COMMENT

Appeals that matter or not on a moratorium on the deployment of the fifth generation, 5G, for microwave radiation

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Abstract. Radiofrequency (RF) radiation in the frequency range of 30 kHz-300 GHz is classified as a 'possible' human carcinogen, Group 2B, by the International Agency for Research on Cancer (IARC) since 2011. The evidence has since then been strengthened by further research; thus, RF radiation may now be classified as a human carcinogen, Group 1. In spite of this, microwave radiations are expanding with increasing personal and ambient exposure. One contributing factor is that the majority of countries rely on guidelines formulated by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), a private German non-governmental organization. ICNIRP relies on the evaluation only of thermal (heating) effects from RF radiation, thereby excluding a large body of published science demonstrating the detrimental effects caused by non-thermal radiation. The fifth generation, 5G, for microwave radiation is about to be implemented worldwide in spite of no comprehensive investigations of the potential risks to human health and the environment. In an appeal sent to the EU in September, 2017 currently >260 scientists and medical doctors requested for a moratorium on the deployment of 5G until the health risks associated with this new technology have been fully investigated by industry-independent scientists. The appeal and four rebuttals to the EU over a period of >2 years, have not achieved any positive response from the EU to date. Unfortunately, decision makers seem to be uninformed or even misinformed about the risks. EU officials rely on the opinions of individuals within the ICNIRP and the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), most of whom have ties to the industry. They seem to dominate evaluating bodies and refute risks. It is important that these circumstances are described. In this article, the warnings on the health risks associated with RF presented in the 5G appeal and the letters to the EU Health Commissioner since September, 2017 and the authors' rebuttals are summarized. The responses from the EU seem to have thus far prioritized industry profits to the detriment of human health and the environment.

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Introduction

Over the years, numerous international appeals on radiofrequency (RF) radiation and health and the environment have been published (e.g., www.emfscientist.org). These seem to have had little or no impact on those proposing limits on RF radiation and on the deployment of this technology. On the contrary, ambient RF radiation exposure has increased and is a potential health risk based on the current knowledge of the biological effects of RF radiation (1-8). There seems to be an 'unholy' alliance between the telecom industry and certain scientists, organizations (even WHO), and some politicians, thus reducing the potential for precautionary actions (9,10).

The International Agency for Research on Cancer (IARC) of WHO in 2011 classified RF radiation in the frequency range of 30 kHz-300 GHz as a 'possible' human carcinogen, Group 2B (11,12). Since then, the evidence of the adverse effects of RF radiation has strengthened based on human epidemiological (7,8,13) and animal studies (14-16). These results add scientific evidence to a previous evaluation (17). Thus, RF radiation may now be classified as a human carcinogen, Group 1. That is the strongest classification, which is the same as that for e.g., asbestos and smoking.

The IARC cancer classification seems to have had little or no impact on protecting the public against risks associated with RF exposure. A major hampering factor has been the exposure guidelines by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) based only on the acute and very short-term thermal (heating) effects of RF radiation. These guidelines are used by the majority of countries worldwide. These guidelines were initially published approximately 20 years ago (18) and were updated in 2009 (19); however, no changes were made to adapt to the

rapidly increasing evidence of the harmful effects of RF and new RF signal characteristics and exposure from new technologies. ICNIRP, with the support of the WHO (10) and the major telecom companies, has made considerable efforts to convince countries worldwide to follow their guidelines. However, with the deployment of the 5th generation of microwave radiation, 5G, even the obsolete ICNIRP guidelines may be exceeded and may become an obstacle for the deployment of 5G (20). Thus, ICNIRP is preparing new guidelines that are briefly commented on below. However, as already published (9,10), the ICNIRP guidelines may be contradictory to a vast number of existing scientific reports demonstrating the harmful effects of RF radiation (21). Furthermore, there may perhaps also be conflicts of interests in terms of ties to the industry.

ICNIRP

On July 11, 2018, the ICNIRP released a draft of the guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (100 kHz-300 GHz). It was open for public consultations until October 9, 2018. Appendix B was based on the assessment of the health risks based on a literature survey (https://www.icnirp.org/en/activities/public-consultation/index.html).

Of note, in the background material to the new ICNIRP guidelines, the IARC classification from 2011 of RF exposure as class 2B, 'possibly' carcinogenic to humans (11,12) was not included. Notably, one of the ICNIRP commission members, Martin Röösli (https://www.icnirp.org/en/about-icnirp/commission/index.html), was also one of the IARC experts evaluating the scientific RF carcinogenicity in May, 2011 (https://monographs.iarc.fr/wp-content/uploads/2018/06/mono102-F05.pdf), which classified RF exposure as a class 2B 'possible' carcinogen. Thus, he should be aware of the IARC classification. Of note, one of the authors of this article (L.H.) was a member of the IARC expert group.

