeTech** pasafetech@gmail.com
Subject: Research
Date: January 10, 2020 at 8:14 AM
To: Liza Mousios cumming@epix.net

CNS Effects - Enzymes

- EMFs modify hydrogen bonds
  → Affecting
  - Hippocampus
  - Cholinergic System
  - GABA
- Structural changes to many enzymes
  - Cytochrome p450-reductase
  - AchE – enzyme that catalyzes hydrolysis of acetylcholine. Affects learning and wakefulness

Author-Year	Frequency- Intensity-Time	Model-Effect
Testylier [2002]	Low intensity EMR.	Rats. modification of the hippocampal cholinergic system.
Bartieri [2005]	EMR exposure.	Structural and biochemical changes in AchE
Vorobyov [2004]	Repeated exposure to low-level extremely low frequency-modulated EMR	Freely moving rats. baseline and scopolamine-modified EEG.
Mausset [2001]	4 W kg	Rat. decrease in GABA. an inhibitory transmitter. content in the cerebellum.
Maussset-Bonnefont [2004]	Acute GSM 900-MHz exposure at 6 W kg	Rat brain. changes in affinity and concentration of NMDA and GABA receptors.
Wang [2005]	900 MHz.	Cultured rat hippocampal neurons. changes in GABA receptors and reduced excitatory synaptic activity.
Xu [2006]	GSM 1800-MHz.	Cultured hippocampal neurons. number of excitatory synapses.
Lopez Martin [2006]	GSM signal.	Rats given subconvulsive doses of picotoxin. a drug that blocks the GABA system. seizure facilitated.
Beason and Semm [2002]	GSM signal.	Birds. increase and decrease in firing rates.

Health Effects of Electromagnetism - McGill Course OCCH-605. January 2019. Dr. Paul Heroux - http://www.invitroplus.mcgill.ca

US Air Force Rome Laboratory – Sleep Effects

v. Analeptic Effect in Animals

Pulsed RF/MW radiation was reported to have an analeptic effect in laboratory animals. Experimental results presented by R. D. McAfee in 1971 showed that anethesized animals could be awakened by irradiation from a pulsed 10 GHz RF/MW source. The energy incident on the test animals was estimated to have a power density of between 20-40 mW/cm^2. Experiments conducted on rats showed that these animals were aroused from

states of deep sleep by irradiation. It was observed that the blood pressure of a rat decreased simultaneously with the arousal response and that laryngeal spasms would occur when the rat was awakened. McAfee reported that the laryngeal spasms would obstruct the airway causing convulsions, asphyxiation, and eventually death. Other experiments performed on rabbits, cats, and dogs showed that these animals could also be awakened by irradiation.

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al response was
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that the

Animals were aroused from states of deep sleep by irradiation with pulsed RF/MW

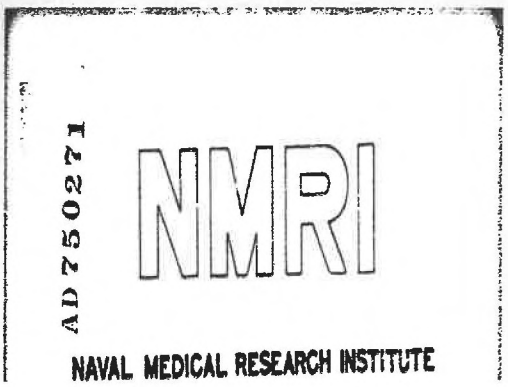
10

Bolen, S. M. (1994). Radiofrequency Microwave Radiation Biological Effects and safety standards: a review (No. RL-TR-94-53). ROME LAB ROME NY.

Neurologic Effects of RFR/MW

1971 U.S. Naval Report

- Headaches
- Insomnia, restlessness, fatigue
- EEG changes/seizures
- Memory loss
- Cranial nerve disorders
- Sympathetic and parasympathetic N.S. changes
- Depression, impotence, anxiety, irritability, anorexia, dizziness
- Insomnia, hallucinations



BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION

Zorach R. Glaser, Ph.D.
LT, MSC, USNR

Glaser, Z. (1971). Bibliography of reported biological phenomena ('effects') and clinical manifestations attributed to microwave and radiofrequency radiation. Naval Medical Research Institute Research Report Project MF12. 524.015-0004B. Res. Inst., Nat. Naval Med. Center, Bethesda, Md.

From: **PA SafeTech** pasafetech@gmail.com
Subject: Papers
Date: January 10, 2020 at 8:13 AM
To: Liza Mousios cumming@epix.net

adiofrequency radiation emitted from Wi-Fi (2.4 GHz) causes impaired insulin ecretion and increased oxidative stress in rat pancreatic islets

i Masoumi[a], Narges Karbalaei[a,b], S. M. J. Mortazavi[c] and Mohammad Shabani[d]

epartment of Physiology, Faculty of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran; [b]Histomorphometry and Stereology Research Center, Shiraz University of Medical Sciences, Shiraz, Iran; [c]Medical Physics and Medical Engineering Department, Faculty of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran; [d]Neuroscience Research Center, Neuropharmacology Institute, Kerman University of Medical Sciences, Kerman, Iran

Masoumi, A., Karbalaei, N., Mortazavi, S., & Shabani, M. (2018). Radiofrequency radiation emitted from Wi-Fi (2.4 GHz) causes impaired insulin secretion and increased oxidative stress in rat pancreatic islets. *International Journal of Radiation Biology, 94(9), 850-857.*

ABSTRACT

Purpose: There is a great concern regarding the possible adverse effects of electromagnetic radiation (EMR). This study investigated the effects of EMR induced by Wi-Fi (2.45 GHz) on insulin secretion and antioxidant redox systems in the rat pancreas.

Materials and methods: Adult male Sprague–Dawley rats in the weight range of 230–260g were divided into control, sham, Wi-Fi exposed groups. After long term exposure (4 h/day for 45 days) to Wi-Fi EMR, plasma levels of glucose and insulin during intraperitoneal glucose tolerance test were measured. Islet insulin secretion and content, lipid peroxidation and antioxidant status in pancreas of rats were determined.

Results: Our data showed that the weight gain in the Wi-Fi exposed group was significantly lower than the control group (p < .05). Wi-Fi (2.45 GHz) exposed group showed hyperglycemia [illegible] level and glucose-stimulated insulin secretion from pancreatic islet were significantly [illegible] Wi-Fi exposed group. EMR emitted from Wi-Fi caused a significant increase in lipid per[illegible] significant decrease in GSH level, SOD and GPx activities of the pancreas.

Conclusions: These data showed that EMR of Wi-Fi leads to hyperglycemia, increased [illegible] and impaired insulin secretion in the rat pancreatic islets.

"Wi-Fi leads to hyperglycemia, ncreased oxidative stress and mpaired insulin secretion"

Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals

Myriam Ben Salah[a,*], *Hafedh Abdelmelek*[a], *Manef Abderraba*[b]

"RF Exposure induced a diabetes like status"

ARTICLE INFO

Article history:
Received [illegible] March 2013
Received in revised form [illegible] July 2013
Accepted [illegible] 2013
Available online [illegible] August 2013

Keywords:
Radio frequencies
Metabolism
Oxidative stress

ABSTRACT

[illegible] Our investigations suggested that RF exposure induced a diabetes-like status through alteration of oxidative response. Olive leaves extract was able to correct glucose metabolism disorder by minimizing oxidative stress induced by RF in rat tissues.

Salah, M. B., Abdelmelek, H., & Abderraba, M. (2013). Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals. *Environmental Toxicology and Pharmacology, 36(3), 826-834.*

Original Article

Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health

American Journal of Men's Health
[illegible]
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DOI: [illegible]
journals.sagepub.com/home/jmh
SAGE

Sultan Ayoub Meo, MBBS, PhD[1], Mohammed Almahmoud, MBBS[1], Qasem Alsultan, MBBS[1], Nawaf Alotaibi, MBBS[1], Ibrahim Alnajashi, MBBS[1], and Waseem M. Hajjar, MD, FRCS[2]

Conclusion: Significant impairment in motor

Abstract

The use of mobile phones has remarkably increas
of mobile phones boost the installation of mobile
residential areas including near school buildings.
electromagnetic field (RF-EMF) radiation generate
volunteer male students aged between 13 and 16
were from School 1 and 93 students were from 5
buildings. In School 1, RF-EMF was 2.019 μW/cm²
μW/cm² with a frequency of 925 MHz. Students
period of 2 years. The Narda Safety Test Solution
cognitive functions tasks were measured by the Cambridge Neuropsychological Test Automated Battery (CANTAB).
Significant impairment in Motor Screening Task (MOT; p = .03) and Spatial Working Memory (SWM task (p = .04)
was identified among the group of students who were exposed to high RF-EMF produced by MPBSTs. High exposure
to RF-EMF produced by MPBSTs was associated with delayed fine and gross motor skills, spatial working memory, and
attention in school adolescents compared to students who were exposed to low RF-EMF.

screening task and spatial working memory was identified among the group of students exposed to the high RF-EMF from mobile phone base station.

Meo, S. A., Almahmoud, M., Alsultan, Q., Alotaibi, N., Alnajashi, I., & Hajjar, W. M. (2019). Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health. *American Journal of Men's Health.*

Li, Y., & Héroux, P. (2014). Extra-low-frequency magnetic fields alter cancer cells through metabolic restriction. *Electromagnetic Biology and Medicine, 33(4), 264-275.*

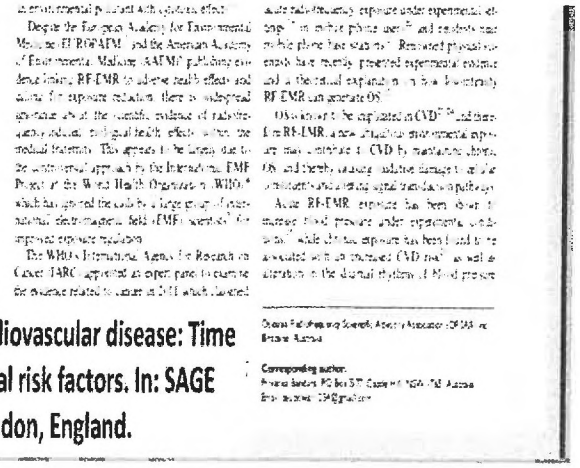
- OBJECTIVES: Examine the effect of ELF-MFs on cancer cells.
- METHODS: Five cancer cell lines were exposed to ELF-MFs within the range of 0.025 to 5 μT, and the cells were examined for karyotype changes after 6 days.
- CONCLUSIONS: **The biological effects of MFs are connected to an alteration in the structure of water that impedes the flux of protons in ATPS channels. These results may be environmentally important, in view of the central roles played in human physiology by ATPS and AMPK, particularly in their links to diabetes, cancer and longevity.**

Oxidative Stress - Definitions

- Redox (reduction-oxidation) reactions are at core of human metabolism
  - Involve the transfer of electrons or hydrogen atoms from one reactant to another
  - Oxidation - taking away an electron (because oxygen does it so well)
  - Reduction - substance receiving electrons becomes reduced
- Free Radical - molecule containing a single unpaired electron
  - Reaction of a radical with non radical→chain reaction generating a new radical. Most molecules in body are stable (non radicals), therefore excessive ROS must be controlled by antioxidants.
  - ROS damage what they collide with seeking electrons (proteins, fats, DNA)

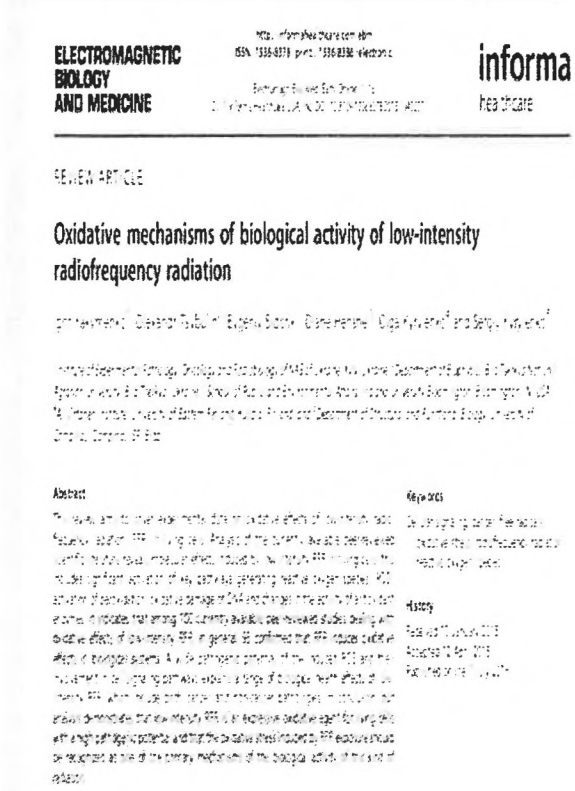
McCord, J. M. (2000). The evolution of free radicals and oxidative stress. *The American journal of medicine, 108(8), 652-659.*

- **RF generates oxidative stress, which is implicated in CVD**
- RF may contribute to CVD via oxidative cellular damage



Bandara, P., & Weller, S. (2017). Cardiovascular disease: Time to identify emerging environmental risk factors. In: SAGE Publications Sage UK: London, England.

RFR Causes Oxidative Stress



ELECTROMAGNETIC BIOLOGY AND MEDICINE

informa healthcare

REVIEW ARTICLE

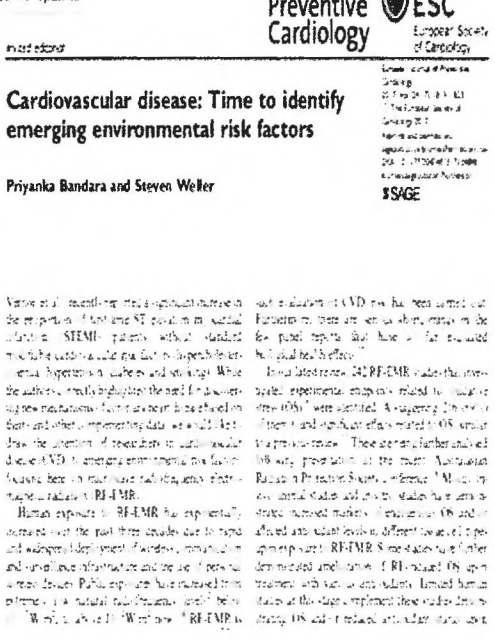
Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation

- Review of 100 available peer reviewed studies of oxidative effects of low intensity RFR
- 93/100 confirmed that RFR induces oxidative effects in biological systems
- **Conclusion: Low intensity RFR is an oxidative agent for living cells with a high pathogenic potential**

ıkymenko, I., Tsybulin, O., Sidorik, E., Henshel, D., Kyrylenko, O., & Kyrylenko, S. .016). Oxidative mechanisms of biological activity of low-intensity diofrequency radiation. *Electromagnetic Biology and Medicine, 35(2), 186-202.*

:MFs – An Emerging Risk Factor or Cardiovascular Disease

- Increasing proportion of ST elevation MI patients lack traditional cardiac risk factors (Vernon ST, *Eur J Prev Cardiol* 2017)
- RF is an environmental pollutant with cytotoxic effects



Check for updates

European Journal of Preventive Cardiology

ESC European Society of Cardiology

Invited editorial

Cardiovascular disease: Time to identify emerging environmental risk factors

Priyanka Bandara and Steven Weller

SAGE

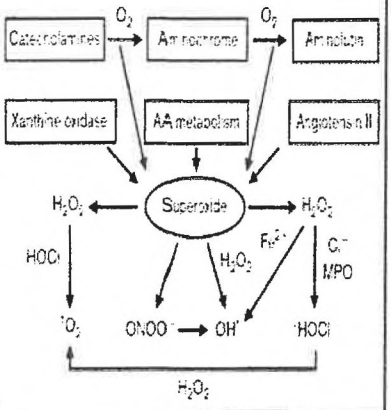
$NO^{\bullet}$	Nitric oxide
$NO_2^{\bullet}$	Nitrogen dioxide
$ONOO^-$	Peroxynitritre
$CCl_3^{\bullet}$	Trichloromethyl
Non-radicals	
H_2O_2	Hydrogen peroxide
HOCl	Hypochlorous acid
$ONOO^-$	Peroxynitrite
$^1O_2$	Singlet oxygen

halla, N. S., Temsah, R. M., & Netticadan, T. 2000). Role of oxidative stress in cardiovascular iseases. *Journal of Hypertension, 18(6), 655-673.*

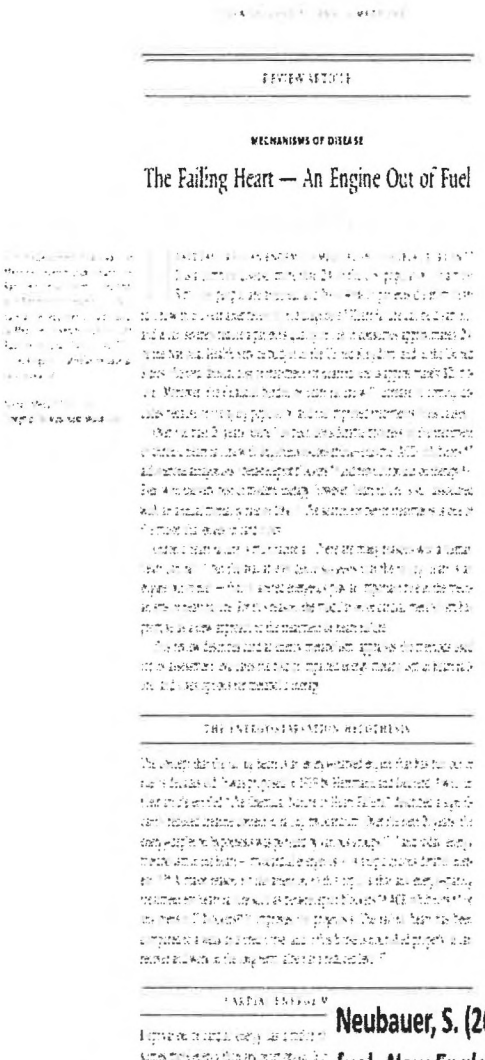
$2GSH + H_2O_2 \rightarrow GSSG + 2H_2O$

$2GSH + ROOH \rightarrow GSSG + ROH + 2H_2O$

Nonenzymatic scavengers
Vitamin A
Vitamin C (ascorbic acid)
Vitamin E (α-tocopherol)
β-carotene
Cysteine
Coenzyme Q
Uric acid
Falvonoids
Sulfhydryl group
Thioether compounds



The superscripted bold dot indicates an unpaired electron and the negative charge indicates a gained electron. GSH, reduced glutathione; GSSG, oxidized glutathione; R, lipid chain. Singlet oxygen is an unstable molecule due to the two electrons present in its outer orbit spinning in opposite directions.