Below, eight excerpts/quotes from the 2018 ICNIRP draft guidelines are presented (https://www.icnirp.org/cms/upload/consultation_upload/ICNIRP_RF_Guidelines_PCD_2018_07_11.pdf). These assertions in the ICNIRP evaluation do not seem to represent the valid evaluation of the published literature on the health risks associated with RF:

i) ***Brain physiology and function.*** *'In summary, there is no evidence of effects of radiofrequency EMF [electromagnetic field] on physiological processes or eye pathology that impair health in humans. Some evidence of superficial eye damage has been shown in rabbits at exposures of at least 1.4 kW m-2, although the relevance of this to humans has not been demonstrated'.*

ii) ***Auditory, vestibular, and ocular function.*** *'In summary, no effects on auditory, vestibular, or ocular function relevant to human health have been substantiated'.*

iii) ***Neuroendocrine system.*** *'In summary, the lowest level at which an effect of radiofrequency EMF on the neuroendocrine system has been observed is 4 W kg-1 (in rodents and primates), but there is no evidence that this translates to humans or is relevant to human health. No other effects have been substantiated'.*

iv) ***Neurodegenerative diseases.*** *'In summary, no adverse effects on neurodegenerative diseases have been substantiated'.*

v) ***Cardiovascular system, autonomic nervous system and thermoregulation.*** *'In summary, no effects on the cardiovascular system, autonomic nervous system, or thermoregulation that compromise health have been substantiated for exposures with whole body average SARs below approximately 1 W kg-1, and there is some evidence that 4 W kg-1 is not sufficient to alter body core temperature in hamsters. However, there is strong evidence that whole body exposures in rats that are sufficient to increase body core temperature by several degrees centigrade can cause serious adverse health effects in rats'.*

vi) ***Immune system and hematology.*** *'The few human studies have not indicated any evidence that radiofrequency EMF affects health in humans via the immune system or haematology'.*

vii) ***Fertility, reproduction and childhood development.*** *'In summary, no adverse effects of radiofrequency EMF exposure on fertility, reproduction or development relevant to human health have been substantiated'.*

viii) ***Cancer.*** *'In summary, no effects of radiofrequency EMF on cancer have been substantiated'.*

Since the ICNIRP 2018 draft guidelines excluded a large number of science-based evidence of health hazards from RF radiation, numerous rebuttals have been sent to the ICNIRP. However, it remains unknown as to whether these rebuttals have been taken into account or not.

Thus, the ICNIRP does not acknowledge the health effects caused by RF radiation. This has been rebutted by several scientists (21-24).

Details and proofs of scientific misinterpretation were outlined in a comprehensive response by Dr Martin Pall (21). He demonstrated that the denials of scientific facts concerning health risks seem to be the rule in the Health Risk Assessments of the ICNIRP 2018 Draft Guidelines. ICNIRP confirmed that Pall's response was received on October 8, 2018 (tinyurl.se/pall). As outlined above in all eight summarizing statements, the ICNIRP denies that any scientific reports exist which demonstrate harmful effects below the ICNIRP guidelines. However, as Dr Pall demonstrated, a large number of peer-reviewed studies have been published over a period of >20 years contradicting the ICNIRP evaluations. Independent peer-reviewed scientific articles (1,7,8) have demonstrated the harmful effects even far below the current public safety limits based on ICNIRP 1998 reference levels 10 W/m^{2}for 2-300 GHz and 2-10 W/m^2 for 400 to 2,000 MHz (18).

The ICNIRP also seems to have disregarded previously published animal studies (14-16) on carcinogenesis. The NTP results have been discussed in a commentary (25) and clarified to that degree that they should have been considered in full. These findings supported human epidemiology results on cancer risks from RF radiation (6,26). The final new ICNIRP guidelines have yet to be published.

In fact, a hint of the ICNIRP final document may be found in a presentation by the ICNIRP chairman Eric van Rongen at a meeting held on April 17, 2019 https://www.anfr.fr/fileadmin/mediatheque/documents/expace/workshop-5G/20190417-Workshop-ANFR-ICNIRP-presentation.pdf.

van Rongen stated that there is no evidence that RF EMF causes diseases, such as cancer and that the US NTP (14-15) and Ramazzini Institute (16) studies are not convincing for carcinogenesis. ICNIRP seems still to hold the view, which is clearly beneficial to the industry, that only thermal effects exist for RF radiation and not any non-thermal effects, which have been proven in research by the majority of scientists in this field.

ICNIRP recently published a note on the NTP and Ramazzini Institute animal studies (27). Some of their incorrect statements are commented on below. The ICNIRP claims that there is no verified mechanism for RF radiation carcinogenesis, in spite of well-designed studies showing the contrary, e.g., oxidative stress (25,28) and DNA damage (25,29). The ICNIRP claims that the histopathological evaluation was not blinded in these studies; however, this is not true, as supported by the methods described in these studies. Furthermore, the ICNIRP claims that the body core temperature was increased in the NTP study (15) and suggested it to be a factor increasing cancer risk, although heat is not a known carcinogen. The ICNIRP also claims that only the Hardell group found an increased risk for acoustic neuroma although the Interphone study had similar findings (7). ICNIRP does not seem to take into account the concordance between the tumor types found in human epidemiological and animal studies. These are just a few examples.

It is noteworthy that ICNIRP repeats certain debatable statements in spite of being rebutted by Melnick (25) and should have been known to the 13 ICNIRP Commission members (https://www.icnirp.org/en/about-icnirp/commission/index.html) with their names listed at the end of the article (27). Perhaps this ICNIRP article lacks scientific authorization. As previously suggested, they seem to create doubt (30,31). Thus, one must be cautious when also interpreting other publications by the 13 Commission members.

The ICNIRP points out an important scientific problem: How incorrect data can achieve lives of their own and gain respectability and credence with inappropriate repetition. Corrections and clarifications (25), seem to have difficult time to counteract any possible errors, which is to the disadvantage of both good science and public health. Of note, President Franklin D. Roosevelt stated that *'Repetition does not transform a lie into a truth'* (https://www.azquotes.com/quote/377323).

Finland, in a new regulation, 1045/2018, dated December 15, 2018, allowed higher average radiation, 200 W, in narrow areas of 1x1 cm (1 cm^2) (please see Table 1.5, Note 3 (in Swedish): (https://www.finlex.fi/data/sdliite/liite/6943.pdf). This was probably decided in order to accommodate the steerable, beam-formed, narrow 5G fields, which will be used by most 5G equipment. The Director of the Radiation Safety Agency in Finland claims that this is no problem, as if you disperse the effect of 200 W (on 1 cm^2) upon a whole square meter it will still be within the ICNIRP guideline of 10 W/m^2 (private communication from Petteri Tiippana, 2018, please see https://www.dropbox.com/s/89cm7bmb410em8w/200W%3Am2-STUK.pdf?dl=0).

On top of the other flaws which ICNIRP members are presenting, they also suggest that only the 'mean values' of RF radiation should be measured. However, the interferences and the supra-additive effects between pulses from different RF radiation sources can lead to 'hundreds of thousands higher density' short-time pulses than the power density mean values with the guideline of 10 W/m^2. This has been well-documented in a report from the Finnish Radiation Safety Agency (32). Panagopoulos (29) has clearly demonstrated that using mean values for RF radiation may underestimate the risk. Intensity, frequency, exposure duration, polarization, pulsing and modulation are crucial parameters for the bioactivity. Puranen (32) states that the instant effect density can be much stronger than the mean values. However, the guidelines only consider the mean values.

Appeals to the EU and responses from the EU

The impact of the many international appeals on RF radiation safety, if any, is unclear. However, they will be historical documents on warnings that have been thus far ignored by the EU and the WHO. This is exemplified below.

The deployment of 5G for microwave radiation has given increasing awareness and concern among individuals regarding the risks to human health and the environment resulting in massive protests and even a moratorium in certain EU countries and US cities (https://tinyurl.se/5gstoppers). 5G uses a different technology compared with previous generations, such as 2G, 3G and 4G. In the following, our 5G appeal to EU is discussed (www.5Gappeal.eu). This has currently been signed by >260 scientists and medical doctors from a number of countries. It is still open for endorsement.

a) The 5G Appeal, September 13, 2017 and response. Below, the full text, with included links to references, is presented although it can also be found online (www.5gappeal.eu), and also at (https://www.environmentandcancer.com/5g-appeal/).

Scientists and doctors warn of potential severe health effects of 5G. *'We the undersigned scientists and doctors recommend a moratorium on the roll-out of the fifth generation, 5G, for telecommunication until potential hazards for human health and the environment have been fully investigated by scientists independent from industry. 5G will substantially increase exposure to radiofrequency electromagnetic fields (RF-EMF)*

on top of the 2G, 3G, 4G, Wi-Fi, etc. for telecommunications already in place. RF-EMF has been proven to be harmful for humans and the environment'.

5G leads to the marked increase of mandatory exposure to wireless radiation. *'5G technology is effective only over short distance. [The range of 5G radiation is decreased due to its increased carrier frequency (up to ~100 GHz) compared to previous mobile telephony generations and other existing microwave telecommunications radiations such as Wi-Fi (up to 2.6 GHz), and according to Rayleigh's law which explains that the intensity of scattered electromagnetic radiation (Jscat) is proportional to f 4 (where f is the frequency of the radiation) when the dimensions of the scattering particles - such as the molecules of the air, of the building materials, etc. - are smaller than the wavelength (which is the case for all mobile telephony radiations): Jscat ∝ f 4 (33)]. It is poorly transmitted through solid material. Many new [base] antennas will be required and full-scale implementation will result in antennas every 10 to 12 houses in urban areas,* ***thus massively increasing mandatory exposure****'.*

'[Moreover, apart from the increase in background exposure, 5G is likely to induce significant thermal effects in addition to the already non-thermal ones, again due to its significantly higher frequency (34)]'.

'With "the ever more extensive use of wireless technologies," (35) nobody can avoid to be exposed. Because on top of the increased number of 5G-transmitters (even within housing, shops and in hospitals) according to estimates, "10 to 20 billion connections" (36) (to refrigerators, washing machines, surveillance cameras, self-driving cars and buses, etc.) will be parts of the Internet of Things. All these together can cause a substantial increase in the total, long term RF-EMF exposure to all EU citizens'.