REVIEW ARTICLE

MECHANISMS OF DISEASE

The Failing Heart — An Engine Out of Fuel

The Failing Heart
An Engine Out of Fuel

- Cardiac metabolism is heavily ATP dependent - Heart consumes more energy than any other organ – about 6 kg of ATP/day
- Activity of electron transport-chain complexes and ATP synthase capacity are reduced in heart failure. Therefore, insufficient ATP available for cardiac myocytes.
- **Author suggests (pharmacologic) stimulation of oxidative phosphorylation as future metabolic therapy for CHF**

Neubauer, S. (2007). The failing heart—an engine out of fuel. *New England Journal of Medicine, 356(11), 1140-1151.*

From: **PA SafeTech** pasafetech@gmail.com
Subject: Research
Date: January 10, 2020 at 8:12 AM
To: Liza Mousios cumming@epix.net

Microwave Effects – Small Versus Large Doses

Small doses increase parasympathetic tone

Higher dose increases sympathetic tone

"Dosage cannot be simply determined even under completely identical physical conditions (wavelength. type of transmitter, etc.) - the same dosage under otherwise equal conditions can cause parasympathetic reactions in one patient and sympathetic reactions in another"

"The effect even differs in one and the same patients at different times"

Consequently, the dosage cannot be based on the principle of measuring the energy absorbed by the body, but must also be based on the principle of measuring the reaction of the body to the absorbed energy.

	Dose	
	Small	Large
Galvanic skin resistance	Increases	Decreases
Blood pressure	Decreases	Increases
Vessels (capillaries)	Dilated	Constricted
EEG	High-frequency oscillations	"Slow" waves
Muscle tone	Decreases	Increases
Diuresis	Promoted	Inhibited
Pain symptoms	Reduced	Enhanced

Table 1. — Indications of the reactions of the autonomic systems with short-wave irradiation.

Bergman, W. (1965). *The Effect of Micro Waves on the Central Nervous System: Ford Motor Company.*

Role of oxidative stress in cardiovascular diseases

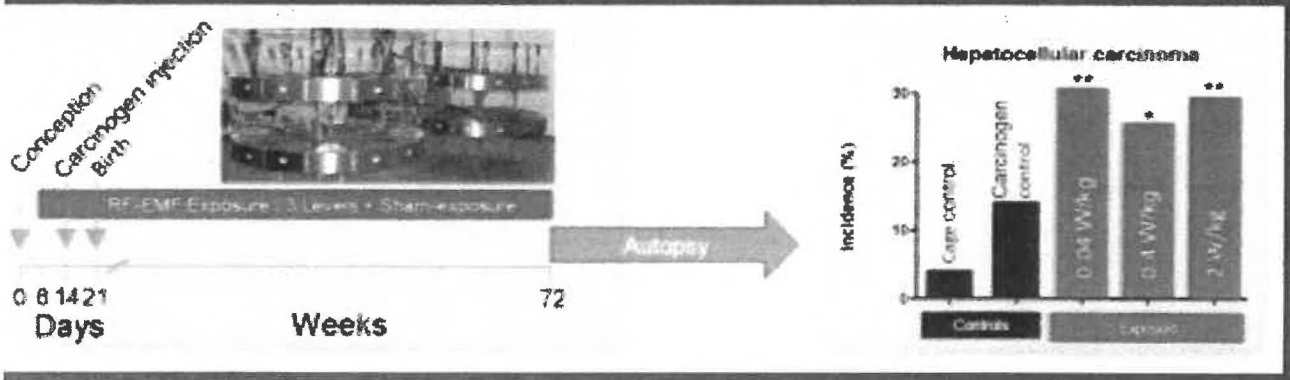
Naranjan S. Dhalla, Rana M. Temsah and Thomas Netticadan

Table 1 The cytotoxic reactive oxygen species and the natural defense mechanisms

Reactive oxygen species		Antioxidant defence mechanisms	
Free radicals		*Enzymatic scavengers*	
$O_2^{\bullet-}$	Superoxide anion radical	SOD	Superoxide dismutase
$OH^{\bullet}$	Hydroxyl radical		$2O_2^{\bullet-} + 2H^{\cdot} \rightarrow H_2O_2 + O_2$
$ROO^{\bullet}$	Lipid peroxide (peroxyl)	CAT	Catalase (peroxisomal-bound)
$RO^{\bullet}$	Alkoxyl		$2H_2O_2 \rightarrow O_2 + H_2O$
$RS^{\bullet}$	Thiyl	GTP	Glutathione peroxidase

From: **PA SafeTech** pasafetech@gmail.com
Subject: Please save me a list of these if you are typing them out.
Date: January 10, 2020 at 8:14 AM
To: Liza Mousios cumming@epix.net

RF Below Safety Limits Promotes Tumors
Mice: 24/7 RF Exposure, In Utero Eno
(A Replication Study)



Higher liver and lung tumors
2.5 fold increases in Lymphoma
Nonlinear effect "may be due to metabolic changes"

Lerchl 2015

"Our findings may help to understand the repeatedly reported increased incidences of brain tumors in heavy users of mobile phones"

ENVIRONMENTAL HEALTH TRUST

From: **PA SafeTech** pasafetech@gmail.com
Subject: **Please save me a list of these if you are typing them out.**
Date: **January 10, 2020 at 8:14 AM**
To: **Liza Mousios** cumming@epix.net

RF Below Safety Limits Promotes Tumors
Mice: 24/7 RF Exposure, In Utero Eno
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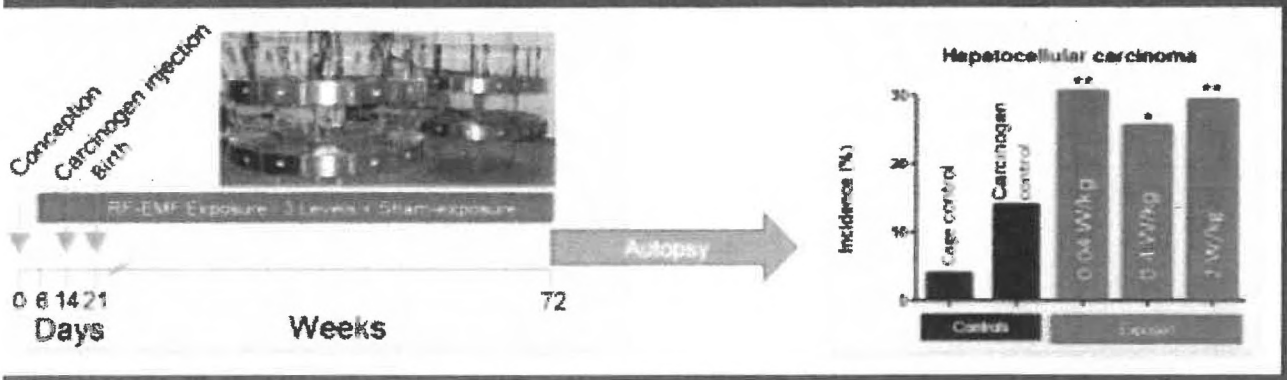


Higher liver and lung tumors
2.5 fold increases in Lymphoma
Nonlinear effect "may be due to metabolic changes"

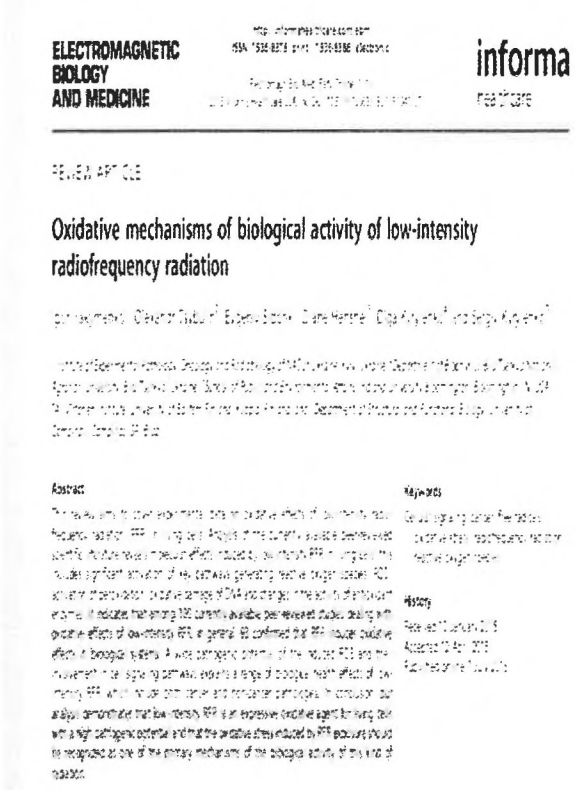
Lerchl 2015

"Our findings may help to understand the repeatedly reported increased incidences of brain tumors in heavy users of mobile phones"

ENVIRONMENTAL HEALTH TRUST

From: **PA SafeTech** pasafetech@gmail.com
Subject: Maybe duplicates
Date: January 10, 2020 at 8:21 AM
To: **Liza Mousios** cumming@epix.net

RFR Causes Oxidative Stress



ELECTROMAGNETIC BIOLOGY AND MEDICINE

informa

RESEARCH ARTICLE

Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation

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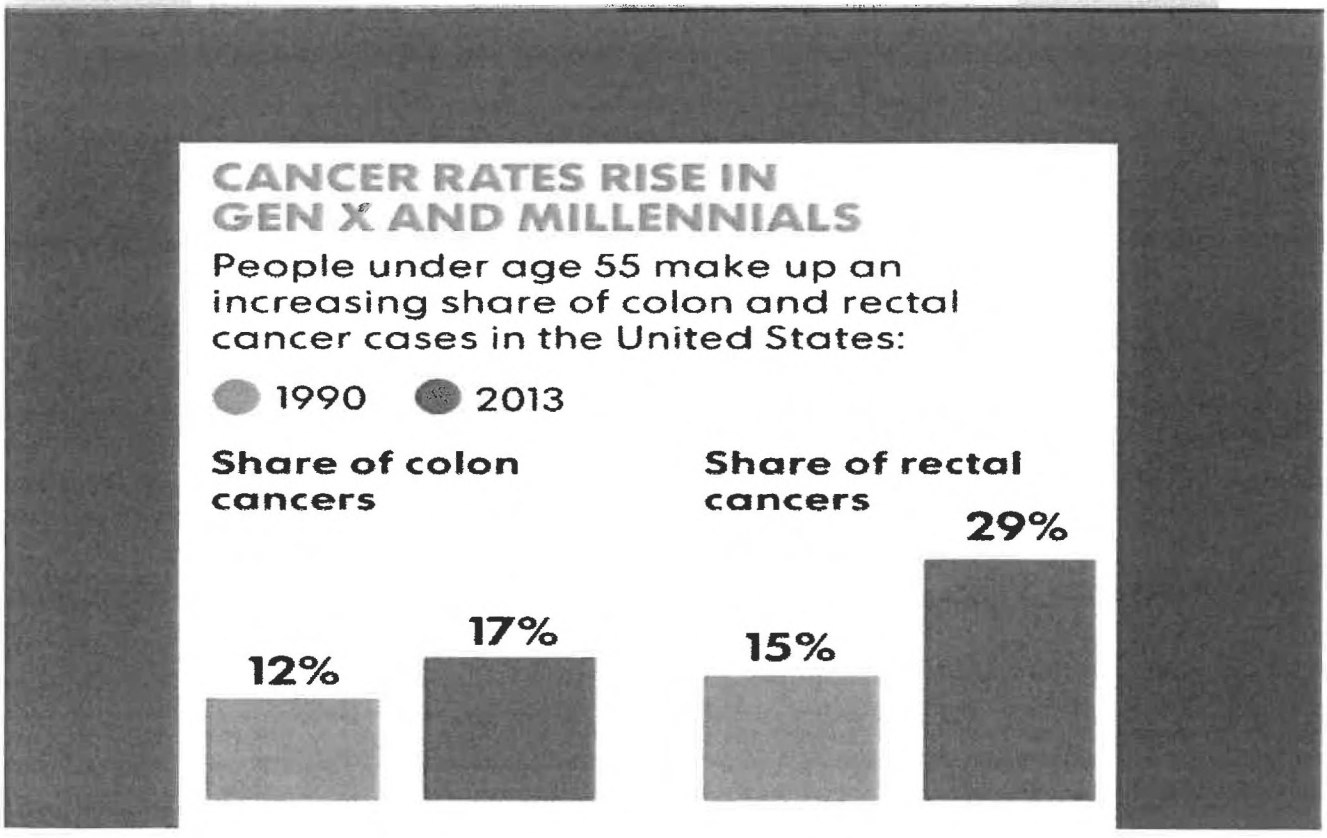
Stroke in the Young – An Epidemic

- George et al. (2017) reviewed U.S. hospitalization data from the National Inpatient Sample
- **Review of two large data sets (combined n=784,154 hospitalizations) showed significant increase in acute ischemic stroke (AIS) hospitalization rates for men and women**
- **Rates have nearly doubled for men aged 18-34 and 35-44 since 1995-1996.** Rates for older adults 55-64 have not changed from 2003-2004
- Trends are consistent with other studies

George, M. G., Tong, X., & Bowman, B. A. (2017). Prevalence of cardiovascular risk factors and strokes in younger adults. JAMA neurology, 74(6), 695-703.

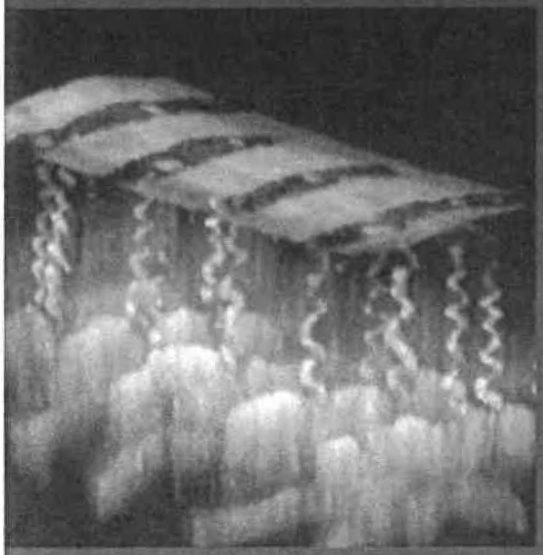


Complaint Exhibit 2

SOURCE

ENVIRONMENTAL HEALTH TRUST

Millimeter Waves Power Active Crowd Control Weapon



--Uniquely Interact With Skin

Sweat glands act as helical antennas that absorb millimeter frequencies
(Betzalel 2018)

A moratorium on the deployment of 5G is warranted..."

-Scientists Appeal to UN, 2015

Image: Lecture by Dr. Ben-Ishai and Dr. Yuri Feldman of the Spectroscopy Laboratory of the Department of Applied Physics, Hebrew University of Jerusalem

ENVIRONMENTAL HEALTH TRU

IMPACT OF RFR ON DNA DAMAGE & ANTIOXIDANTS IN PERIPHERAL BLOOD LYMPHOCYTES OF HUMANS RESIDING IN THE VICINITY OF MOBILE PHONE BASE STATIONS. (ZOTHANSIAMA ET AL. 2017)

- Study evaluated the effect of radiofrequency radiation from mobile phone base stations.

Compared residents- matched for demographics.

- Exposed group: Within 80 meters

- Control group: Over 300 meters

RF measurements ensured all RF levels were below India's limits (1/10 of ICNIRP)

Significant biological effects found on individuals closer to mobile base stations (within 80 meters).

- Alteration in antioxidant status in the plasma of exposed individuals
- Decreased glutathione concentration, activities of catalase, superoxide dismutase

Woodlands Healing Research Center
Family, Environmental & Preventive Medicine

Complaint Exhibit 3

01/12/2020

Liza Mousios
P O. Box 116
Revere, PA 18953-

To Whom It May Concern:

Since 1996, Ms. Mousios has resided the majority of the time at her home residence without incident. However, on or about March 27, 2019, she has been living in her car or tent since, beginning of the day after the a smart meter was installed at her adjacent next door neighbor's house. She continues to be itinerant, living in various locations including her car, a tent and intermittently at friends houses who do not have a smart meter or smart meter close to their house.

Prior to the instillation of the adjacent neighbors smart meter, she had been treated at our office for chronic kidney infections, multiple chemical intolerance syndrome and neuralgia pain from a motor vehicle accident.

However, she developed sudden and new symptoms upon the smart meter installation at the end of March, 2019. SHe was first evaluated at our office on 4/2/2019 with exposure related symptoms included stabbing chest pains, shortness of breath with tightness in the chest, headache, head and ear pressure with high-pitched ringing, joint and muscle pain. In addition she had new onset of vomiting blood and accompanying weight loss. At that office visit of 4/2/2019, she had physical examination findings revealing new thyroid fullness and sweling.
Of note, and unrelated to her medical conditions, she also reports that her pet dogs began vomiting and losing weight.

Despite having to experience significant cold temperatures and wind conditions, her symptoms improved from living in her car or tent away from the smart meter. She also reported that when she was able to periodically stay with friends that did not have a smart meter nor any neighbor adjacent smart meter, her symptoms resolved. Anytime she would return to her residence, with the adjacent neighbor smart meter, her above-stated symptoms would return.

On 5/31/2019, at a follow up office visit, after the patient left her residence to avoid smart meter exposure, she had a repeat thyroid exam that was entirely normal.

In my medical opinion, to a reasonable degree of medical certainty, Ms. Mousios has electromagnetic hypersensitivity. Her smart meter exposure symptoms consistently recur upon exposure and dramatically improve with avoidance measures. The current smart meter at her adjacent neighbors home prevents her from residing in her residence in which she has a piano, and a companion, heat, shower and a bed. She is a professional musician and her piano is required in order for her to perform her music profession. Consequently, I medically recommend that her neighbors smart meter be removed or relocated at a significant distance from Ms. Mousios' residence.

Sincerely,

WJKracht

Provider:
Kracht DO, William 01/12/2020 3:58 PM

Document generated by: William Kracht 01/12/2020

Woodlands Healing Research Center
Integrative Family Medicine
5724 Clymer Rd., Quakertown, PA 18951
www.woodmed.com / foffice@woodmed.com
Phone: 215-536-1890 / Fax: 215-529-9034

Complaint Exhibit 4

William S. Bathgate

Certifications - *PMP, ITIL, COBIT, CISA, CRISC, CISM, CGEIT*
US DOD Top Secret Security Clearance
Bachelors of Sciences, Western Illinois University
bill.bathgate@gmail.com
10909 Monticello Road
Pinckney, MI 48169
256-529-1076

Global Technology Professional

Professional Work History

2015 - 2018 TATA Consulting, Fiat Chrysler Automotive Account – Current Position

2015 – 2018 Global Program Manager – Auburn Hills, MI

Manger of Global Programs for enhancements of systems for MOPAR, Secure Vehicle. U-Connect Radio Systems, Connected Vehicle and Autonomous Vehicles. Reports directly to FCA Director of Systems Planning.

2009 - 2015 Emerson Electric Corporation, Avocent Division

2009 – 2015 Global Engineering Program Manager, Emerson Corporation, Avocent Div. – Huntsville, AL

Program Manager of a power distribution products portfolio. Responsible for global engineering development and release of newly developed electrical products engineered in the USA and Germany but built in in Mexico and Czech Republic. This product is called MPH and MPH II. This is a computer network controlled high voltage and high amperage load control device engineered for worldwide installations adapted for each local countries either three phase and single phase AC distribution grid. As Program Manager I also provided direction and oversite of product safety testing and certifications, such as UL, CSA, CE, and PSE for product safety compliance in over 100 countries. So far over 1 Million units of the products I developed are in service. This role reported to the Vice President of Engineering of Emerson's Avocent Division.

1995–2009 Hewlett-Packard Co.

1995-2009 Managing Director, Computer Systems Engineering

Now this division is called "Keysight Technologies". Developed new automated instrument calibration systems and new circuit designs for oscilloscopes, high precision DC power supplies, EMI & EMC Measurements, Phase Noise, Physical Layer Test Systems, RF & Microwave Test Accessories, Device Current Waveform Analyzers, AC and DC power analyzers. Network analyzers and vector signal analyzers.

1983–1995 IBM Corporation

1983-1995 IBM Corporation, Electronic Systems Engineer, Systems Division – Armonk, New York

Developed Mainframe computer CPU, Memory and Input and Output peripherals for S/370 and S/3090 platforms. Part of the design team for the first IBM PC products, responsible for power supplies, main computer circuit boards and Operating Systems integration. Also assigned to NASA in Houston, Cape Canaveral and Marshall space flight centers for launch control and space vehicle telecommunications using high frequency and microwave RF signals.

1977–1983 Textron Corporation

1977-1983 Textron Corporation, Sundstrand Division, Control Systems Engineer – Rockford, IL

Developed Electronic Control Systems for control of Aerospace applications generating power for inflight services, control of engine start, elevators, rudder and aileron controls. Subcontractor to Lockheed Martin for enhancements to the flight data recorder (Black Box) improving circuit mountings for improved crash survival.

Developed control systems for off road construction equipment such as cement mixers, combines, bulldozers and high rise cranes.

Industry Certifications & Expertise

Certified Project Management Professional (PMI/PMP)
Certified in Governance of Enterprise IT (CGEIT)
Certified in Risk and Information Systems Control (CRISC)
Certified Information Systems Auditor (CISA)
Certified Information Security Manager (CISM)
Certified in Control Objectives of IT (COBIT)
Certified in Information Systems IT Infrastructure Library (ITIL) for Operations, Design and Configuration

FCC Amateur Extra Class License Holder
FCC Land Mobile License Holder
FCC Marine Mobile License Holder

High tech power management systems, UPS and power distribution
Switched Mode Power Supplies
Electrical and Electronic hardware engineering
Computer systems engineering
Radio Systems design and testing
High Current and High Voltage switches
Internet communications using both wired and wireless technologies
UL, CE (Europe), Africa, Japan, Australia and China product safety certifications
Cyber encryption and protection of Radio Communications using digital signals
RFI/EMI mitigation

Hold a US DOD Top Secret Clearance and am an instructor of information security encryption control and compliance to the US Missile Defense Agency, NASA, and US Department of Homeland Security.

Complaint Exhibit 5

REVIEW ARTICLE

Self-Reporting of Symptom Development From Exposure to Radiofrequency Fields of Wireless Smart Meters in Victoria, Australia: A Case Series

Federica Lamech, MBBS

ABSTRACT

Context • In 2006, the government in the state of Victoria, Australia, mandated the rollout of smart meters in Victoria, which effectively removed a whole population's ability to avoid exposure to human-made high-frequency nonionizing radiation. This issue appears to constitute an unprecedented public health challenge for Victoria. By August 2013, 142 people had reported adverse health effects from wireless smart meters by submitting information on an Australian public Web site using its health and legal registers.

Objective • The study evaluated the information in the registers to determine the types of symptoms that Victorian residents were developing from exposure to wireless smart meters.

Design • In this case series, the registers' managers eliminated those cases that did not clearly identify the people providing information by name, surname, postal address, and/or e-mail to make sure that they were genuine registrants. Then they obtained consent from participants to have their deidentified data used to compile the data for the case series. The author later removed any individual from outside of Victoria.

Participants • The study included 92 residents of Victoria, Australia.

Outcome Measures • The author used her medical experience and judgment to group symptoms into clinically relevant clusters (eg, pain in the head was grouped with headache, tinnitus was grouped with ringing in the ears). The author stayed quite close to the wording used in the original entries. She then calculated total numbers and percentages for each symptom cluster. Percentages were rounded to the nearest whole number.

Results • The most frequently reported symptoms from exposure to smart meters were (1) insomnia, (2) headaches, (3) tinnitus, (4) fatigue, (5) cognitive disturbances, (6) dysesthesias (abnormal sensation), and (7) dizziness. The effects of these symptoms on people's lives were significant.

Conclusions • Review of some key studies, both recent and old (1971), reveals that the participants' symptoms were the same as those reported by people exposed to radiofrequency fields emitted by devices other than smart meters. Interestingly, the vast majority of Victorian cases did not state that they had been sufferers of electromagnetic hypersensitivity syndrome (EHS) prior to exposure to the wireless meters, which points to the possibility that smart meters may have unique characteristics that lower people's threshold for symptom development. (*Altern Ther Health Med.* 2014;20(6):28-39.)

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The Victorian Auditor-General's November 2009 report[1] criticized the rollout of smart meters, which had commenced in 2009 under a previous government's mandate from 2006. As a result, a freshly elected Victorian Premier announced in 2010 that his government would review the program. Following a number of reports, including those by Deloitte,[2] EMC Technologies,[3] and Lockstep Consulting,[4] the new Victorian government announced on December 14, 2011, that it would continue with the program. Although the program would result in an overall net cost to consumers of $319 million dollars (NPV at

2008 values), Deloitte's analysis of the costs and benefits of the program had concluded that it made economic sense to continue given that a large portion of the costs had already been sunk into the project.[2] The rollout was scheduled to conclude by the end of 2013, but the deadline has been extended because of delays caused by technical difficulties, inaccessible sites, and customer refusals.

Issues Surrounding Rollout

After installation of wireless smart meters began, anecdotes of people developing symptoms started to be reported in mainstream media. For example, an article in the *Herald Sun* in Melbourne reported that Marc and Maureen Florio and their 4 children had left their home, claiming that they had been experiencing constant headaches and sleep deprivation since a neighbor's smart meter had been installed 3 weeks earlier.[5]

Public concerns over a number of issues with the compulsory rollout of smart meters have since intensified and multiplied. They have included (1) adverse health effects; (2) safety issues, such as a possible increased risk of house fires; (3) the incompatibility of the smart meter with existing wiring and appliances, possibly causing damage to electrical devices in the home; (4) privacy issues surrounding the collection and on-selling of vast amounts of data that reveal customers' energy usage patterns; (5) security issues, such as those inherent in any type of wireless communication (ie, a vulnerability to hacking and to cyber-attacks); (6) cost concerns; and (7) a perceived lack of democratic process because of the way in which the rollout had proceeded.[6] In response to these concerns, Energy Safe Victoria (ESV) released a report in July 2012, "Safety of Advanced Metering Infrastructure in Victoria," which stated that "smart meters are safe,"[7] notwithstanding the fact that ESV had mentioned in their draft in May 2012 that the issue of possible health effects was "beyond the detailed scope" of the report.[8]

Victoria's smart meters are electronic meters that are capable of measuring electricity consumption in 30-minute intervals and have a transmitter/antenna that is able to broadcast the collected data wirelessly to the base.[6] Victoria's smart meters also have a second internal antenna for the Home Area Network (HAN) radio, which can be turned on when requested by the customer.[3] The electronic meter is all that is needed to implement time-of-use tariffs (ie, charging different rates for electricity at different times); however, the remote-reading function means that meter readers are no longer required and that the power companies can disconnect and reconnect power remotely.[6] In effect, a smart grid, as opposed to deployment of electronic meters, constitutes the power companies' communication system. The bulk of Victoria's power distributors use wireless mesh networks that rely on the smart meters to act as relay stations, with households' data hopping unpredictably from meter to meter, thus forming a mesh.[6] Any reflective surface can cause a deviation in the transmission route of the radiofrequency signal. One distributor has deployed a WiMax network, which involves transmission from each meter directly to a collection tower in a star-like configuration.[6,9]

Smart meters do not have to be wireless. Italy has completed the largest smart meter rollout to date. Their smart meters are hard-wired and communicate over the existing power lines.[10] Other options have been proposed, such as communication via telephone lines, whereas fiber optic cabling has already been successfully deployed in other parts of the world.[11] Claims have been made that all types of electronic meters, including wired smart meters, can introduce dirty electricity (ie, high-frequency voltage transients and harmonics) along the wiring of a house, because of their switching-mode power supply, as well as back into the main powerline.[12] The function of the switching-mode power supply is to convert alternating current (AC) coming in from the power lines to direct current (DC), which is required to run the electronic meter. This process creates high frequency voltage spikes, which are emitted constantly, 24/7, and which travel along building wires and radiate outward from them. Critics claim that this dirty electricity can lead to short- and long-term, adverse health effects.[12,13]

Sources of Radiation

Electromagnetic fields (EMFs) is a broad term that encompasses both natural and human-made sources of radiation. The electromagnetic spectrum describes the continuum of different frequencies put together with the associated wavelength of each frequency.[14,15] The frequency is the number of oscillations or cycles per second, whereas wavelength describes the distance between successive peaks of a wave.[16] As a result, wavelength and frequency are inseparably intertwined: The higher the frequency, the shorter the wavelength is.[14] The electromagnetic spectrum is divided into 2 main types: (1) ionizing radiation, which comprises cosmic and gamma rays, X-rays, and ultraviolet rays; and (2) nonionizing radiation.[14,15,17]

Ionizing radiation has so much energy per quantum that it is able to break chemical bonds between molecules.[14] The negative effect on health of ionizing radiation is well recognized.[17] In this report, however, the term *radiation* will be used to describe nonionizing radiation, which does not carry sufficient energy to break molecular bonds.[14]

Nonionizing radiation includes (1) extremely low-frequency fields, such as those emitted by electrical appliances and power lines; (2) intermediate-frequency fields, such as those used in some antitheft and security systems; and (3) high-frequency radiation, which includes radiofrequency fields, such as those produced by mobile telephones, television and radio transmitters, and radar, as well as microwaves, a subset of radiofrequency radiation, which have frequencies in the 300 MHz to 300 GHz range.[16] The last are used in microwave ovens and for wireless Internet.[14,15]

These definitions are arbitrary but represent a useful way of describing different parts of the nonionizing component of the spectrum. Discussions of and research on the effects of nonionizing radiation revolve around thermal and

nonthermal effects.[17] According to the main regulatory agencies in Australia and the United States, only thermal effects are capable of affecting human health[17]; however, this article will deal exclusively with the nonthermal, or biological, effects on humans of nonionizing radiation. For this reason, the author has used the terms *radiation*, *radiofrequency*, and *microwaves* interchangeably in this article.

As societies industrialize, an unprecedented increase in the number and diversity of EMF sources occurs.[18] These sources include (1) video display units (VDUs) associated with computers and mobile phones and their base stations,[18] (2) wireless Internet, (3) digital television and radio, and—more recently—(4) wireless utility meters and their associated infrastructure. For some time, individuals have reported a variety of health problems that they relate to exposure to EMF.[18]

Electromagnetic Hypersensitivity Syndrome

Electromagnetic hypersensitivity syndrome (EHS) is characterized by a variety of nonspecific symptoms. The most common ones include dermatological symptoms—redness, tingling, and burning sensations—as well as neurasthenic and vegetative symptoms—fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitations, and digestive disturbances.[18] This syndrome was first described by Russian researchers in the 1950s, who called it microwave sickness.[17]

Although the range of estimates of the EHS prevalence in the general population is broad, a survey of self-help groups has indicated that approximately 10% of reported cases have been considered severe.[18] The World Health Organization (WHO) has expressed a willingness to consider professional and public input on evidence supporting the inclusion of EHS into the 11th version of the International Classification of Diseases (ICD), to be released in 2015.[15] Various national governments have also recognized EHS as an emerging public problem. Sweden classifies EHS as a functional impairment,[15] whereas the Council of Europe Resolution 1815 calls for particular attention to be paid to the needs of electrosensitive people and for the introduction of special measures to protect them, including the creation of wave-free areas not covered by the wireless network.[19]

In May 2013, the author of the current study became aware that people were registering adverse health effects from smart meters on a public Web site. Two ways existed for people to register: (1) a health register and (2) a legal register. The health register requested that people send their data to a specific e-mail address if they believed that their health had been affected following installation of smart meters, asking 2 questions: (1) "Are you hypersensitive to electromagnetic radiation from sources such as smart meters and mobile phones?" and (2) "Has your health been affected following the installation of smart meters?" The legal register contained 1 similarly worded open-ended question: "Do you believe your health has been affected by the installation of smart meters?" If the answer was "yes," people were asked to state the symptoms from which they were suffering that they believed had resulted from exposure to electromagnetic radiation (EMR) that had been emitted from smart meters. The information could be submitted online or the form could be printed and filled in by hand, then sent to a designated postal address. Neither form of registration posed direct questions about types of symptoms or offered any form of tick-a-box questionnaire, thereby avoiding the suggestion of various symptoms, and both steered clear of a recruitment-style approach to the collection of information.

The author subsequently approached the managers of the Web site and the registers, and based on her status as a medical practitioner, she received permission to view people's deidentified data in both registers in hard-copy form. It was immediately apparent to the author that people from disparate parts of Victoria were listing the same or similar symptoms from exposure to smart meters. The majority of people could not possibly have known each other, and they certainly had no access to information that had been registered by others, as data sent to the registers had been kept strictly private and confidential. Because the information appeared to point to a new and ongoing public health problem for Victoria, the author decided that a case series report, based on the cases in the registers, was warranted.

METHODOLOGY

The author began by enlisting the agreement and cooperation of the managers of the public Web site and registers and by instructing them on her planned methodology. The managers were given the task of selecting appropriate cases from both their health register and legal register. The cases were included when the managers could clearly identify the person by name, surname, postal address, and/or e-mail address to make sure that they were genuine registrants. In the case of children, name and surname, together with postal address and/or e-mail address of at least 1 parent, were considered sufficient for identification of the child.

The managers then proceeded to print or photocopy each qualifying individual's entry and to deidentify each case, providing the author with each person's gender, date of birth, and the name of his or her residential suburb. The author considered these details important for statistical purposes. Children's symptoms were reported by their parents. E-mail addresses and phone numbers were hidden by the registers' managers, and the author made no attempt to contact any person to obtain additional details or ask for clarification(s). This practice was judged by the author to be appropriate, not only for the maintenance of anonymity but also because any further questioning would have had the potential to introduce biases in reporting and interfere with its spontaneous and unsolicited nature. What was not written or written clearly was simply omitted from the report. This fact must be kept in mind when reading the case series.

The Web site's managers then proceeded to seek signed written consent to use people's deidentified data to compile a report. This request was done by sending a letter to each

individual, mainly via post, but in a few cases in which postal addresses were not available, via e-mail. In the case of children, consent had to be signed by 1 of the parents. One case was drawn directly from the public side of the earlier-mentioned Web site, and for this reason, consent was not sought for that case because it was already available in the public domain. The Web site contained a significant number of publicly available cases of symptoms from smart meters; however, the chosen case was included because it was the only one that provided fully identifiable details: name, surname, residential address, and phone number. The author subsequently removed 1 case from outside the state of Victoria and 1 from a resident of New Zealand.

Of 142 fully identifiable cases before this removal, 91 consented, with the 1 additional case being in the public domain and not requiring consent. Therefore, the sample size was 92, and the author received all deidentified submissions in hard-copy form only. They were stored in her home office under lock and key. The author intends to keep all documents for a period of 5 years after publication of this article. At the end of this period, the documents will be destroyed.

For the results, the author has used her medical experience and judgment to group symptoms into clinically relevant clusters (eg, pain in the head was grouped with headache; tinnitus was grouped with ringing in the ears). The author has stayed quite close to the wording used in the original entries. Total numbers and percentages were calculated for each symptom cluster. Percentage values were rounded to the nearest whole number.

RESULTS

Of the 92 participants reporting symptoms from exposure to wireless smart meters, 87 were adults and 5 were children. Of the adults, the youngest person was 23 years of age and the oldest was 74; 55 (63%) were female and 32 (37%) were male. The children were aged 6, 10, and 14 years, with the ages of the remaining 2 children unknown. The children's group was composed of 2 females and 3 males. Therefore, for the total group, 57 (62%) were female and 35 (38%) were male.

Of all the individuals, 39 (42%) did not specify whether their symptoms were caused by their neighbors' or their own smart meters. This lack of information was not surprising, because that kind of information was not sought in either the health or the legal registers. Therefore, it is of note that a total of 53 people (58%) volunteered this data: (1) 27 (29%) claimed that their symptoms were from exposure to their neighbors' smart meters, (2) 20 (22%) thought the adverse health effects were from a smart meter at their own homes, and (3) 2 wrote that their symptoms were from both their neighbors' and their own smart meters. It is also interesting that 3 people stated that they experienced symptoms when visiting friends or relatives who had a smart meter, and 1 person became ill after exposure to a smart meter at work.

Only 7 people (8%) stated that they considered themselves to have been suffering from EHS prior to smart meter exposure. Of these, 2 felt that radiation from smart meters had aggravated their conditions. The place of residence of the person representing each case study was important, because the locations illustrate that individuals reporting symptoms were not concentrated in 1 geographical area but were from different and varied parts of metropolitan and rural Victoria. Figure 1 shows the residential locations of the current study's cases marked with red dots; 67% of the Victorians in this study lived within Melbourne's metropolitan area (ie, Melbourne's suburbs), which is shaded a darker green on the map. This correlates almost perfectly with current demographics for the state, which show more than 70% of all Victorians living in Melbourne's suburbs.

As Figure 2 shows, the most common symptoms were (1) insomnia, sleep disturbance, or sleep disruption—44 people (48%); (2) headaches, head pain, or dull head—41 people (45%); (3) tinnitus, ringing in the ears, or buzzing/noises in the ears—30 people (33%); (4) tiredness, lethargy, or fatigue, including chronic fatigue, exhaustion, or weakness—29 people (32%); and (5) cognitive disturbances, inability to concentrate or think, disorientation, or memory loss—28 people (30%). Table 1 identifies the symptoms that were experienced by participants, other than the 5 most common, with their incidence.