Harmful effects of RF-EMF exposure have already been proven. *'Over 230 scientists from >40 countries [now 252 scientists from 43 nations] (37) have expressed their "serious concerns" regarding the ubiquitous and increasing exposure to EMF generated by electric and wireless devices already before the additional 5G roll-out. They refer to the fact that "numerous recent scientific publications have shown that EMFs affect living organisms at levels well below most international and national guidelines". Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects (38) to both plants (39) and animals (40)'.*

'After the scientists' appeal was written in 2015 additional research has convincingly confirmed serious health risks from RF-EMF fields from wireless technology. The world's largest study (25 million US dollar) National Toxicology Program (NTP) (41), shows statistically significant increase in the incidence of brain and heart cancer in animals exposed to EMF [intensities] below the ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines followed by most countries. These results support results in human epidemiological studies (17) on RF radiation and brain tumour risk. A large number of peer-reviewed scientific reports (2) demonstrate harm to human health from EMFs'.

'The International Agency for Research on Cancer (IARC), the cancer agency of the World Health Organization (WHO), in 2011 concluded that EMFs of frequencies 30 KHz - 300 GHz are possibly carcinogenic to humans (Group 2B) (12,42). However, new studies like the NTP study mentioned above and several epidemiological investigations including the latest studies on mobile phone use and brain cancer risks confirm that RF-EMF radiation is carcinogenic to humans (17)'.

'The EUROPA EM-EMF Guideline 2016 (1) states that "there is strong evidence that long-term exposure to certain EMFs is a risk factor for diseases such as certain cancers, Alzheimer's disease, and male infertility…Common EHS (electromagnetic hypersensitivity) symptoms include headaches, concentration difficulties, sleep problems, depression, lack of energy, fatigue, and flu-like symptoms"'.

'An increasing part of the European population is affected by ill health symptoms that have for many years been linked to exposure to EMF and wireless radiation in the scientific literature. The International Scientific Declaration on EHS & multiple chemical sensitivity (MCS), Brussels (43), declares that: "In view of our present scientific knowledge, we thereby stress all national and international bodies and institutions… to recognize EHS and MCS as true medical conditions which acting as sentinel diseases may create a major public health concern in years to come worldwide i.e. in all the countries implementing unrestricted use of electromagnetic field-based wireless technologies and marketed chemical substances… ***Inaction is a cost to society*** *and is not an option anymore… we unanimously acknowledge this serious hazard to public health…that major primary prevention measures are adopted and prioritized, to face this* ***worldwide pan-epidemic*** *in perspective"'.*

Precautions. *'The Precautionary Principle (44) was adopted by EU 2005 (45): "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm"'.*

'The Council of Europe Resolution 1815 (46): "Take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours…Assembly strongly recommends that the ALARA (as low as reasonably achievable) principle is applied, covering both the so-called thermal effects and the athermic [non-thermal] or biological effects of electromagnetic emissions or radiation" and to "improve risk-assessment standards and quality"'.

'The Nuremberg code (47) applies to all experiments on humans, thus including the roll-out of 5G with new, higher

RF-EMF exposure. All such experiments: "should be based on previous knowledge (e.g., an expectation derived from animal experiments) that justifies the experiment. No experiment should be conducted, where there is an a priori reason to believe that death or disabling injury will occur; except, perhaps, in those experiments where the experimental physicians also serve as subjects," Nuremberg code pts 3-5 (47). Already published scientific studies show that there is "a priori reason to believe" in real health hazards'.

'The European Environment Agency (48) is warning for "Radiation risk from everyday devices" in spite of the radiation being below the WHO/ICNIRP standards (49). EEA also concludes: "There are many examples of the failure to use the precautionary principle in the past, which have resulted in serious and often irreversible damage to health and environments…harmful exposures can be widespread before there is both 'convincing' evidence of harm from long-term exposures, and biological understanding [mechanism] (50) of how that harm is caused"'.

***'Safety guidelines' protect the industry, not health.** 'The current ICNIRP "safety guidelines" are obsolete. All proofs of harm mentioned above arise although the radiation is below the ICNIRP "safety guidelines" (49). Therefore new safety standards are necessary. The reason for the misleading guidelines is that "conflict of interest of ICNIRP members (10) due to their relationships with telecommunications or electric companies undermine the impartiality that should govern the regulation of Public Exposure Standards for non-ionizing radiation…To evaluate cancer risks it is necessary to include scientists with competence in medicine, especially oncology'.*

'The current ICNIRP/WHO guidelines for EMF are based on the obsolete hypothesis that "The critical effect of RF-EMF exposure relevant to human health and safety is heating of exposed tissue" (51). However, scientists have proven that many different kinds of illnesses and harms are caused without heating ("non-thermal effect") (52) at radiation levels well below ICNIRP guidelines'.

***The authors thus urge the EU to carry out the following.** i) 'To take all reasonable measures to halt the 5G RF-EMF expansion until independent scientists can assure that 5G and the total radiation levels caused by RF-EMF (5G together with 2G, 3G, 4G, and WiFi) will not be harmful for EU-citizens, especially infants, children and pregnant women, as well as the environment'. ii) 'To recommend that all EU countries, especially their radiation safety agencies, follow Resolution 1815 and inform citizens, including, teachers and physicians, about health risks from RF-EMF radiation, <u>how</u> and <u>why</u> to avoid microwave radiation, particularly in/near e.g., daycare centers, schools, homes, workplaces, hospitals and elderly care'. iii) 'To appoint immediately, without industry influence, an EU task force of independent, truly impartial EMF-and-health scientists with no conflicts of interest (to re-evaluate the health risks and: a) To decide about new, safe "maximum total exposure standards" for all microwave radiation within EU. b) To study the total and cumulative exposure affecting EU-citizens. c) To create rules that will be prescribed/enforced within the EU about how to avoid exposure exceeding new EU "maximum total exposure standards" concerning all kinds of EMFs in order to protect citizens, especially infants, children and pregnant women'. iv) 'To prevent the wireless/telecom industry through its lobbying organizations from persuading EU-officials to make decisions about further propagation of RF radiation including 5G in Europe'. v) 'To favor and implement wired digital telecommunication instead of wireless'.*