Figure 1. Map of Victoria and Places of Residence of the People in the Study's Cases

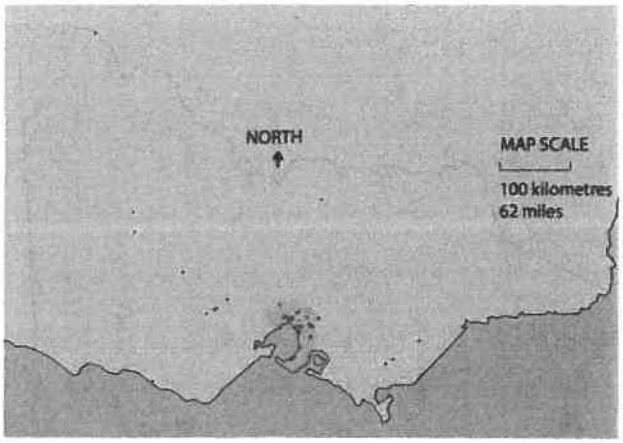


Figure 2. Five Most Common Symptoms

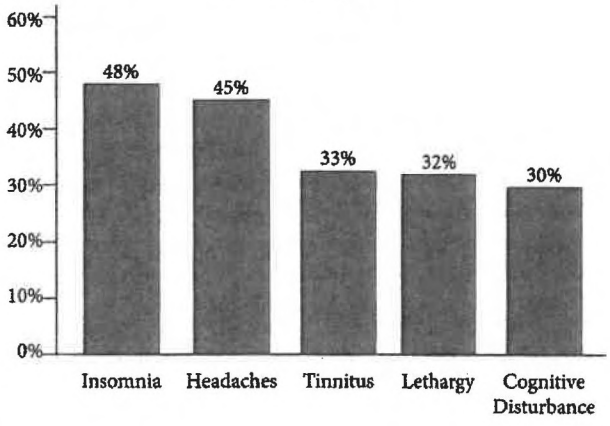


Table 1. Other Symptoms

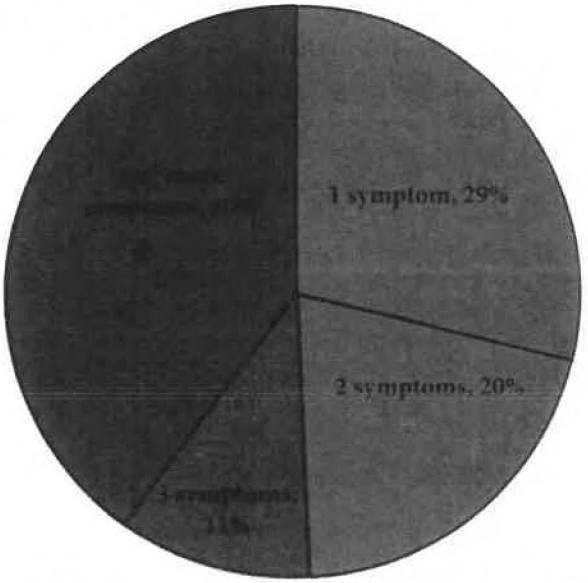
Symptom/Symptom Cluster	n (%)
Dysesthesias, including nerve pain, neuropathy, burning sensations, tremors, cold extremities, and poor circulation	20 (22%)
Dizziness/loss of balance	19 (21%)
Heart palpitations	16 (17%)
Nausea	15 (16%)
Onset of EHS	14 (15%)
Pain (in joints, bones, muscles, other and including arthritic changes)	13 (14%)
Pressure/heat/weird feeling in or on head	12 (13%)
Anxiety/agitation/irritability/restlessness	12 (13%)
Adverse health effects not otherwise specified	11 (12%)
Problems with eyes or eyesight/blurred vision	10 (11%)
Chest pain/pain in the heart	9 (10%)
Rashes/skin irritation/skin discoloration/dry skin	7 (8%)
Aggravation of pre-existing medical condition	6 (7%)
Digestive problems/bowel irritability/stomach pain	5 (5%)
Muscle spasms/cramps/twitches	5 (5%)
Nose bleeds	4 (4%)
Ear problems (ear pain, loss of hearing)	3 (3%)
Depression/loss of motivation	3 (3%)
Increased rate of infections/colds	3 (3%)
Allergies/food sensitivities	3 (3%)
Aggravation of EHS	2 (2%)
Sinus problems	2 (2%)
Lump in throat/sore throat	2 (2%)
Weight loss/loss of appetite	2 (2%)
Swollen face/lips	2 (2%)
Bladder infections/strains	2 (2%)
Flu-like symptoms	1 (1%)
Dehydration/thirst	1 (1%)
Weight gain	1 (1%)
Inability to talk	1 (1%)
Loss of motor skills	1 (1%)
Loss of feeling and movement from waist down	1 (1%)

Abbreviations: EHS = electromagnetic hypersensitivity syndrome.

It is concerning that 40% of all participants reported 4 or more symptoms, as this finding is very likely to be predictive of a greater level of disability (Figure 3). Eleven percent had developed only 3 symptoms, 20% only 2 symptoms, and 29% only 1 symptom. Note that the author counted "adverse health effect(s) not otherwise specified" as 1 symptom. She is of the opinion that even 1 symptom, depending on its type and severity, could result in significant disruption for an individual. An example of this result is the experience of the person in Case 82, an adult male who developed only 1 symptom—chronic, severe nerve pain—and had to go on a disability pension as a result.

It may reasonably be expected that a random sample of the population would also report a number of symptoms at any one time, but the difference in these cases is that all people in this study self-reported symptoms that they attributed directly to smart meters. Because EHS is a self-reported syndrome and given the current absence of a reliable assessment tool for identifying EHS in individuals, Eltiti et al[20] concluded that researchers have to rely on the

Figure 3. Number of Symptoms per Person



individual's self-diagnosis of their symptoms as caused by exposure to EMF. The researchers proposed an EHS screening tool that is centered on the fact that an individual explicitly attributes his or her symptoms to exposure to EMF-producing object(s).[20]

Similarly, a survey conducted by the Dutch Electrohypersensitivity Foundation in 2007 argues that EMF-affected individuals simply know, often by experimentation, that certain pieces of electrical equipment, installations, or facilities make them sick and that most of the problems are solved when these items are switched off or the EMF exposure is lowered by shielding or increasing the distance from a device.[21] This statement mirrors the experience of the majority of the Victorian cohort, who were specific in their description of their health problems as being directly related to smart meter exposure. A chronological relationship existed between the onset of exposure and symptom development.

A chronological relationship between length of exposure and an increase in the number or severity of symptoms, however, did not necessarily exist. This finding suggested a possible all-or-nothing mechanism, whereby smart meter exposure leads people to reach a personal threshold beyond which adverse health effects are consciously perceived. More than one-half (58%) of all the current participants also volunteered a statement with regard to the location of the smart meter(s) that they had identified as causing their symptom(s) and described clear alleviation of symptom(s) when they moved away from the smart meter(s) or when shielded from the smart meter(s).

As a consequence, a large number of people self-helped either by using shielding measures or by putting distance between themselves and the smart meter(s), which meant either relocating their bedrooms, moving to another residence, ceasing employment, restricting their movement in general, or moving out of the state of Victoria (Table 2).

Table 2. Effect on People's Lives

Effect
1. Having to go on a disability pension
2. Not being able to use part of one's house
3. Restricting freedom of movement
4. Spending a lot of money on shielding products
5. Causing financial problems
6. Causing relationship problems
7. Having to undergo otherwise unnecessary medical investigations
8. Needing to see a psychologist and doctors
9. Producing general deterioration in quality of life
10. Needing to restrict time spent using a computer
11. Needing to avoid all EMR-emitting devices
12. Being unable to drive
13. Causing secondary stress
14. Having to temporarily move out of one's home while it was being shielded
15. Developing concerns about long-term effects of exposure
16. Relocating bedroom
17. Decreased performance at work
18. Being unable to work
19. Being able to feel normal only when away from home
20. Causing several issues, such as lethargy or cognitive impairment, secondary to sleep disturbances
21. Needing to move into a caravan 25 km out of town
22. Sleeping in a van for 6 months
23. Relocating to another state

Abbreviation: EMR = electromagnetic radiation.

Figure 1 shows that people in this study were from disparate parts of the state of Victoria. They were from metropolitan as well as regional and rural areas and were not concentrated in any geographical area, which makes possible causes of symptoms related to a specific location unlikely (eg, proximity to airports, wind farms, open-cut coal mines, or chemicals used in agriculture). It is also unlikely for the reported symptoms to be associated with any seasonal factor (eg, extremes of temperatures, degree of humidity, bushfire smoke, or a high pollen count), because the reporting period stretched between September 2012 and August 2013, which meant that symptoms were reported during all 4 seasons.

Smart meters represent an ubiquitous presence throughout the state of Victoria, having been rolled out across the entire state. Their presence is not subject to seasonal variation. Therefore, they are a credible possible cause of the symptoms reported in this study, although a case series cannot prove causality. It can and does, however, offer a new hypothesis, one that will have to be tested by further research.

More than one-half (55) of all the cases did not state what effect the symptoms had had on their lives. This lack is possibly caused by the fact that the registration of their symptoms occurred in an open-ended style that did not

directly ask questions other than whether they thought that smart meters had affected their health. Moreover, participants had consented for their deidentified data to be used to compile a report at a time after their initial submission to the Web site's registers. This situation had the benefit of eliminating the likelihood of a real or perceived secondary gain for registrants but also led to the writing of short, simple statements that did not elaborate on how the symptoms had affected their lives. Table 2 provides details about the effect on the lives of the 37 people who made a statement about those effects..

DISCUSSION

Biological Effects of Radiation

With regard to the reported symptomatology related to wireless smart meters, it is interesting to look back at a research report by Dr Zorach R. Glaser for the Naval Medical Research Institute (NMRI) in the United States, completed in 1971 and revised in 1972.[22] The report lists in excess of 2300 references on the biological responses to radiofrequency and microwave radiation in its bibliography. What is immediately apparent is the fact that most of the symptoms reported in the current case series were also present in the NMRI report. This fact indicates that biological effects from nonionizing radiation are the same irrespective of the device that emits them—accounting for frequency, intensity, and duration—and that such biological effects were already known and reported to the public in 1971. In fact, Glaser mentions 2 even earlier studies that were both published in 1969.[22] The value of Glaser's report lies particularly in its lack of bias and conflict of interest because the sponsoring department was the Bureau of Medicine and Surgery (Navy) in Washington, DC.

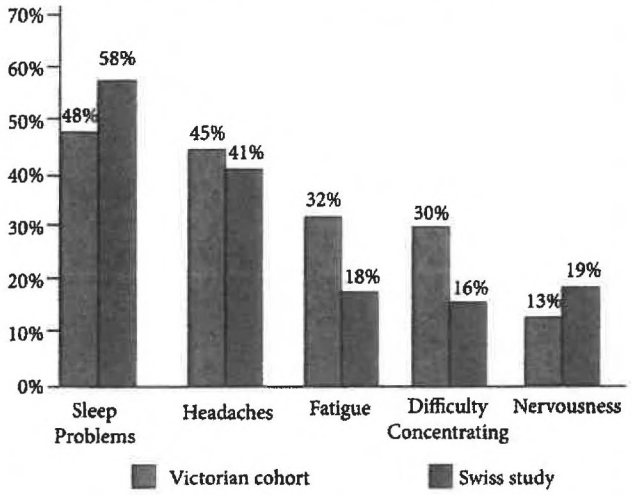
In terms of the biological symptoms listed, an almost complete overlap exists with symptoms reported in the current case series. All commonly reported symptoms in the current case series, such as insomnia, headaches, tinnitus (described as buzzing about the ears in the NMRI document), fatigue, cognitive disturbances, memory problems, dizziness, buzzing in the head, heart rate problems, eye problems, chest pain, dysesthesias, anxiety, and restlessness are very clearly biological symptoms that were listed in Glaser's report,[22] together with less common symptoms, such as heat/weird feeling in/on the head, skin problems, digestive problems, muscle cramps, sinus problems, depression, loss of appetite, and dehydration.[22]

The symptoms reported by Victorians but not mentioned in the 1971 report are (1) nausea; (2) pressure in the head; (3) pain other than head or chest pain, although the pain could be caused by changes in oxidative processes in tissues as listed by Glaser, and consequent tissue inflammation; (4) shortness of breath; (5) ear problems—pain and decreased hearing; (6) allergies and food sensitivities; (7) nose bleeds; (8) increased rate of infections/colds; (9) bladder infections/strains (10) flu-like symptoms; (11) lumps in the throat (the NMRI report instead mentions a peculiar metallic taste in the mouth); (12) swollen face or swollen lips; (13) weight gain; (14) inability to talk, which could be caused by electroencephalogram (EEG) changes and/or pyramidal tract lesions as mentioned in the 1971 report; and (15) loss of motor skills or loss of feeling and movement from the waist down, which are both consistent with pyramidal tract lesions and effects on locomotor nerves that are listed in the NMRI paper. In looking at these symptoms that were not obviously listed in the NMRI report, it is important to keep in mind that the language of that report was more technical and clinical compared with the current case series, in which the author has purposely stayed true to the wording and terms used by participants and which is, therefore, less technical and less interpretive.

In 1990, a study was commissioned in response to a petition that had been signed by a group of residents in Schwarzenburg, Switzerland, who claimed to be experiencing ill health from a shortwave-radio transmitter present in their small town. The Federal Office of Energy was charged with setting up a study group, which was chaired by Dr J. Cattin, head of the Section Energy Management, and which included the University of Berne and Swiss Telecom, among others.[23] The study was criticized, particularly because of Swiss Telecom's involvement and because of its 5-year duration, which was too short a time for any conclusive findings on long-term health effects, including cancer, to emerge.[24] It nevertheless revealed some impressive understandings on short-term effects from exposure to radiofrequency fields. The most important of these effects was that of sleep disruption, which was very common, affecting 55% of those older than 45 years, and which was directly associated with the electromagnetic-field strength of the transmitter.[23] Other symptoms reported by residents included headaches, tiredness, general weakness, irritability, nervousness, limb pain, lower-back pain, and palpitations. Most important, personality studies were carried out that showed that symptoms were not related to a health-worrying personality but displayed a dose-response relationship with logistic regression. The strong correlation between the type of symptoms experienced by the Victorian cohort and by the residents of Schwarzenburg, together with the shared high prevalence of sleep disruptions in both groups, should further inform assessment of the significance of the findings of the current case series.

A consensus paper of the Austrian Medical Association's EMF Working Group, adopted on March 3, 2012, in Vienna and titled "Guideline of the Austrian Medical Association for the Diagnosis and Treatment of EMF-related Health Problems and Illnesses (EMF Syndrome)," mentions a survey carried out in Switzerland in 2001.[25] In it, 394 respondents attributed specific health problems to EMF exposure. The following symptoms were reported: (1) sleep problems (58%), (2) headaches (41%), (3) nervousness (19%), (4) fatigue (18%), and (5) difficulty concentrating (16%). It is apparent at first glance that the first 2 symptoms are of the same order of frequency as for the Victorians in the current case series (Figure 4). A very similar percentage of people complained of headaches in both the current study (45%) and the Swiss one (41%). A similar, albeit slightly lower, number of participants reported sleep problems, such as insomnia and frequent waking, in Victoria (48%) versus those reported in the Swiss study (58%). All 5 symptoms

Figure 4. Victorian Cohort Versus Swiss Study



reported in the Swiss survey corresponded to symptoms experienced by the Victorian cohort, with fatigue (32%) and difficulty concentrating (30%) being more common in Victoria and nervousness (anxiety/agitation) (13%) being less common.

The Austrian Guidelines also list a number of what their authors consider to be EMF-related symptoms: sleep problems, fatigue, exhaustion, lack of energy, restlessness, heart palpitations, muscle and joint pain, headaches, depression, difficulty concentrating, forgetfulness, anxiety, urinary urgency, anomia, dizziness, tinnitus, and a sensation of pressure in the head and the ears.[25] All listed symptoms were experienced by Victorians in the current study, if the reader accepts that anomia corresponds with inability to talk and urinary urgency to bladder infections/strains.

Short-term effects from exposure to radiofrequency fields are also mentioned in another recent publication, the BioInitiative 2012 report prepared by 29 independent scientists and health experts from around the world. It documents bioeffects (ie, adverse health effects) and public health conclusions about effects of nonionizing radiation, including radiofrequency microwave fields. It replaces the BioInitiative 2007 report.[26] These effects involve cognition; memory and learning; behavior; reaction time; attention and concentration; and altered brainwave activity (altered EEG), as well as insomnia; discomfort; loss of well-being; sleep disruption; aberrant immune, allergic, and inflammatory responses in tissues; interference with normal cardiac function; alteration of circadian rhythms; and desynchronization of neural activity that regulates critical functions in the brain, gut, and heart. Radiofrequencies can act as disrupters of synchronized neural activity.

The BioInitiative report offers a detailed explanation on how environmental exposures to artificial EMFs can interact with fundamental biological processes in the human body.[26] This finding should not be unexpected because "human beings are bioelectrical systems."[26] In addition to short-term effects, the report dwells on the long-term sequelae (pathological conditions) from chronic exposure to nonionizing radiation, which include genotoxicity and DNA breakages among others.[26] It is not strictly within the scope of this case series to explain the biophysical mechanisms that may account for acute symptoms or effects or to discuss the long-term serious health endpoints associated with radiofrequency radiation; however, a summary of the nonthermal biological effects of nonionizing radiation is contained in Table 3. It is distilled from the BioInitiative report and intends to be a basic guide for clinicians.