First reply from the EU. A reply from the EU was sent on October 13, 2017 by the Directorate-General Health and Food Safety (Public health, country knowledge, crisis management) in Luxembourg. It was not replied to by the Commissioner Andriukaitis, but instead by Mr. John F. Ryan, Director (for the full text please see: http://www.5gappeal.eu/wp-content/uploads/2018/06/reply_ryan.pdf). Some paragraphs are presented below:

'It is worth underlining that for the Commission health protection is always taken into account in all of its proposals. There is consistent evidence presented by national and international bodies (International Commission on Non Ionising Radiation Protection - ICNIRP, Scientific Committee on Emerging and Newly Identified Health Risks - SCENIHR) that exposure to electromagnetic fields does not represent a health risk, if it remains below the limits set by Council Recommendation 1999/519/EC (https://ec.europa.eu/health//sites/health/files/electromagnetic_fields/docs/emf_rec519_en.pdf)'.

'The Scientific Committee on Emerging and Newly Identified Health Risks, which is independent of the Commission, has a standing mandate to provide this update'.

'It has already produced five opinions. The last opinion was adopted in January 2015 on "Potential health effects of exposure to electromagnetic fields". (https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf)'.

'These scientific opinions have not provided any scientific justification for revising the exposure limits (basic restrictions and reference levels) under Council Recommendation 1999/519/EC'.

'Digital technologies and mobile communication technologies, including high speed internet, will be the backbone of Europe's future economy, allowing all citizens to be connected. At the same time, all citizens deserve appropriate protection against electromagnetic fields from all types of sources including from wireless devices'.

'Most 5G networks are expected to use smaller cells than previous generations with lower electromagnetic fields exposure levels. This is confirmed by the experience so far gained. The introduction of 3G and 4G has not increased exposure from environmental fields and this has been published also in peer-reviewed journals. In particular, the introduction of 3G has lowered exposure of mobile phone users for calls, compared to 2G'.

'Related to the issue of the alleged conflicts of interests, the Commission is not aware of any conflicts of interests of members of international bodies such as ICNIRP or the members of SCENIHR. Please be informed that the Ombudsman conclusion in case 208/2015/P concerning conflicts of interests in a Commission expert group on electromagnetic fields is that there was no maladministration by the European Commission (https://www.ombudsman.europa.eu/en/cases/decision.faces/en/78175/html.bookmark)'.

'Please be assured that the Commission will pursue scrutiny of the independent scientific evidence available to ensure the highest health protection of our citizens'.

Comment: There are obvious misconceptions in this reply such as: *'The introduction of 3G and 4G has not increased exposure from environmental fields and this has been published also in peer-reviewed journals'*. On the contrary, numerous peer-reviewed articles have demonstrated that exposure to ambient RF radiation has increased substantially, as discussed (3-6).

In addition, the statement that: *'the Commission is not aware of any conflicts of interests of members of international bodies such as ICNIRP or the members of SCENIHR'* does not represent the scientific evidence of inherent conflicts of interest both in ICNIRP and SCENIHR (9,10). The very Commission seems to be ill-informed or even misinformed, as the EU seems to take information mainly from these two fraudulent organizations, but not from independent researchers. The EU does not seem to rely on sound science and thereby downplays the RF-related risks (7-12,53,54).

b) First rebuttal to the EU and the response. On November 13, 2017, a rebuttal was sent to the EU Commissioner of Health, Dr Andriukaitis. The whole letter can be found at: https://www.environmentandcancer.com/letter-to-vytenis-andriukaitis-13-11-2017/.

'We suppose that you know that Director John F. Ryan, October 13, 2017 replied (Ares 2017 5015409 - Reply to the EU 5G-appeal, and that he said: "There is ***consistent evidence*** *that exposure to electromagnetic fields* ***does not represent a health risk… if below the limits*** *…" His conclusion is based on the opinions of ICNIRP and SCENIHR'.*

'As early as February 1, 2016, in a Comment on SCENIHR to Mr. Ryan it was shown in article and letter by Drs. *[Sage], Carpenter and Hardell, representing BioInitiative and ECERI, that: "The evidence in the SCENIHR Final Opinion on EMF* ***clearly and convincingly establishes the potential for health effects of exposure to electromagnetic fields*** *[EMF]. Based on the evidence provided in this Opinion, the Committee is obligated to draw to the attention of the [EU] Commission that EMF is a new and emerging problem that may pose an actual or potential threat"' (55).*

'In spite of all this, Mr Ryan in his reply to us still continues to claim that EMF 'does not represent a health risk' and - without any other references than ICNIRP and SCENIHR - defends industry's standpoint that EMFs are harmless if below the ICNIRP "safety guidelines". In addition he ignores the IARC evaluations on both ELF-EMF and RF-EMF to be 'possible' human carcinogens, Group 2B'.