It also needs to be mentioned that in 2011, the International Agency for Research on Cancer (IARC), which is part of the WHO, classified radiofrequency fields as a Group 2B Possible Human Carcinogen, based on an increased risk of glioma after 10 years or longer of cell phone use.[27] The IARC clarified that the evidence for carcinogenicity applies to exposures to radiofrequency radiation from all sources, not only cell phones (ie, it is not device-specific).[28] This finding has implications for the continued massive rollout of wireless technologies, in particular the wireless smart utility

Table 3. Summary of Biological Effects of Nonionizing Radiation

Effects
1. Pathological leakage of the blood-brain barrier, which allows toxins into brain tissues
2. Pathological leakage of the blood-gut barrier
3. Altered immune function, including increased allergic and inflammatory responses
4. Cardiovascular effects, particularly on blood pressure and heart rate
5. Disregulation of circadian rhythms and reduced melatonin production, which may account for insomnia
6. Nervous system effects, which include altered brainwave activity, changes in neuronal functioning and changes in autonomic nervous system electrophysiology
7. Desynchronization of neural activity that regulates critical functions in brain, gut, and heart
8. Lipid peroxidation of cell membranes
9. Elevated intracellular calcium with consequent disruption of cell metabolism
10. Poorly functioning mitochondria
11. Production of stress proteins as a result of the direct interaction of EMF with the DNA molecule, whereby DNA acts as a fractal antenna (because of its coiled-coil configuration)
12. Altered biochemical functions and production of hormones
13. Increased production of free radicals and deficiencies of antioxidants such as glutathione and melatonin leading to oxidative stress

Abbreviation: EMF = electromagnetic field.

meter, which was described in a recent statement to the UK Parliament as having triggered thousands of complaints of ill health and disabling symptoms worldwide.[29]

Mandated, Involuntary Exposure

With regard to smart meters, 2 unique features should be considered: (1) exposure may be involuntary and (2) exposure can be universal. In Victoria, smart meters were mandated, thereby removing the individual's choice to avoid exposure in his or her own home, and involuntary exposure also occurred to meters in neighboring homes. Each smart meter in the mesh networks transmits an unknown and variable number of burst transmissions per day, which typically reach into many thousands in number.[30] Meters on the WiMax network,[9] although not communicating with each other and deploying only bidirectional communication between a meter and the base station, nevertheless send hourly time synchronization signals in addition to their daily session transmissions.[3]

A submission by the Public Utilities Commission of California shows that only 45.3 seconds of transmissions per day (<0.1% duty cycle) still equates to 9600 transmissions.[30] Exposures are likely to be physiologically additive in nature.[25,26,31] Moreover, belief is increasing in the concept that intermittent pulses of radiofrequencies, such as those used in the smart grid, are more biologically significant compared with constant-type exposures, even when the time-averaged exposure is miniscule.[26,31] This kind of signal is biologically active and *not* invisible to the human body and its proper biological functioning, because the unpredictable pulses disrupt the synchronized biological oscillations within cells.[26] The Austrian Medical Association recommends that such periodic signals should be critically evaluated, whereas nonperiodic signals may be considered more leniently.[25]

In a 2012 memorandum titled "Health Risks Associated with SmartMeters," Dr Poki Namkung, public health officer of the County of Santa Cruz (CA, USA) stated that no scientific literature exists on the health risks of smart meters because they are a new technology.[31] This statement parallels the Austrian EMF Working Group's statement that "new technologies and applications have been introduced without certainty about their health effects."[25] Dr Namkung also explains that research on the potential health risks from radiofrequencies has been funded largely by industry because little funding is available for basic scientific research.[31]

The report indicates:

> ... exposure is additive and consumers may have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices such as cell and cordless phones, personal digital assistants (PDAs), routers for internet access, home security systems, wireless baby surveillance monitors (baby monitors), and other emerging devices. It would be impossible to know how close a consumer might be to his or her limit, making safety a uncertainty if SmartMeters are mandatorily installed.[31]

Again, this statement correlates with the conclusion in the Austrian Guidelines that "multiple exposures to different EMF sources must be taken into account."[25] Dr Namkung's conclusion that "... governmental agencies are the only defense against such involuntary exposure" to mandated smart meters' nonionizing radiation emissions[31] applies in a particularly relevant way to the Victorian experience.

A similar view is also shared by Dr David O. Carpenter and 53 other scientists and doctors, who, in an article published in 2012, outline some of the effects of EMF exposure with the intent to correct some of the gross misinformation regarding wireless smart meters and advocate for the application of a precautionary principle, such as using wired meters.[32]

Although some of the studies discussed in this report offer recommendations regarding wireless smart meter deployment (Table 4), virtually no published studies are available with respect to smart meters and human health, and no long-term studies exist because of the newness of the technology.

Notably, an early voice of concern on this issue was that of Don Maisch, PhD, from Tasmania, who posed the question of whether smart meters would end up creating a public health nightmare in an article published in September 2012.[33] In it, he explained how current exposure standards are outdated and no longer relevant and warned that, given the sheer number of people exposed, simply dismissing anecdotal evidence of symptoms from smart meters as a nocebo (harmless) effect without a serious research effort would be inexcusable.

Incidence of Effects

This article has discussed the fact that people from various regional and metropolitan areas in the state of Victoria, of all ages and during all seasons, have reported symptoms from exposure to the radiofrequency fields of wireless smart meters as well as the onset or aggravation of EHS and the aggravation of pre-existing medical conditions after installation of the meters. Interestingly, only 8% of the participants in the current study stated that they had suffered from EHS prior to exposure to smart meters, which suggests that the threshold for symptom development appears to be significantly lower when it comes to wireless meters compared with that for other wireless devices.

Of an initial 142 people who had formally registered their adverse health effects from smart meters related to the current study, 92 consented to participation. The author considers this number to be significant and most likely to represent the tip of the iceberg in terms of total numbers. Underestimation could be caused by the fact that people do not associate their symptoms with smart meter exposure when the symptoms are not severe or do not occur concurrently. In addition, this underdiagnosis may be caused by a lack of knowledge about the effects of wireless technologies on the part of the general population and the majority of the medical fraternity. The ongoing campaign of

Table 4. Summary of Scientific Reports

Title	Author(s)	Country	Year	Subject Matter and Findings	Recommendations
"Bibliography of Reported Biological Phenomena and Clinical Manifestations Attributed to Microwave and Radio-frequency Radiation"	Glaser[22]	United States	1971	Provides more than 2000 references on the biological responses to radiofrequency radiation	No specific recommendation; prepared for the Naval Medical Research Institute, Bethesda, Maryland; approved for unlimited public release
"Study on Health Effects of the Shortwave Transmitter Station of Schwarzenburg, Berne, Switzerland"	Altpeter, Krebs, Pfluger, et al[23]	Switzerland	1995	Notes marked deterioration of sleep quality in persons exposed to radio transmitter	No urgent protection measures; review of current exposure guidelines; further research
"Guideline of the Austrian Medical Association for the Diagnosis and Treatment of EMF-related Health Problems and Illnesses (EMF Syndrome)"	Austrian Medical Association's EMF Working Group[25]	Austria	2012	Discusses EMF-related problems and outlines clinical-management approach	Primary method of treatment of EMF-related health problems to consist of prevention or reduction of EMF exposure
"BioInitiative 2012–A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation"	Prepared by 29 experts, edited by Sage & Carpenter[26]	Experts from more than 10 countries	2012	Reviews more than 1800 new scientific studies added to the BioInitiative Report 2007, which cited 2000 studies on adverse health effects from extremely low frequencies and radiofrequencies	New, biologically based public-exposure standard; precautionary approach to RF exposure levels
"Health Risks Associated with SmartMeters"	Namkung[31]	United States	2012	Indicates objective evidence supports EHS diagnosis; no scientific literature on health risks of smart meters	All available, peer-reviewed research data on EMF applicable to smart meters; governmental agencies to protect public health from involuntary exposure
"Smart Meters: Correcting the Gross Misinformation"	Carpenter et al[32]	Authors from a number of countries; published in Canada	2012	Summarizes long-term and short-term health effects of EMF exposure, in particular from smart meters	Application of Precautionary Principle, such as using wired meters
"Electromagnetic and Radiofrequency Fields Effect on Human Health"	Dean, Rea, Smith, Barrier (American Academy of Environmental Medicine)[17]	United States	2012	Discusses different types of radiation and effect of the increasing use of wireless technology on human health	Immediate caution on smart-meter installation; further research on effects of EMF and RF exposure; use of safer technology, including for smart meters

Abbreviations: EMF = electromagnetic field; RF = radiofrequency; EHS = electromagnetic hypersensitivity syndrome.

the state government and power distributors to portray smart meters as safe has also contributed to this lack of knowledge. Even when people believe that their new symptom(s) are caused by smart meters, some are not able to report or register their symptoms because they have no Internet access, and of those who do, not all are aware of Web sites or ways to make reports.

Limitations of Current Study

The main limitation of the current study is that, being a case series, it is a descriptive, retrospective study that does not have a control arm and can therefore help formulate a new hypothesis, but can only make limited statements on the causality of correlations observed.

Another limitation, which is specific to this type of noninterventional analysis of existing nonidentifiable data, is that the author was not able to contact individual case studies and was therefore unable to clarify or add to the information given by them. For the same reason, the author was also unable to follow up these cases longitudinally, which is something that could have potentially yielded valuable information.

CONCLUSIONS

This case series has discussed the most commonly reported symptoms from wireless smart meters. Although some of these symptoms are also reported in relationship to other environmental exposures, such as proximity to airports

or wind turbines, Victorians in this report claimed a direct chronological association between exposure to wireless smart meters and symptom development. A look at the place of residence of people reporting symptoms does not suggest a link to any possible environmental factors that are geographically specific. Seasonal factors are also excluded, because the reporting period stretched over all 4 seasons. The effect of these symptoms on people's lives is far-ranging, from stress, financial problems, and unnecessary investigations to needing to move out of one's home and even to another state.

The author of the current study offers the hypothesis that some people can develop symptoms from exposure to the radiofrequency fields of wireless smart meters. This hypothesis cannot be disproven without further assessment of the affected individuals and the electromagnetic fields in which they live. An evidence-based approach, such as the one used in all other areas of medicine, must be applied, which would mean the establishment of a postrollout surveillance study and funding for further research into the particular effects of wireless smart meters, in conjunction with research into the short-term and long-term consequences of EMR exposure. Until more knowledge is accumulated and until this type of wireless technology can be proven safe, the author believes that communities should use a cautionary approach, asking for a moratorium on deployment of wireless smart meters and smart grids and for the use of safer technologies for smart meters, such as hard-wiring, fiber optics, or other nonharmful methods of data transmission, including reading of meters by meter readers. Living in a wireless smart grid makes the Austrian Medical Association's recommendation to "take all reasonable measures to reduce exposure to electromagnetic fields" impossible to implement.

Dr Maisch's article title, "Smart Meter Health Concerns: Just a Nocebo (Harmless) Effect or an Emerging Public Health Nightmare?", resonates strongly with the Victorian experience so far. This question is very pertinent and one that must be urgently answered.

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Complainant Exhibit 6

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www.stopsmartmeters.org.nz

Cell Phone Tower Tinnitus

This is a major public health disaster and has been sent to the following with a request for remedial action.

- Local Government & Environment Select Committee - 13/10/2009
- Vodafone - 6 Company Representatives - 28/10/2009
- Manukau City Council - Mayor Len Brown - 30/10/2009
- 2 Degrees - 2 Company Representatives - 30/10/2009
- Ministry of Health - Minister Tony Ryall - 30/10/2009
- Local Government & Environment Select Committee - Chair Chris Auchinvole - 3/11/2009
- Ministry of Health - Director General Stephen McKernan - 4/11/2009
- 2 Degrees - CEO Eric Hertz, Chair Bill Osborne - 5/11/2009
- Ministry of Local Government - Minister Rodney Hide - 5/11/2009
- Ministry of Environment - Minister Nick Smith - 5/11/2009

A Personal Note
Dear Global Friends,
I developed Tinnitus or the ringing of the ears within six weeks of the Cell Phone Tower being installed in front of my home in early 2009. Once measuring equipment arrived we determined that our lounge was in direct line of sight of the Tower and was receiving the highest readings of Microwave Radiation.

I visited an Audiologist at the Auckland University Audiology Clinic. They confirmed that I had recently developed Tinnitus, however my age (30s), excellent health, excellent hearing meant that they were unable to determine the cause. However most people do develop Tinnitus but generally in the 60s and unfortunately it is permanent.

The cause is a well documented Microwave Hearing Effect as detailed in the below studies. I took this all the way up to the Director General of Health. I ended up in contact with the lead scientist on Microwave Hearing who also worked for Motorola. Although the measured power levels were very low for an immediate effect he had not exposed humans to months of Microwave Radiation and therefore could not rule this out as the cause.

To date **40%** of visitors to this site are now reading this page on Tinnitus. You are not alone in your ill health so please add your story to the Health Register as together we will make a difference.

Regards
T Greening
B.Technology (Information Engineering)
CCDA, CCNA
info@nes.org.nz

Tinnitus and mobile phone use - 2010
http://www.emf-portal.de/viewer.php?aid=18434&l=e

Overall, no statistically significant increased risk for mobile phone use and tinnitus was observed in subgroups, **except for the subgroup of ipsilateral use for 4 years and longer (OR 1.95; CI 1.00-3.80)**. The authors concluded that high intensity and long duration of mobile phone use might be associated with tinnitus.

Auditory response to pulsed radiofrequency energy - 2003
http://www.ncbi.nlm.nih.gov/pubmed/14628312?ordinalpos=2&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubn
The human auditory response to pulses of radiofrequency (RF) energy, commonly called **RF hearing**, is a well established phenomenon. RF induced sounds can be characterized as low intensity sounds because, in general, a quiet environment is required for the auditory response. The sound is similar to other common sounds such as a click, buzz, hiss, knock, or chirp. Effective radiofrequencies range from 2.4 to 10000 MHz, but an individual's ability to hear RF induced sounds is dependent upon high frequency acoustic hearing in the kHz range above about 5 kHz. The site of conversion of RF energy to acoustic energy is within or peripheral to the cochlea, and once the cochlea is stimulated, the detection of RF induced sounds in humans and RF induced auditory responses in animals is similar to acoustic sound detection. The fundamental frequency of RF induced sounds is independent of the frequency of the radiowaves but dependent upon head dimensions. The auditory response has been shown to be dependent upon the energy in a single pulse and not on average power density. The weight of evidence of the results of human, animal, and modeling studies supports the thermoelastic expansion theory as the explanation for the RF hearing phenomenon. RF induced sounds involve the perception via bone conduction of thermally generated sound transients, that is, audible sounds are produced by rapid thermal expansion resulting from a calculated temperature rise of only 5 x 10(-6) degrees C in tissue at the threshold level due to absorption of the energy in the RF pulse. The hearing of RF induced sounds at exposure levels many orders of magnitude greater than the hearing threshold is considered to be a biological effect without an accompanying health effect. This conclusion is supported by a comparison of pressure induced in the body by RF pulses to pressure associated with hazardous acoustic energy and clinical ultrasound procedures. Copyright 2003 Wiley-Liss, Inc.

Microwave Auditory Effect - 2007
Hearing of microwave pulses by humans and animals: effects, mechanism, and thresholds.
http://www.ncbi.nlm.nih.gov/pubmed/17495664
The hearing of microwave pulses is a unique exception to the airborne or bone-conducted sound energy normally encountered in human auditory perception. The hearing apparatus commonly responds to airborne or bone-conducted acoustic or sound pressure waves in the audible frequency range. But the hearing of microwave pulses involves electromagnetic waves whose frequency ranges from hundreds of MHz to tens of GHz. Since electromagnetic waves (e.g., light) are seen but not heard, the report of auditory perception of microwave pulses was at once astonishing and intriguing. Moreover, it stood in sharp contrast to the responses associated with continuous-wave microwave radiation. Experimental and theoretical studies have shown that the microwave auditory phenomenon does not arise from an interaction of microwave pulses directly with the auditory nerves or neurons along the auditory neurophysiological pathways of the central nervous system. Instead, the microwave pulse, upon absorption by soft tissues in the head, launches a thermoelastic wave of acoustic pressure that travels by bone conduction to the inner ear. There, it activates the cochlear receptors via the same process involved for normal hearing. Aside from tissue heating, microwave auditory effect is the most widely accepted biological effect of microwave radiation with a known mechanism of interaction: the thermoelastic theory. The phenomenon,

mechanism, power requirement, pressure amplitude, and auditory thresholds of microwave hearing are discussed in this paper. A specific emphasis is placed on human exposures to wireless communication fields and magnetic resonance imaging (MRI) coils.

Sound perception induced by extracranial magnetic stimulation in deaf patients. - 1992

http://www.ncbi.nlm.nih.gov/pubmed/1488610?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubn

Two profoundly hard-of-hearing and deaf patients were examined by non-invasive extracranial magnetic stimulation (EMS) in an effort to determine whether EMS could evoke auditory sensations. The patients were fitted with standard earplugs and were stimulated at the auricle, the mastoid and the temporal lobe area. The threshold of auditory sensation (TAS) was determined at each stimulus position and found to be approximately 20-40% of the maximum EMS level (2.0 Tesla). The TAS was generally lowest in mastoid stimulation, but was variable, and dependent on the angle and position of the stimulating coil relative to the skull. Middle-ear muscle reflex (MEMR) tests performed by EMS of the auricle, mastoid and temporal lobe area contralateral to the probe ear were negative. It was concluded that EMS of the auditory system, particularly the mastoid area, can evoke auditory sensations in cochlea-deaf ears, and that this technique deserves further study as a non-invasive procedure for evaluating potential cochlear implant patients in conjunction with electrostimulation.

Electromagnetic stimulation of the auditory system: effects and side-effects. - 1993

http://www.ncbi.nlm.nih.gov/pubmed/8210963?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubn

Extracranial electromagnetic stimulation (EMS) is a recently developed clinical technique which may be used in place of conventional transcutaneous electrical stimulation to activate the central and peripheral nervous systems. This technique is widely used in neurology and otolaryngology for non-invasive stimulation of the brain and facial nerve. EMS uses electromagnetic field pulses which pass unimpeded through the cranium and soft tissues to activate excitable membranes of volume conductors. In this series of studies, the effects and side-effects of electromagnetic stimulation on the auditory system of humans and experimental animals were investigated. In the first study, 18 profoundly hard-of-hearing and deaf patients who were candidates for cochlear implants were examined by non-invasive EMS in an effort to determine whether EMS could stimulate residual neurons in the cochlea, 8th nerve proper, or higher auditory brain centers, and evoke auditory sensations. The patients were stimulated with a magnetic coil positioned at the (1) auricle, (2) mastoid process, and (3) the temporal lobe area. EMS elicited auditory sensations in 26 ears (of 14 patients/subjects). The lowest threshold of auditory sensation (TAS) at each stimulus position was found to be at the 20% EMS level, with a range of 20-50% of the maximum level (2.0 Tesla), and with equal sensitivity in each coil position.

Occupational safety: effects of workplace radiofrequencies on hearing function. - 2004

http://www.ncbi.nlm.nih.gov/pubmed/15631877?ordinalpos=7&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubn

Results of BERA indicated no statistically significant differences between exposure and control subjects. In audiometric evaluation, hearing threshold of people occupationally exposed to RF were found higher than the control group subjects for frequencies of 4000 Hz and 8000 Hz in terms of bone and air conduction of right and left ear ($p < 0.01$). CONCLUSIONS: The results of traditional audiometer indicated that RF promotes sensorineural hearing loss and affects cochlea parts related to 4000 Hz and 8000 Hz. These findings may have immediate implications and considerations for workplace safety in order

to provide an occupationally safe environment to employees working in such settings.