'In the 5G-Appeal we urge EU to appoint a truly independent expert group of EMF-and-health researchers (contrary to ICNIRP and SCENIHR) to decide about new safe guidelines for EMF exposure. It is imperative to ***immediately apply EU:s Precautionary Principle (and ALARA)*** *enabling rapid response to stop distribution of 5G products in order to diminish the harm that has already been proven by scientists. A* ***European pan-epidemic*** *may follow if you don't do so'.*

Second reply from EU on 29 November, 2017. This was sent from the European Commission, Cabinet of Commissioner Vytenis Andriukaitis, Head of Cabinet Brussels, written by Arūnas Vinciunas. The full reply can be found at: http://www.5gappeal.eu/wp-content/uploads/2018/06/reply_vinciunas.pdf).

'When Mr Ryan answered your email, in which you stated your disagreement with the Commission's stance on the 5G appeal, he presented the conclusions of roughly two decades of research on the potential health effects of EMF, and the views expressed in the Scientific Opinions produced by the independent Scientific Committees. [ICNIRP - International Commission on Non-Ionizing Radiation Protection and SCENIHR - Scientific Committee on Emerging and Newly Identified Health Risks]. The Committee's last Opinion on EMF, published in 2015, is based on hundreds of peer-reviewed studies published worldwide and is the fourth Opinion on EMF published since EMF legislation was adopted in 1999. The Committee's conclusion in this latest Opinion was based on exposure studies, epidemiological studies and in vivo and in vitro studies, and studies on any suggestions of causality were considered for the weighting'.

'The Commission services are confident that the advice provided by the Scientific Committees is unbiased, accurate and scientifically sound and therefore do not feel it necessary to appoint an independent expert group of EMF-and-health researchers to discuss new safe guidelines for EMF exposure'.

'The recourse to the EU's Precautionary Principle to stop the distribution of 5G products appears too drastic a measure. We first need to see how this new technology will be applied and how the scientific evidence will evolve. Please rest assured that the Commission will keep abreast of future developments in view of safeguarding the health of the European citizens at the highest level possible and in line with its mandate'.

Comment: This reply from EU is far from adequate. It does not represent a sound evaluation of the RF-related radiation risks based on published peer-reviewed studies. This is again outlined in our response to the EU.

c) Second rebuttal to the EU and the response. On January 17, 2018, a letter was sent to Dr. Vytenis Andriukaitis, EU Commissioner of Health. Sections of this letter are presented

below and the full text can be found at: https://www.environmentandcancer.com/letter-to-vytenis-andriukaitis-and-donald-tusk-17-01-18/.

'Following the letter and the Scientist Appeal calling for a moratorium on 5G ("The 5G Appeal"), which we sent to your office, we received a response from Director John F. Ryan on October 13, 2017 and then, upon our reply, a letter from Mr. Arūnas Vinciūnas dated 29.11.2017'.

'Despite the conclusive evidence presented in our letters, both Director Ryan and Mr. Vinciūnas gave generic responses and continued to claim that EMF "does not represent a health risk". In doing so they only refer to ICNIRP and SCENIHR opinions without explaining why they disregarded the compelling evidence and references under the 5G-Appeal headline: "Harmful effects of RF-EMF exposure are already proven"'.

'The ICNIRP exposure limits are dependent on an unproven hypothesis that "only heat from EMF can cause health hazards". This hypothesis has clearly been rejected in a large number of scientific studies'.

'Both EU officials defend the industry-supportive standpoint that EMFs are harmless if below the ICNIRP "guidelines". However, many of the scientists on both ICNIRP's and SCENIHR's committees are connected to the telecom industry with obvious conflicts of interest'.

'Mr Vinciūnas stated in his letter: "The recourse to the EU's Precautionary Principle to stop the distribution of 5G products appears ***too drastic a measure****." Mr Vinciūnas finishes his letter: "we need to see … how the scientific* ***evidence will evolve****"'.*

'According to Communication from the Commission on the precautionary principle: "Whether or not to invoke the Precautionary Principle is a decision exercised where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on the environment, or human, animal or plant health may be potentially dangerous and inconsistent with the chosen level of protection." That describes the situation with 5G perfectly. Existing data shows that 5G frequencies [radiations] are hazardous. However, additional studies will be necessary to fully determine the extent of the risk'.

Third reply from the EU. This letter was replied to on April 27, 2018 by Mr. Arūnas Vinčiūnas from the Cabinet of Commissioner Vytenis Andriukaitis. For the full third reply to our appeals please see: https://www.environmentandcancer.com/answer-from-arunas-vinciunas-27-04-2018/.

'Thank you very much for your letter of 15 March 2018 which was also transmitted by email on 19 March. Commissioner Andriukaitis has asked me to reply to you on his behalf'.

'Finally, let me refer to the previous correspondence you have had with John F. Ryan, Director of Public Health and me (29 November 2017, 13 October 2017 and 19 February 2018) where we have comprehensively explained our position with regard to the arguments you have raised. It is my view that we have now extensively deliberated on the matter and that we should refrain from further repetition'.

'Please rest assured that the Commission will remain committed to safeguarding the health of the European citizens, at the highest level possible and in line with his mandate'.

d) Third rebuttal to the EU and the response. This rebuttal had the title *"Request for a moratorium on the 5G rollout. Request for guidelines based on independent research. Request for documents showing that 5G is safe"*. On May 20, 2019 a letter with these requests was sent to Dr Karmenu Vella, EU Commissioner of Environment and Dr Vytenis Andriukaitis, EU Commissioner of Health. For the full text please see: https://www.environmentandcancer.com/letter-to-vytenis-andriukaitis-20-05-2019/.

'We make reference to the Precautionary Principle (PP) (56) It "enables a rapid response to be given in the face of a possible danger to human health…institutions may take protective measures without having to wait until the reality… of risks become apparent … preventive action should be taken" (57). Research confirms 5G to be a risk to all life on earth'.

'With this communication we touch upon three points:' i) 'Firstly, we request in the 5G Appeal to EU (www.5gappeal.eu), of which you are a public servant and representative, to declare an immediate ***moratorium*** *on 5G deployment. The 5G appeal to EU is now confirmed by 230+ truly independent scientists and physicians from 36 countries. The Space 5G appeal (58) has more than 83,000 affirmations from 168 countries. According to PP (56) and EU IP/00/96 (59) "protection of health takes precedence over economic considerations."' ii) 'Secondly, we ask for groups of truly industry-independent researchers to establish* ***new guidelines for exposure****. An "In-depth analysis" of the deployment of 5G (60), published by EU in April 2019, needs to be seriously considered. It stated that" One aspect, for example, that is not well understood today is the unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation."(p. 6)'. iii) 'Thirdly, with this letter we are formally requesting, in accordance with Art. 42 (61) on EU Fundamental Rights,* ***access to all documents*** *in your possession, either created by you or at your disposal, related to the effects of EMF to human health and the environment. Once in possession of such a list, we will decide which of those documents, if any, are of interest and show that 5G is safe. The list of the documents, and the ways to access them, should be sent to the email addresses below'.*

'We note that, while the EU is eagerly promoting the rollout of 5G, a new EU report admits (60) "the problem is that currently it is not possible to accurately simulate or measure 5G emissions in the real world" (p. 12). *"Significant concern is emerging over the possible impact on health and safety arising from potentially much higher exposure to radiofrequency electromagnetic radiation arising from 5G" (p. 4). The EU report also stresses dangers: "Increased exposure*

may result not only from the use of much higher frequencies in 5G but also from the potential for the aggregation of different signals, their dynamic nature, and the complex interference effects that may result, especially in dense urban areas." (p. 11)'.

Fourth reply from the EU. Finally, a response was delivered by the EU on September 5, 2019, although with reference to the wrong date of our letter. It was sent by Arunas Vinciunas from the Cabinet of Commissioner Vytenis Andriukaitis. The full response can be read at: https://www.environmentandcancer.com/answer-from-arunas-vinciunas-05-09-2019/.

'Thank you for your email of 7 July 2019 to Commissioner Andriukaitis in which you request to halt the 5G expansion in the EU immediately in order to allow a moratorium for industry independent research. Commissioner Andriukaitis has asked me to reply to you on his behalf'.

'In my latter note to you I already expressed my view that we had extensively deliberated on the matter and that we should refrain from further repetition'.

'As regards your request to halt the launch of the new 5G technology, I would like to confirm the view already expressed in my note of 29 November 2017 to you that stopping the distribution of 5G products appears too drastic a measure. I repeat that first there is a need to see how this new technology will be applied and how the scientific evidence will evolve'.

'Concerning your call for a scientific evaluation and new guidelines for exposure, the second point you have raised, let me stress that the Commission will review the situation once the review of the guidelines issued by the International Commission on Non-Ionizing Protection (ICNIRP) will be finalised which is expected in due course'.

'As regards your third point, documents related to the effects of electromagnetic fields to human health and the environment, please be referred to the opinion of the Commission's Scientific Committee on Emerging and Newly Identified Health Risks of 20 January 2015 on potential health effects of exposure to electromagnetic fields (EMF) (https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf) that provides an extensive list of references to scientific literature on this issue'.

Comment on the fourth reply from the EU appeal: There is no new evidence of the safety in this letter from EU compared with the earlier replies. Of note, the EU relies on documentation of risk only on old and biased selection of references in one single report from SCENIHR (https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf). Thus, EU officials still seem to base the evaluation of the health risks on reports from the ICNIRP and SCENIHR that have been seriously criticized. Of note, the EU relies on a report from 2015 as to scientific publications on the safety of 5G, a technology that was not developed during that time. This suggests that perhaps the EU is reluctant to deal with the safety issues associated with 5G technology.

e) Fourth rebuttal to the EU. On October 24, 2019 a fourth rebuttal was sent to the EU (https://www.environmentandcancer.com/letter-to-arunas-vinciunas-24-10-2019). We wrote that *'Specifically now, as we wish to assist the Commissioner in giving due response, it can be further specified from this side that we need the **list of documents** related to EMFs created by RF/Radiofrequencies (so: not by ELF) and even more specifically, to the list of those documents based on which the Commission is basing its current position that 5G should not be stopped nor subject to a moratorium (see the statement of your letter that "first there is a need to see how this new technology will be applied and how the scien6fic evidence will evolve"). We leave aside our total disagreement on the merits of such position at this time: formally, we are entitled to receive from you such a list of documents based on which the Commissioner determined that 5G is safe. Based on that list we will decide which of those documents, are of interest. Please provide such list by email no later than October 31, 2019. This is urgent'.*

Fifth reply from the EU. In this response, dated December 19, 2019, it was stated that new ICNIRP guidelines are expected. Thus, the same approach to this issue as previously and no new commitment (https://www.environmentandcancer.com/answer-from-martin-seychell-19-12-2019).