Microwave auditory effect- a comparison of some possible transduction mechanisms - 1976
http://www.ncbi.nlm.nih.gov/pubmed/1046077?ordinalpos=23&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pub
When human subjects are irradiated with pulse modulated microwave energy they report the perception of a sound that appears to originate from within or slightly behing the head. Three of the possible mechanisms are examined using first order mathematical approximations and several simplifying assumptions. The results show that while all three (radiation pressure, strictive force and thermal expansion) are capable of producing the phenomenon, the stress resulting from thermal expansion may be so great that it masks the effect of the others completely.

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Review

Electrohypersensitivity as a Newly Identified and Characterized Neurologic Pathological Disorder: How to Diagnose, Treat, and Prevent It

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Abstract: Since 2009, we built up a database which presently includes more than 2000 electrohypersensitivity (EHS) and/or multiple chemical sensitivity (MCS) self-reported cases. This database shows that EHS is associated in 30% of the cases with MCS, and that MCS precedes the occurrence of EHS in 37% of these EHS/MCS-associated cases. EHS and MCS can be characterized clinically by a similar symptomatic picture, and biologically by low-grade inflammation and an autoimmune response involving autoantibodies against O-myelin. Moreover, 80% of the patients with EHS present with one, two, or three detectable oxidative stress biomarkers in their peripheral blood, meaning that overall these patients present with a true objective somatic disorder. Moreover, by using ultrasonic cerebral tomosphygmography and transcranial Doppler ultrasonography, we showed that cases have a defect in the middle cerebral artery hemodynamics, and we localized a tissue pulsometric index deficiency in the capsulo-thalamic area of the temporal lobes, suggesting the involvement of the limbic system and the thalamus. Altogether, these data strongly suggest that EHS is a neurologic pathological disorder which can be diagnosed, treated, and prevented. Because EHS is becoming a new insidious worldwide plague involving millions of people, we ask the World Health Organization (WHO) to include EHS as a neurologic disorder in the international classification of diseases.

Keywords: electrohypersensibility; multiple chemical sensitivity; neurologic disease; oxidative stress; melatonin; O-myelin; inflammation; histamine; radiofrequency; extremely low frequency; electromagnetic fields

1. Introduction

The term electromagnetic hypersensitivity or electrohypersensitivity (EHS) was first proposed in 1991 by William Rea to identify the clinical condition of patients reporting health effects while being exposed to an electromagnetic field (EMF) [1]. This term was then used in 1997 in a report provided by a European group of experts for the European Commission to clinically describe this unusual pathology, which may imply EMF exposure [2].

In 2002, Santini et al. in France reported similar symptomatic intolerance in users of digital cellular phones and among people living near wireless communication base stations [3,4]. In 2004, because of the seemingly worldwide prevalence increase in EHS, the World Health Organization (WHO) organized an international scientific workshop in Prague to define and characterize EHS. Although not acknowledging EHS as being caused by EMF exposure, the Prague working group clearly defined EHS as "a phenomenon where individuals experience adverse health effects while using or

being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields" [5]. WHO then acknowledged EHS as an adverse health condition [6]. However, according to a previous 1996 International Program on Chemical Safety (IPCS)-sponsored conference in Berlin on multiple chemical sensibility (MCS) [7], it was recommended to qualify such unknown new pathological conditions under the term of "idiopathic environmental intolerance (IEI)". Thus, following the Prague workshop, instead of using the term EHS, it was proposed to use the term "idiopathic environmental intolerance attributed to EMF (IEI-EMF)" to name this particular pathological condition, because of the lack of a proven causal link between EHS and EMF exposure, and no proven physiopathological mechanism linking EMF exposure with clinical symptoms.

That is indeed what WHO officially stated in its 2005 fact sheet 296 [6], indicating that "EHS resembles MCS, another disorder associated with low-level environmental exposure to chemicals ... " and that because of "non-specific symptoms" and "no clear diagnostic criteria", this "disabling condition" could not be diagnosed medically. In addition, in 2002 and 2013, WHO classified extremely low frequencies (ELF) and radiofrequencies (RF) respectively as possibly carcinogenic (group IIB), meaning that EMFs may cause cancer. This past scientific evolution is summarized in Table 1.

Table 1. Electrohypersensitivity (EHS)/multiple chemical sensitivity (MCS) and cancer statements including those of the World Health Organization (WHO) or on behalf of WHO. COST—European action for co-operation in the field of science and technological research on biological effects of electromagnetic fields; EMF—electromagnetic field; IARC—international agency for research on cancer.

1996	Berlin: WHO-sponsored workshop; MCS classified as idiopathic environmental intolerance (IEI)
1997	Stockholm: Possible health implication of electromagnetic field exposure; a report prepared by a European group of experts for the European Commission
1998	Austria: COST 244 bis international workshop on EHS
1998	Atlanta (US): MCS 1999 consensus meeting
2002	IARC: Extremely low frequency (ELF) EMFs classified as possibly carcinogenic (Group IIB)
2004	Prague: WHO workshop; identification of idiopathic environmental intolerance attributed to EMF
2005	WHO: WHO fact sheet n° 292 aiming at defining EHS
2013	IARC: Radiofrequency (RF) EMFs classified as possibly carcinogenic (Group IIB)
2015	Brussels: Fourth Paris Appeal Colloquium; a focus on electromagnetic fields and EHS

However, since the 2005 WHO statement on EHS and a more recent 2014 WHO report on mobile phone exposure and public health [8], much clinical and biological progress has been made in identifying and characterizing EHS, as summarized during the international scientific consensus meeting on EHS and MCS which we organized in May 2015 in Brussels at the Royal Belgium Academy of Medicine [9].

Because we suspected that EHS prevalence was increasing worldwide, since 2009, we constituted and maintained a database which was registered by the French Committee for the protection of persons (CPP), under the registration number 2017-A02706-47, as well as in the European Clinical *Trials* Database (*EudraCT*), under the registration number 2018-001056-36. This database presently includes more than 2000 EHS and/or MCS cases. All the patients included in this series gave their informed consent for clinical and biological research investigations. In addition, all these patients were anonymously registered in the database.

By querying this database, we showed for the first time that EHS is frequently associated with MCS [10], and that EHS and MCS are characterized by a common similar clinical picture which can be identified objectively by the detection of similar biomarkers in the peripheral blood and urine [10,11], and by similar pulsometric abnormalities in the brain [10,12]. Thus it finally appears that EHS and MCS could in fact be two etiopathogenic aspects of a unique pathological disorder [10]. We would like here to overview our original data and discuss the possibility that EHS is part of a true pathologic neurologic disorder resulting from a comprehensive physiopathologic mechanism, in common with MCS. We conclude that EHS—whatever its causal origin—is becoming a worldwide plague. Thus, as

we showed that it can be diagnosed, treated medically, and eventually prevented, we ask WHO to include EHS in the international classification of diseases (ICD).

2. Demography

In a prospective study involving systematic face-to-face questionnaire-based interviews and clinical physical examinations of many patients constituting part of the database, we reported that EHS is a well-defined clinico-biological entity [10].

Table 2 presents the demographic data we obtained from the serial analysis of the first 726 consecutive cases included in the database. No children were included. Median and mean ages were 48 years for the EHS group, 48 and 47 years, respectively, for the MCS group, and 46 years for the EHS and MCS-associated group. Sex ratio shows a clear predominance of women among patients, reaching two-thirds in the EHS group and the MCS group, while it was three-quarters in the group of patients presenting with both disorders. This strongly suggests that women are genetically more susceptible than men to the environmental intolerance attributed to EMFs and/or chemicals.

Table 2. Age and sex ratio in EHS and/or MCS self-reported patients, according to Reference [10].

Demographic Data	EHS	MCS	EHS/MCS
n (%)	521 (71.7%)	52 (7.1%)	154 (21.2%)
Age (mean ± SD)	48.2 ± 12.9	48.5 ± 10.3	46.7 ± 11.2
Age (median (range))	48 (16–83)	47 (31–70)	46 (22–76)
Sex ratio (women/men)	344/177	34/18	117/37
Female (%)	66	65	76

3. Clinical Description

Table 3 presents the detailed symptomatic picture that we obtained during face-to-face interviews and clinical examinations for the groups of (1) EHS self-reported patients, (2) MCS self-reported patients, and (3) both disorder self-reported patients. Symptoms in patients with EHS were compared with those from a series of apparently healthy control subjects that showed no clinical evidence of EHS and/or MCS. As indicated in the table, EHS is characterized by the occurrence of neurologic symptoms including headache, tinnitus, hyperacusis, dizziness, balance disorder, superficial and/or deep sensibility abnormalities, fibromyalgia, vegetative nerve dysfunction, and reduced cognitive capability, including immediate memory loss, attention–concentration deficiency, and eventually tempo-spatial confusion. These symptoms were associated with chronic insomnia, fatigue, and depressive tendency, in addition to emotional lability and sometimes irritability. A major observation is that symptoms were repeatedly reported by the patients to occur each time they reported being exposed to presumably EMF sources, even of weak intensity, and to regress or even disappear after they left these presumed sources. With the exception of arthralgia and emotivity, which were observed at a similar frequency range in the control group, all clinical symptoms occurring in EHS patients were found to be significantly much more frequent than those in apparently normal controls.

Contrary to what was claimed from studies reporting clinical symptoms in EHS patients [2,5,6,13], these symptoms were not all subjective. In many cases, they were confirmed by family members; moreover, we were able to detect, at physical examination, a Romberg sign (objective posture test) in 5% of the cases and to observe the presence of cutaneous lesions in 16%. Overall, although many of these symptoms are considered as non-specific in the scientific literature, the general clinical picture resulting from their association and frequency strongly suggests that EHS can in fact be recognized and identified as a typical neurologic disorder as it is also the case for MCS and MCS-associated EHS.

Table 3. Clinical symptoms in EHS self-reported patients in comparison with those in normal controls and in comparison with those in MCS and EHS/MCS self-reported patients *, according to Reference [11].

Clinical Symptoms	EHS (%)	Normal Controls (%)	p **	MCS (%)	p ***	EHS/MCS (%)	p ****
Headache	88	0	<0.0001	80	0.122	96	0.065
Dysesthesia	82	0	<0.0001	67	0.0149	96	0.002
Myalgia	48	6	<0.0001	48	1	76	<0.0001
Arthralgia	30	18	0.067	24	0.611	56	<0.001
Ear heat/otalgia	70	0	<0.0001	16	<0.0001	90	<0.001
Tinnitus	60	6	<0.0001	35	<0.001	88	<0.0001
Hyperacusis	40	6	<0.0001	20	<0.001	52	0.118
Dizziness	70	0	<0.0001	52	0.0137	68	0.878
Balance disorder	42	0	<0.0001	40	0.885	52	0.202
Concentration/attention deficiency	76	0	<0.0001	67	0.210	88	0.041
Loss of immediate memory	70	6	<0.0001	56	0.040	84	0.028
Confusion	8	0	0.007	0	0.0038	20	0.023
Fatigue	88	12	<0.0001	72	0.0047	94	0.216
Insomnia	74	6	<0.0001	47	<0.0001	92	0.001
Depression tendency	60	0	<0.0001	29	<0.0001	76	0.022
Suicidal ideation	20	0	<0.0001	9	0.027	40	0.003
Transitory cardiovascular abnormalities	50	0	<0.0001	36	0.046	56	0.479
Ocular deficiency	48	0	<0.0001	43	0.478	56	0.322
Anxiety/panic	38	0	<0.0001	19	0.003	28	0.176
Emotivity	20	12	0.176	16	0.461	20	1
Irritability	24	6	<0.001	14	0.071	24	1
Skin lesions	16	0	<0.0001	14	0.692	45	<0.0001
Global body dysthermia	14	0	<0.0001	6	0.236	8	0.258

* These data result from the clinical analysis of 150 consecutive clinically evaluable cases issued from the database including an already published series of EHS and/or MCS patients who were investigated for biological markers [10]. Symptoms in EHS self-reported patients were compared with symptoms obtained from a series of 50 apparently normal subjects used as controls. These symptoms were also compared to those occurring in MCS and EHS/MCS self-reported patients. Percentage of patients with symptoms were compared by using the chi-square independence test. ** Statistical difference between EHS self-reported patients and normal controls. *** Statistical difference between EHS self-reported patients and MCS self-reported patients. **** Statistical difference between EHS self-reported patients and EHS/MCS self-reported patients.

Table 3 reveals that between EHS and MCS there is no statistically significant difference in types and frequencies of clinical symptoms for headache, myalgia and arthralgia, balance disorder, concentration/attention deficiency, emotivity and irritability, skin lesions and global body dysthermia, whereas dysesthesia, ear heat/otalgia, tinnitus, hyperacusis, dizziness, loss of immediate memory, insomnia and fatigue as well as depression tendency and suicidal ideation appear to be statistically more frequent in EHS than in MCS. Moreover, in the case of EHS associated with MCS, most of the symptoms—such as headache, dysesthesia, myalgia and arthralgia, tinnitus, and, above all, cognitive capability, including loss of immediate memory, concentration/attention deficiency, and tempo-spatial confusion—were found to be significantly more frequent than in EHS alone, suggesting that the presence of an additional chemical intolerance component to the intolerance attributed to EMF exposure is associated with a more severe pathology. This was especially the case for skin lesions which were found in 45% of the cases, as well as for physical and mental suffering and depressive tendency with underlying suicidal ideation in 40%.

Note that cutaneous lesions were more frequent on the superior members than on the inferior members of the patients, and more frequent on the hands, particularly on the hand which held the mobile phone (as exemplified in Figure 1A). Note also that the cutaneous lesions were not only more frequent in the group of patients with EHS- and MCS-associated disorders (45%) than in the group of

patients with only EHS (16%), but also that they were more extensive and persistent in the cases of both associated disorders than in the case of EHS alone (Figure 1B).

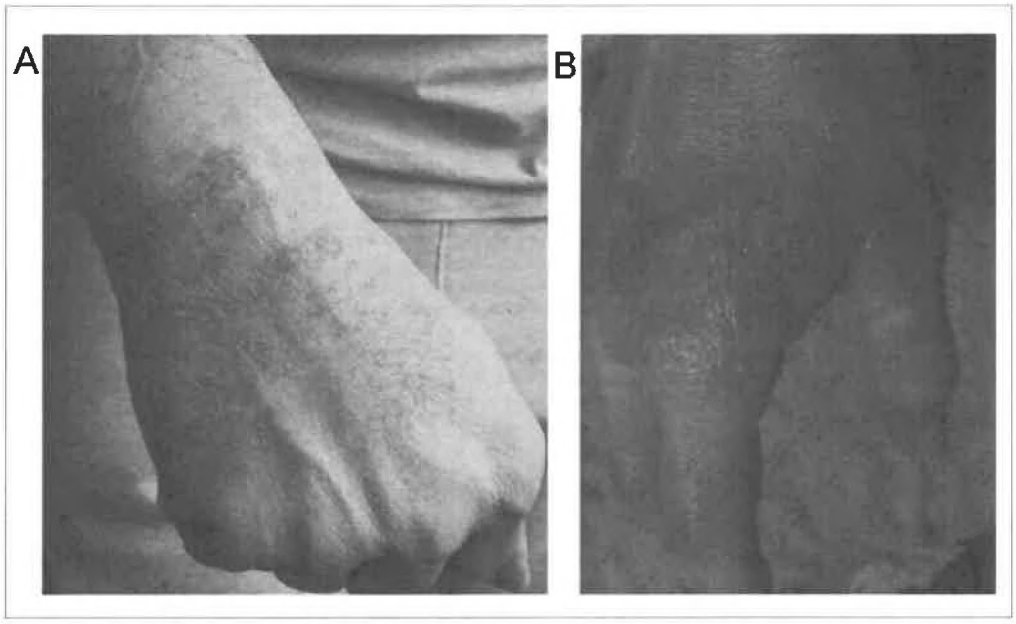

Figure 1. Examples of skin lesions observed on the hand of an EHS-bearing patient (**A**) and of an EHS/MCS-bearing patient (**B**). (Photographs are issued from the database).

These clinical observations strongly suggest that EHS and EHS/MCS are objective somatic disorders, which can neither be claimed as originating from some psychologic or psychiatric-related conditions, nor from nocebo effects [11] (see further).

4. Identification of Biomarkers

On the basis of previously published experimental data, we selected and identified several biomarkers in the peripheral blood and urine of EHS and/or MCS patients which can allow physicians to objectively characterize EHS and MCS as true somatic pathological disorders [10], discounting the hypothesis that EHS and MCS could be caused by a psychosomatic or nocebo-related process [11]. As indicated in Table 4, there is a similar increase in mean level values of low-grade inflammation-related biomarkers in the peripheral blood of patients with EHS, MCS, or both associated disorders. In addition, as far as frequency is concerned, we found hypersensitive C reactive protein (hs-CRP) to be increased in 12–15% of the cases, histamine in 30% to 40%, immunoglobulin E (IgE) in 20% to 25%, and heat-shock protein 27 (Hsp 27) and Hsp 70 in 12% to 30%. Note that, among these markers, IgE and histamine were found to be increased in patients with no proven allergy; thus, in the case of no associated allergy, histamine appears to be the most frequently involved biomarker in EHS, as well as in MCS, suggesting a low-grade inflammatory process is involved in the genesis of these two disorders. Consequently, it is believed that, as an inflammation mediator, histamine could play a major key contributing role in the physiopathologic mechanism which may account for the occurrence of the two disorders [11,14] (see further). Note also that, with the exception of Hsp 70, which was found to be less frequently increased in the MCS group, there was no significant difference between the three groups of patients for the percentage of patients with values above normal, nor any significant difference in mean increased values in comparison with normal values for all biomarkers in the three groups studied, meaning that EHS, MCS, and the association of both disorders may share a common low-grade inflammation-related physiopathologic mechanism for genesis.

Table 4. Increase in low-grade inflammation-related biomarker mean blood level values in the peripheral blood of patients with EHS and/or MCS, according to References [9,10]. SE—standard error; hs-CRP—hypersensitive C reactive protein; IgE—immunoglobulin E; Hsp—heat-shock protein.

	Patient Groups							
Marker Normal Values	**EHS Mean ± SE**	**Above Normal (%)**	**MCS Mean ± SE**	**Above Normal (%)**	***p* ***	**EHS/MCS Mean ± SE**	**Above Normal (%)**	***p* ****
hs-CRP < 3 mg/L	10.3 ± 1.9	15	5.3 ± 1.7	12	0.50	6.9 ± 1.7	14.3	0.36
Histamine < 10 nmol/L	13.6 ± 0.2	37	23.5 ± 4.5	33	0.91	13.6 ± 0.4	41.5	0.52
IgE < 100 UI/mL	329.5 ± 43.9	22	150.9 ± 18.3	20	0.23	385 ± 70	24.7	0.53
Hsp 70 < 5 ng/mL	8.2 ± 0.2	18.7	5.9 ± 0.5	12	0.03	8 ± 0.3	25.4	0.72
Hsp 27 < 5 ng/mL	7.3 ± 0.2	25.8	6.8 ± 0.1	6 ***	0.59	7.2 ± 0.3	31.8	0.56

* Comparison between the EHS and MCS groups of patients for marker mean level values was done using the two-tailed *t*-test. Except for Hsp 70, there is no statistically significant difference between EHS and MCS patients for increased mean level values of the different biomarkers analyzed, suggesting that EHS and MCS share a common physiopathological mechanism for genesis. ** Comparison between the EHS and EHS/MCS groups of patients by using the two-tailed *t*-test. There is no statistically significant difference between EHS and EHS/MCS patients for increased mean level values of the different biomarkers analyzed. *** With the exception of MCS, for which there is a statistically significantly lower frequency percentage value for Hsp 27, the frequency percentage values obtained in EHS and EHS/MCS for all the other investigated parameters do not differ significantly on the basis of the chi-square independence test.

Moreover, as indicated in Table 5, we were able to show that, in peripheral blood, there is an increase in S100B protein in 15–20% of the patients and an increase in nitrosative stress-related nitrotyrosine (NTT) in 8–30% in the EHS and/or MCS groups, suggesting that these biomarkers may reflect opening of the blood–brain barrier (BBB) in these patients, whatever the patient group considered, since it was shown that S100B protein [15,16] and nitrotyrosine [17–20] are markers associated with BBB opening. In addition, we detected the presence of autoantibodies against O-myelin in about 20% of all cases, whether EHS, MCS or both; meaning that an autoimmune response against the white matter of the nervous system occurres in patients; a finding that may in fact be the consequence of the occurrence of oxidative/nitrosative stress [10,21].

Table 5. Increase in mean blood level values of peripheral blood S100B protein, nitrotyrosine (NTT), and O-myelin autoantibodies in EHS and/or MCS patients, according to References [10,11].

	Patient Groups							
Markers Normal Values	**EHS Mean ± SE**	**Above Normal (%)**	**MCS Mean ± SE**	**Above Normal (%)**	***p* ***	**EHS/MCS Mean ± SE**	**Above Normal (%)**	***p* ****
S100B < 0.105 µg/L	0.20 ± 0.03	14.7	0.25 ± 0.05	21.15	0.56	0.17 ± 0.03	19.7	0.69
NTT * > 0.9 µg/ml	1.36 ± 0.12	29.7	1.26 ± 0.13	8	0.85	1.40 ± 0.12	28.9	0.86
O-myelin (qualitative test)	Positive	22.8	Positive	13.6	_	Positive	23.6	_

* Comparison between the EHS and MCS groups of patients using the two-tailed *t*-test. There is no statistically significant difference between the two groups of EHS and MCS patients for increased mean level values of the two different biomarkers analyzed, suggesting that EHS and MCS share a common physiopathological mechanism for genesis. ** Comparison between the EHS and EHS/MCS groups of patients using the two-tailed *t*-test. There is no statistically significant difference between EHS and EHS/MCS patients for increased mean level values of the different biomarkers analyzed, suggesting here too that EHS and MCS share a common physiopathological mechanism for genesis.

Moreover, more recently, we measured different oxidative and nitrosative stress-related biomarkers such as thiobarbituric acid reactive substances (TBARS), oxidized glutathione (GSSG), and NTT in the peripheral blood of EHS patients. As reported in Figure 2, we found that nearly 80% of EHS patients presented with an increase in oxidative/nitrosative stress-related biomarkers—more precisely, with only one of these three studied biomarkers in 43% of the patients, two of these biomarkers in 21% of them, and all three in 15% [22]. This clearly indicates that, in addition to low-grade inflammation and an anti-white matter autoimmune response, EHS can also be diagnosed by the presence of oxidative/nitrosative stress.

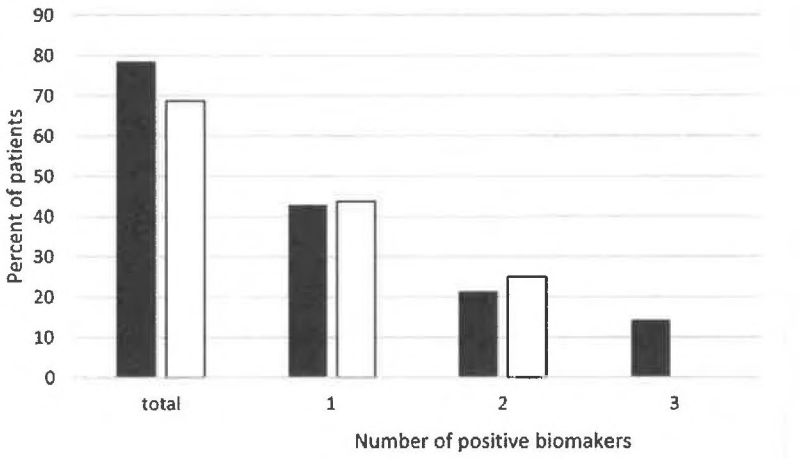

Figure 2. Percentage of EHS self-reported patients having positive thiobarbituric acid reactive substances (TBARS), oxidized glutathione (GSSG), and/or NTT oxidative stress biomarkers measured in the peripheral blood, according to Reference [22]. ■ Corresponds to NTT, TBARS, and GSSG, i.e., all three biomarkers measured in 14 of the 32 included patients. □ Corresponds to TBARS and GSSG analyzed in all 32 included patients. "Positive" biomarkers correspond to patients having one, two, or three markers with levels above the upper normal limits, and "total" corresponds to patients having at least one positive biomarkers, i.e., having one, two, or possibly three positive biomarkers.

Finally, we also found that, in comparison with normal reference values, the 24-h urine 6-hydroxymelatonin (6-OHMS)/creatinine ratio was normal or significantly decreased in 88% of cases, while, due to a still unexplained process, it was significantly increased in 12%, whatever the group of patients considered. 6-OHMS is a melatonin metabolite. Decrease in melatonin production as a consequence of prolonged EMF exposure was experimentally evidenced both in animals and in humans [23,24]. However, since EMF exposure was also reported not to alter melatonin synthesis and secretion [25], an alternative plausible explanation could be that a decrease in the excretion of 6-OHMS in the urine may result from a decrease in melatonin metabolic bioavailability due to its increased intake and utilization of melatonin as a free radical scavenger [26,27]. This indeed could be the case in patients with a decrease in the 24-h urine 6-OHMS/creatinine ratio level, since, as shown above, most EHS patients present with oxidative/nitrosative stress. Thus, a decrease in 6-OHMS in the urine may in fact be a consequence of the antioxidative stress effect of this hormone rather than its decreased synthesis in the pineal gland. Consequently, such reduction in bioavailability may contribute not only to clinical sleep disturbance in these patients, but also to a decrease in host defense mechanisms, possibly putting these patients at risk of neurodegenerative disease and cancer [28,29].

Moreover, the development of oxidative/nitrosative stress-related autoimmune response may also contribute to weakening the putative protective health effect of the chaperone proteins Hsp 70 and Hsp 27 [30]. There is presently no clear explanation why, in 12% of the cases, instead of having a normal or significant decrease in the 24-h urine 6-OHMS/creatinine ratio, this ratio was significantly increased in comparison with normal control values. As indicated in Table 6, this may be due in some cases to an increased production of serotonin in the brain, since serotonin is a precursor neurotransmitter of melatonin.

As indicated in Table 6, changes in neurotransmitter levels revealed that EHS is associated with different abnormal neurotransmitter profiles, confirming EHS is a well-established new brain-related neurologic disorder.

Table 6. Preliminary unpublished data based on the measurement of neurotransmitters and their metabolites in the urine of 42 EHS-bearing patients. 3-4 DOPAC—3,4-Dihydroxyphenylacetic acid.

Neurotransmitters	Patients	%
Dopamine increase	17/42	31
3-4 DOPAC decrease	18/42	43
Noradrenaline increase	11/42	26
Adrenaline increase	8/42	19
Adrenaline decrease	12/42	22
Serotonin increase	4/42	9.5
Serotonin decrease	5/42	12

5. Radiological Identification of Cerebral Neuro-Vascular Abnormalities

Classical brain imaging techniques including brain computerized tomography (CT) scans, brain magnetic resonance imaging (MRI), and brain angioscans are usually normal in EHS patients and in MCS or EHS/MCS patients, meaning that the normality of these investigations is not an argument against the diagnosis of these pathological disorders. Fortunately we have shown that development and use of other imaging techniques could be greatly helpful to increase our ability of objectively characterizing EHS and MCS, should they show abnormal function. In fact, as indicated in Table 7, by using transcranial Doppler ultrasound (TDU) in patients with EHS, we showed a decrease in the mean pulsatility index in one or both middle cerebral arteries, i.e., for one artery in 25% and 31% of the cases respectively for the right and left artery, and for both arteries in 50%. Moreover, for the dual EHS/MCS group of patients, it was for one artery in 20% of the cases and for both arteries in 50%. In addition, as far as resistance in the blood flow (BBF) is concerned, we found that, in EHS patients, BBF resistance was increased for one artery in 6.25% of the cases and for both arteries in 18.75%, while in EHS/MCS patients, it was 5–10% for one artery and 25% for both arteries. Note also that mean blood flow velocity was below normal values in 9.75% to 40% of the cases, while it was above normal values in 5% to 18.75%, depending on the EHS and EHS/MCS group considered (see Table 7). This suggests that, in EHS and/or MCS, BBF may be decreased in one or both of these brain arteries.

Table 7. Results of resistance index, pulsatility index, and mean flow velocity in comparison with normal values in the right and left middle cerebral arteries using transcranial Doppler ultrasound in 32 EHS cases and 20 EHS/MCS cases (unpublished data).

				EHS $n = 32$					
	Normal Value	Mean ± SE		Below Normal (%)			Above Normal (%)		
	Right and Left	Right	Left	Right Only	Left Only	Both	Right Only	Left Only	Both
Resistance index	<0.75	0.62 ± 0.03	0.65 ± 0.04	–	–	–	6.25	6.25	18.75
Pulsatility index	>0.60	0.55 ± 0.02	0.55 ± 0.03	25	31.25	50	–	–	–
Mean flow velocity	62 ± 12	59.56 ± 5.98	61.35 ± 5.27	9.75	9.75	31.25	3.12	9.25	18.75
				EHS/MCS $n = 20$					
	Normal values	Mean ± SE		Below Normal (%)			Above Normal (%)		
	Right and Left	Right	Left	Right only	Left only	Both	Right only	Left only	Both
Resistance index	<0.75	0.79 ± 0.09	0.64 ± 0.04	–	–	–	5	10	25
Pulsatility index	>0.60	0.48 ± 0.03	0.61 ± 0.02	20	0	65	–	–	–
Mean flow velocity	62 ± 12	53.03 ± 9.09	51.77 ± 7.63	20	20	40	10	10	5

Moreover, by using ultrasonic cerebral tomosphygmography (UCTS) applied to the temporal lobes [12], we showed there is a significant decrease in mean pulsometric index in the middle cerebral artery-dependent tissue areas of these lobes, especially in the capsulo-thalamic area, which corresponds to the limbic system and the thalamus [12]. As exemplified in Figure 3, this tissue hypo-pulsation—mainly detected in the capsulo-thalamic area of these lobes—suggests that EHS and/or MCS are associated with a capillary BBF decrease in these two brain structures, thus leading to the hypothesis that they may be associated with some vascular and/or neuronal dysfunction [10–12]. Although these abnormalities are not specific, since they may be similar to those found in Alzheimer's disease and other neurodegenerative disorders, we recently confirmed that UCTS could presently be one of the most accurate imaging techniques to be used to diagnose EHS and/or MCS and to follow objectively treated patients [12].

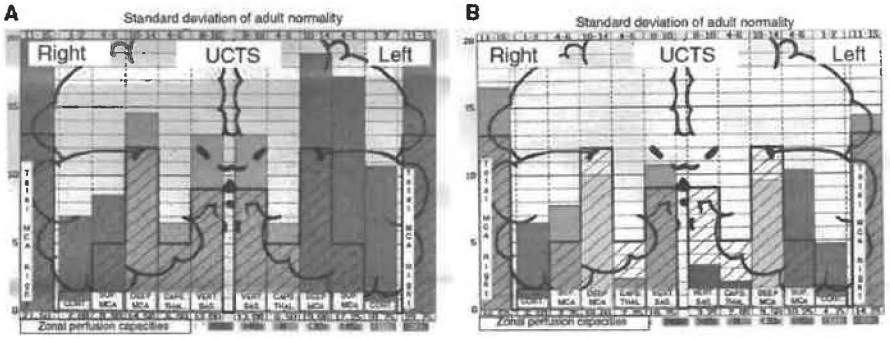

Figure 3. Examples of diagrams obtained from the database by using ultrasonic cerebral tomosphygmography (UCTS), exploring the global centimetric ultrasound tissue pulsatility in the two temporal lobes of a normal subject (**A**) and of an EHS self-reported patient (**B**), according to References [11,12]. Measurements are expressed as pulsometric index (PI). Note that, in A and B, mean values of PI in each explored area are recorded from the cortex to the internal part of each temporal lobe (i.e., from left to right for the right lobe, and from right to left for the left lobe). In addition, note that, in A (normal subject), all values are over the median normal PI values, whereas, in B (EHS self-reported patient), values in the so called capsulo-thalamic areas (the fifth and the second column for the right and left temporal lobes, respectively) are significantly under the median normal values, suggesting that the limbic system and the thalamus in each temporal lobe may be involved in EHS, as exemplified in this patient.

It appears, however, that these brain abnormalities are not restricted to the limbic system and the thalamus, since, by using TDU as indicated above, we showed that, in EHS and/or MCS patients, BBF in the middle cerebral arteries may be abnormal. Moreover, by using functional MRI (fMRI) in EHS patients exposed chronically to extremely low-frequency (ELF) radiation, regional BBF changes were also reported by Heuser and Heuser, but mainly in the frontal lobes, as an abnormal default mode network (DMN) (particularly as hyper-connectivity of this DMN), in association with a decrease in cerebral BBF and metabolic processes in the two so far individualized fragment hyper-connected components [31]. For example, in Figure 4, abnormal DMN is represented with fragmented hyper-connectivity of the anterior component and posterior component, which may lead to decreased BBF and/or metabolism in the bi-frontal lobes.

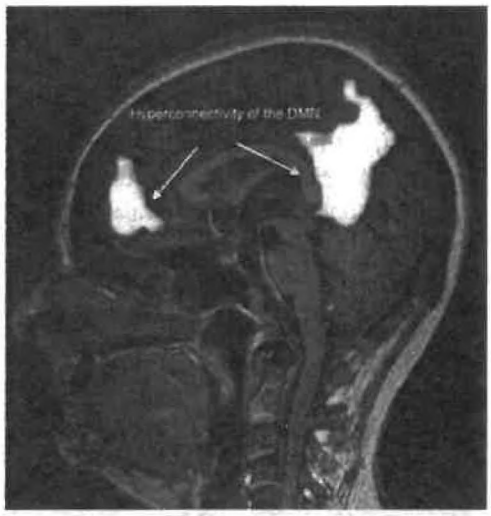

Figure 4. Abnormal functional MRI brain scan in patients complaining of EHS after long-term exposure to EMF, according to Reference [31].

6. Diagnostic Criteria

On the basis of the above clinical, biological, and radiological reported investigations, it appears that there is presently sufficient comprehensive and relevant data allowing the objective characterization and identification of EHS as a well-defined new neurologic pathological disorder. As a result, patients who self-report that they suffer from EHS should be investigated utilizing presently available objective tests, including the use of the above-reported blood and urine biomarkers and imaging techniques.

At a clinical level, isolated symptoms such as headache, tinnitus, dizziness, or cognitive defects, although they may be referred by the patients as being due to EMF or chemical exposure, are indeed not sufficient for the diagnosis to be made, as they may reflect another pathology. Clinical arguments for EHS could nevertheless be the following: (1) absence of known pathology accounting for the observed clinical symptoms; (2) characteristic association of symptoms such as those we identified, with the association of headache, tinnitus, hyperacusis, dizziness, loss of immediate memory, and attention/concentration deficiency being the most characteristic and reproducible; (3) reproducibility of symptoms under the said influence of EMFs; (4) regression or disappearance of symptoms in the case of said EMF avoidance; (5) finally and most importantly, the association with MCS. As we showed that MCS is associated with EHS in 30% of the cases, and as MCS was well defined during a 1999 international consensus meeting [32], this latter association may in fact be the best clinical criterion for the diagnosis of EHS.

However, because many of these clinical criteria are subjective, they are not sufficient to objectively prove the disease and, thus, establish the diagnosis. Among biological markers, histamine in the blood is presently the best available marker in the case of no associated allergy and the easiest to measure routinely in medical practice. Moreover, detection in the blood of an increase in protein S100B and oxidative/nitrosative stress-related biomarkers such as GSSG and NTT may also be objective contributing elements for the diagnosis. Note, however, that, in 30% of the cases, there were no positive detectable biomarkers in the blood; thus, in addition to the availability of clinical criteria, the EHS diagnosis could be made by using imaging techniques, such as TDU, fMRI, and, if possible, UCTS. Overall, by using this approach, we were able to objectively diagnose EHS in about 90% of EHS self-reported patients.

7. Treatment and Prognostic Evolution

There is, at the moment, no recognized standardized treatment of EHS. There are, however, some treatments that could be indicated, on the basis of biological investigations. We showed, for example, that patients with EHS present frequently with a profound deficit in vitamins and trace elements, especially in vitamin D and zinc, which should be corrected [10,11,22]. Anti-histaminics should also be used in the case of increased histamine in the blood. Furthermore, antioxidants such as glutathione and, more specifically, anti-nitrosative medications should also be used in case of oxidative/nitrosative stress. Moreover, as exemplified in Figure 5, we showed that natural products such as fermented papaya preparation (FPP) and ginkgo biloba can restore brain pulsatility in the various middle cerebral artery-dependent tissue areas of temporal lobes, thereby improving brain hemodynamics and, consequently, brain oxygenation [33]. Since FPP was shown to possess some antioxidant, anti-inflammation, and immune-modulating properties [34–36], we recommend the use of this widely available natural product.

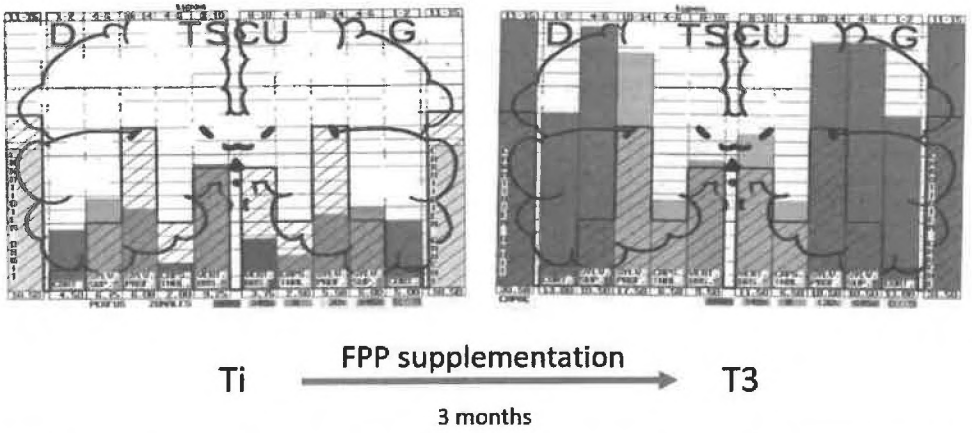

Figure 5. Example of diagrams obtained from the database by using UCTS exploring the global centimetric ultrasound pulsatility in the two temporal lobes of an EHS subject at inclusion (Ti) and three months later (T3) after fermented papaya preparation (FPP) supplementation (9 g per day in two divided doses), according to Reference [33].

In the case of no treatment and no protection against environmental stressors such as EMF and multiple chemicals, EHS may evolve toward some neurodegenerative and psychiatric disorders, possibly including some seemingly Alzheimer's disease-related states. However, in treating and protecting patients as soon as possible, we never observed the occurrence of true Alzheimer's disease in any patient included in the database. By contrast, regression and even disappearance of symptoms of intolerance may occur after treatment and protection of patients. However, in our experience and to our knowledge, hypersensitivity to EMF and/or MCS-related chemical sensitivity never disappears, meaning – unlike symptomatic intolerance – EHS and MCS appear to be associated with some irreversible neurologic pathological state, requiring strong and persistent prevention. So, contrary to some recent claims, we believe these disorders cannot be merely reduced to some type of functional impairment.

8. Proposed Physiopathological Mechanism

In its 2005 official statement on EHS, WHO indicated there is "no scientific basis to link EHS symptoms to EMF exposure" meaning there is no accepted physiopathological mechanism to link environmental cause to disease. This is no longer the case. The basic low-grade inflammation and oxidative/nitrosative stress-related states we showed in EHS patients [10,11,22] are remarkable since they confirm the detrimental health effects of (1) non-thermal or weak thermal non-ionizing

radiation, which were proven experimentally in animals [37–39] and in humans [11] exposed to different environmental stressors including ELF and RF EMFs, and (2) multiple man-made environmental chemicals [40–42], especially in the brain [43,44].

Figure 6 summarizes the different steps of the model we have so far been able to construct from the presently available published data, including our own. On the basis of the inflammation and oxidative/nitrosative stress processes which we evidenced in EHS and/or MCS patients, this model accounts for the mechanisms via which physiopathological effects could take place in the brain and, consequently, how EHS and/or MCS genesis can occur.

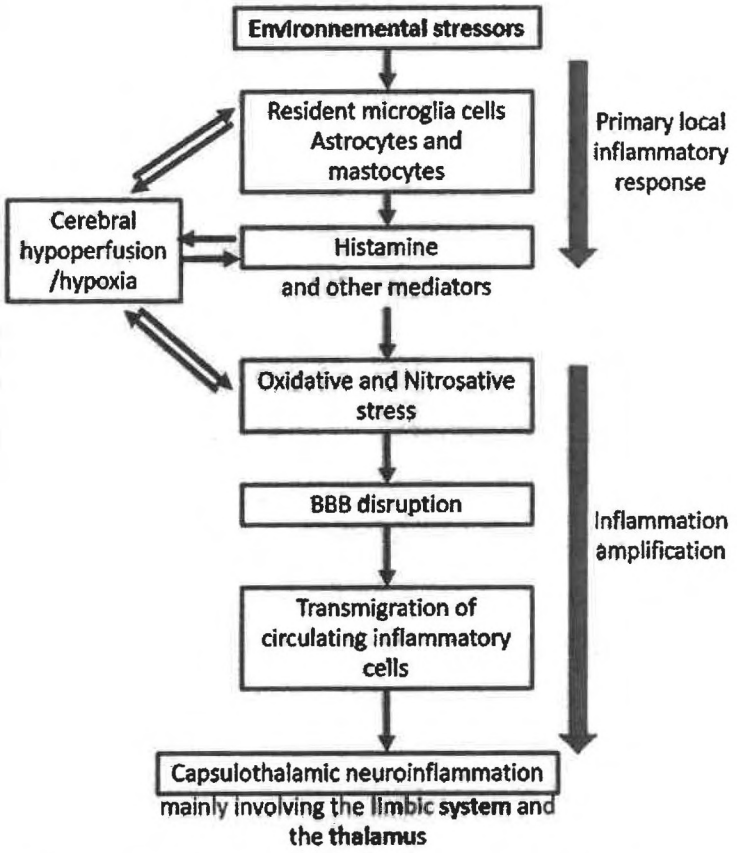

Figure 6. EHS/MCS physiopathological model based on low-grade neuroinflammation and oxidative/nitrosative stress-induced blood–brain barrier disruption, according to Reference [10].

In a first step, there could be an initial local inflammatory response to environmental stressors, whatever they may be. Resident microglia cells, astrocytes, and mastocytes could be the first cells in the brain locally involved in the inflammatory process, releasing inflammatory mediators such as histamine. On the basis of our data [10–12,22,33], it is speculated that histamine is a key mediator contributing to the induction of oxidative/nitrosative stress and, consequently, to cerebral hypoperfusion, thereby leading to some local cerebral hypoxia.

In a second step, amplification of inflammation could occur, including oxidative/nitrosative stress-related BBB disruption, allowing transmigration of circulating inflammatory cells from the blood to the brain. Finally, neuroinflammation in the brain would occur, mainly involving the capsulo-thalamic area of temporal lobes, i.e., the limbic system and the thalamus.

The major interest of this comprehensive physiopathological model is that it can explain the main clinical symptoms occurring in EHS and/or MCS patients, since the limbic system involvement may

account for both the emotional and cognitive pathological alterations (in particular memory loss), while the thalamic involvement may explain sensibility-related abnormalities, both superficial and deep. Naturally, the possible extension of neuroinflammation into the frontal lobes and possibly into the hypothalamus [45] may, in addition, account for the other associated clinical symptoms.

9. Etiopathogenesis and Prevention

The causal origin of EHS is still debated, and the present current institutional message is that there is no proof that EHS genesis is causally related to EMF exposure. There is, however, great confusion in the present scientific literature in addressing this problem, since there is presently no clear distinction between the cause of clinical symptoms occurrence in EHS patients, i.e., after EHS has already occurred, and the environmental causal origin of EHS itself. In fact, as reported in Table 8, by querying the database and analyzing retrospectively previous exposure to EMFs and/or chemicals in EHS- and EHS/MCS-bearing patients, we found there are presently several direct and indirect arguments which strongly suggest that EMF exposure and even chemicals may cause or contribute to cause EHS.

Table 8. Clinical analysis of self-reported excessive presumed EMF and chemical exposure preceding the occurrence of electrohypersensibility (unpublished data). DECT—digital enhanced cordless telecommunications; RF—radiofrequency; ELF—extremely low frequency.

Sources	EHS (%)	Frequency Bands
Mobile phone	37	RF
Mobile phone/DECT	8	
DECT	7	
Cathode-ray screen	9	
WiFi	16	
Relay antenna towers	3	
Energy-saving lamps/mobile phone *	1.4	RF and ELF
High-voltage power lines	2.7	ELF
Power transformer	1.7	
Railway	0.8	
Chemicals	11	
Idiopathic **	2.4	

* Presumed excessive source exposure concern both low frequencies (LF) and radiofrequencies (RF); ** possible genetic susceptibility.

Moreover, a further distinction should be made between the general term of intolerance, which refers to the clinical symptoms and/or the biological abnormalities occurring in a particular environmental situation, and the term hypersensitivity, which should in fact be defined as a particular endogenous physiopathological state characterized by a decrease in the environmental tolerance threshold to such a critical point that patients become intolerant to low-dose stressors. Such a distinction is already made in medicine as, for example, the individualization of atopy in allergic patients.

Thus, if we agree on the distinction between the concept of intolerance and that of EHS, EHS should be characterized by definition as a particular decrease in the intolerance threshold according to which patients become intolerant to low-dose-intensity EMF exposure, while MCS (as already indicated by the MCS consensus meeting report in 1999 in Atlanta) was defined by a similar physiopathological state in which patients become intolerant to low-dose multiple chemicals [32]. This distinction may explain why most studies using provocation tests aiming to reproduce the clinical symptoms which may occur under EMF exposure in EHS self-reported patients report negative findings. Indeed, these negative results may in fact be due to different, unacceptable scientific flaws: (1) the lack of objective inclusion criteria, because objective biomarkers were not used to define EHS in so-called EHS-self reported patients; (2) EHS patients may be sensitive to certain frequencies and not necessarily to others; (3) duration of exposure was generally too short and assessment too early; (4) association with MCS

was not considered; (5) as reported above, EHS patients have cognitive defects and, thus, can make mistakes in distinguishing EMF exposure from sham exposure; (6) and above all, patients may respond positively in the case of sham exposure because of a decrease in environmental tolerance threshold, as well as because of psychologic conditioning from their past history of suffering.

Hence, on this basis, and because of the experimental evidence provided by studies in animals [37–39,43,44] and in humans [11,14,23,24] have shown the detrimental impact of EMF on health we believe, there is presently no sufficiently robust scientific data to refute a role of EMF exposure in inducing the previously described clinical symptoms and biological alterations in EHS patients.

Therefore, the causal origin of EHS should be established with a different scientific approach. RF and ELF were found to cause persistent adverse biological effects not only in animals [46,47] but also in plants [48,49] and microorganisms [50]. Here too, such observations certainly dismiss the hypothesis of a nocebo effect as the initial cause of EHS. In fact, the inflammation and oxidative/nitrosative states we showed in EHS patient are remarkable since they confirm the data obtained experimentally in animals exposed to these two types of non-ionizing frequencies [37–39], especially in the brain [43,44]. Furthermore, the limbic system-associated capsulo-thalamic abnormalities that we showed to characterize these patients [12,33] may likely correspond to the hippocampal neuronal alterations caused by EMF exposure in rats [51–53].

We therefore consider that the biological effects we observed in EHS patients may be due to both the pulsed and the polarized characteristics of man-made EMF emitted by electric or wireless technologies, as opposed to terrestrial non-polarized and continuously emitted natural EMFs [54–56].

In addition, as indicated in Table 9, we showed that, in 30% of the EHS cases, EHS was associated with MCS, with MCS preceding the occurrence of EHS in 37% of these EHS/MCS-associated cases; meaning that in this group of patients, EHS evolved toward MCS in 63% of the cases. As reported in Table 8, we thus speculate that man-made environmental chemicals may also be causally involved in EHS genesis in around 11% of the cases.

Table 9. Percentage of MCS patients who later suffered from EHS and vice versa.

	Total EHS/MCS Patients	Total EHS Patients Including EHS/MCS Patients *
Percentage of MCS patients that later suffered from EHS	37	11
Percent of EHS patients that later suffered from MCS	63	19

* EHS/MCS patients represent 30% of the total number of EHS patients.

These various considerations should not be neglected, since to avoid risks, knowledge of them could lead to protective measures in EHS and/or MCS patients. Such measures should include as much as possible EMF and chemical avoidance, use of anti-EMF clothes, and earthing-related electric charge detoxication. In addition, public preventive measures for the most vulnerable people—particularly pregnant women, infants, children, and adolescents—should be taken by limiting or even totally avoiding the use of wireless technology in these conditions. Such protective measures should also be taken and carried out in vulnerable patients, i.e., in cardiac patients with pacemakers, in patients with auditive prothesis, and in patients with neurodegenerative diseases.

10. The Worldwide Health Plague

Another argument incriminating the role of new wireless technology and possibly man-made chemicals introduced in the environment [57,58] is that, as indicated in Table 10, the increase in EHS prevalence is not restricted to a single country but is presently a worldwide plague, which started as soon as these industrial technologies became widespread. Prevalence of EHS occurrence is estimated

to range from 0.7% to 13.3%, mainly affecting about 3% to 5% of the population in many countries (Table 10), meaning that millions of people may in fact be affected by EHS worldwide.

Table 10. Estimated prevalence of people with self-reported EHS in different worldwide countries. USA—United States of America.

Country	Date	Sample Size	People Contribution Rate (%)	Estimated % of People with EHS	References
Sweden	1997	15,000 (19–80) *	73	1.5	Hillert et al., 2002 [59]
Sweden	2010	3406	40	2.7	Palmquist et al., 2014 [60]
Swiss	2004	2048 (>14) *	55.1	5	Schreier et al., 2006 [61]
Swiss	2008	1122 (30–60) *	37	8.6	Roosli et al., 2010 [62]
Swiss	2009	1122 (30–60) *	37	7.7	Roosli et al., 2010 [62]
Germany	2004	30,047	58.6	10.3	Blettner et al., 2009 [63]
Germany	2004	30,047	58.4	8.7	Kowall et al., 2012 [64]
Germany	2006	30,047	58.4	7.2	Kowall et al., 2012 [64]
USA (California)	1998	2072	58.3	3.2	Levallois et al., 2002 [65]
Finland	2002	6121	40.8	0.7	Korpinen et al., 2009 [66]
Great Britain	Before 2007	3633	18.2	4	Eltiti et al., 2007 [67]
Taiwan	2007	1251	11.5	13.3	Tseng et al., 2011 [68]
Austria	Before 2008	460	88	3.5	Schröttner and Leitgeb, 2008 [69]
Japan	Before 2009	2472	62.3	1.2	Furubayashi et al., 2009 [70]
Holland	2011	5789	39.6	3.5	Batiatsas et al., 2014 [71]
Holland	Before 2013	1009	60	7	Vabn Dongen et al., 2014 [72]

* When precised, age intervals of included patients are indicated in brackets.

Furthermore, although these reported EHS prevalence figures are only estimations, not critically evaluated due to a lack of objective criteria to clearly define EHS, it is possible—as speculated in Figure 7—that the EHS prevalence will continue to grow in the future, in as much as the manufacture of wireless technology and industrial chemicals will continue to develop.

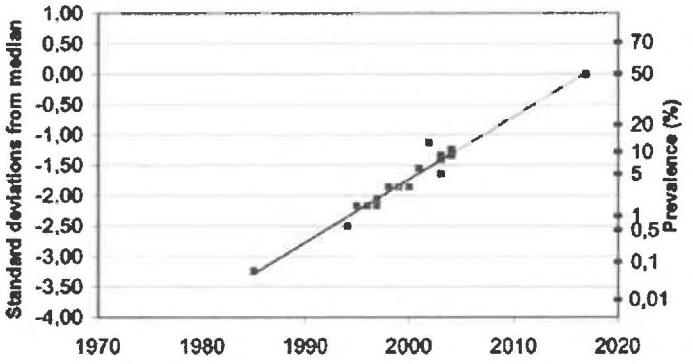

Figure 7. Estimated prevalence (%) of people around the world who consider themselves to be electrohypersensitive, plotted over time in a normal distribution graph, according to Reference [73].

11. Conclusions

In summary, we showed that there are presently sufficient clinical, biological, and radiological data for EHS to be acknowledged as a well-defined, objectively identified, and characterized pathological neurologic disorder. As a result, patients who self-report they suffer from EHS should be diagnosed and treated on the basis of presently available biological tests, including the detection of peripheral blood and urine biomarkers and the use of imaging techniques such as fMRI, TDU, and, when possible, UCTS. Moreover, because we showed for the first time that EHS is frequently associated with MCS and that both clinico-biological entities may be associated with a common physiopathological mechanism for genesis, it clearly appears that they can be identified as a unique neurologic pathological syndrome,

whatever their causal origin. Moreover; as it was shown that MCS genesis may be attributed to toxic chemical exposure, and EHS genesis to potentially excessive EMF and/or chemical exposure; protective measures against these two environmental stressors should be taken.

Whatever its causal origin and mechanism of action, EHS should therefore be from now on recognized as a new identified and characterized neurological pathological disorder. As it is already a real health plague potentially involving millions of people worldwide it should be acknowledged by WHO, and thus be included in the WHO ICD. As stated during the international scientific consensus meeting on EHS and MCS that we have organized in 2015 in Brussels, scientists unanimously asked WHO to urgently assume its responsibilities, by classifying EHS and MCS as separate codes in the ICD; so as to increase scientific awareness of these two pathological entities in the medical community and the general public, and to foster research and train medical practitioners to efficiently diagnose, treat, and prevent EHS and MCS–, which in fact constitute a unique, well-defined, and identifiable new neurologic disease.

Author Contributions: Conceptualization: D.B. and P.I.; methodology, D.B.; software, P.I.; validation, D.B. and P.I.; formal analysis, P.I.; investigation, D.B.; resources, D.B.; data curation, P.I.; writing—original draft preparation, D.B.; writing—review and editing, D.B. and P.I.; visualization, P.I.; supervision, D.B.; project administration, P.I. All authors read and agreed to the published version of the manuscript.

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Abbreviations

6-OHMS	6-hydroxymelatonin
BBB	blood–brain barrier
BBF	brain blood flow
CT scan	computerized tomography (CT) scan
DECT	digital enhanced cordless telecommunications
DMN	default mode network
EHS	electrohypersensitivity
EHS/MCS	electrohypersensitivity and multiple chemical sensitivity
EMF	electromagnetic field
ELF	extremely low frequencies
fMRI	functional magnetic resonance imaging
GSSG	oxidized glutathione (GSSG)
Hs-CRP	hypersensitive C reactive protein
ICD	international classification of disease
IEI-EMF	idiopathic environmental intolerance attributed to EMF
IgE	immunoglobulin E
IPCS	International Program on Chemical Safety
MCS	multiple chemical sensitivity
MRI	magnetic resonance imaging
NTT	nitrotyrosine
PI	pulsometric index
RF	radiofrequencies
TBARS	thiobarbituric acid reactive substances

TDU	transcranial Doppler ultrasound
UCTS	ultrasonographic cerebral tomosphygmography
WHO	World Health Organization
WiFi	Wireless Fidelity

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