Appeals to the Nordic Prime Ministers

The 5G Appeal was also sent to the Nordic Prime Ministers (https://www.environmentandcancer.com/letter-to-nordic-ministers-27-6-2018/); (https://www.environmentandcancer.com/letter-to-nordic-ministers-5-3-2019/). The only reply, dated March 29, 2019, was sent from the Swedish government (Ministry of Enterprise and Innovation, Mari Mild). It was stated that the government relies on Swedish Radiation Safety Authority (SSM) and their yearly update of health risks and that no new health risks have been reported. According to the letter there is no reason for a moratorium on the deployment of 5G, see (in Swedish) (https://www.miljoochcancer.com/svar-fran-naringsdepartementet-29-3-2019/). SSM relies on ICNIRP.

Discussion

Our experience with the EU and the Governments of the Nordic countries suggests that the majority of decision makers are scientifically uninformed on health risks from RF radiation (62). In addition, they seem to be uninterested to being informed by scientists representing the majority of the scientific community, i.e., those scientists who are concerned about the increasing evidence or even proof of harmful health effects below the ICNIRP guidelines (www.emfscientist.org). Instead, they rely on evaluations with inborn errors of conflicts, such as ICNIRP. In fact, the ICNIRP, with the support of WHO and major telecommunications companies, has been rather successful in implementing their views in the EU and worldwide. Their guidelines seem to be based on the omission of scientific facts. Thus, their possible ignorance of the health risks is of concern, as well as their reluctance to adhere to warnings from large numbers of scientists around the world.

It is striking that 5G is deployed without previous scientific evaluation of health risks. Not only cancer risks, but also other health effects such as fertility, cognitive and neurobehavioral effects, oxidative stress and electromagnetic hypersensitivity (EHS) have been associated with RF exposure [for a more detailed discussion on this tope, please see previous publications (1,7,8,28,35)]. It is thus noteworthy that the ICNIRP thermal paradigm is still used for the evaluation of the health risks associated with RF radiation. One issue of major concern is that there seems to be conflicts of interest among persons in the evaluating groups. Furthermore the same persons may often be found in different bodies, thereby in fact citing themselves representing a cartel (https://www.saferemr.com/2018/07/icnirps-exposure-guidelines-for-radio.html). This has been outlined in peer-reviewed publications (9,10).

This is also an ethical question. Thus, it would not be possible to test a new drug on individuals without information and signed permission by each individual. Certainly, this principle should apply to 5G that is furthermore, mandatory. Exposure to RF radiation from 5G must be regarded as a medical experiment with potential health risks, some known and expected based on current knowledge, some unknown since this is a new untested technology. A letter of information to those exposed must be sent for informed consent. However, it must be concluded that such a letter, affirming no risk, cannot be formulated based on the limited number of studies on 5G, in fact most of them with no assurance of no risks.

This is also a moral question for all the individuals involved in the propagation of 5G. It is to be noted that individuals within e.g., ICNIRP, national governmental bodies and the EU, partly a cartel, seem to neglect scientific warnings. They instead seem to follow the no-risk paradigm. It is thus questionable as to how it is possible to thereby disregard the diseases caused by this technology and to not consider the affected persons.

Taking the history of e.g., tobacco and smoking and the long period of time it took for cancer classification into account, it is fully understandable that RF radiation is still in the beginning of that history. However, if no action is currently taken, the costs to society will most likely be very high in terms of premature deaths, deteriorated public health and damage to the ecological system. It is however, important to publish the history of neglected RF radiation warnings. The EU seems to perhaps lacking in that respect. It must be concluded that the polluter has to pay the full cost of harm from this technology (63). Those in responsible positions in governments and organizations intended to protect the public and the environment from harm (WHO and ICNIRP), but who fail to do so by ignoring the increasing warnings from scientists worldwide about the dangers of 5G, should also be held responsible for the harm to the public that they thereby induce (64). No doubt damage to the environment by the business sector may be substantial (https://www.theguardian.com/environment/2010/feb/18/worlds-top-firms-environmental-damage).

The EU principle that the Polluter Pays (Article 191, pt 2) states: *'Union policy on the environment shall aim at* ***a high level of protection taking*** *into account the diversity of situations in the various regions of the Union.* ***It shall be based on the precautionary principle*** *and on the principles that* ***preventive action should be taken****, that environmental damage should as a priority be rectified at source and that* ***the polluter should pay****'.* (https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12008E191:EN:HTML).

'The fundamental principle of this Directive should therefore be that an operator whose activity has caused the environmental damage or the imminent threat of such damage is to be held financially liable, in order to induce operators to adopt measures and develop practices to minimise the risks of environmental damage so that their exposure to financial liabilities is reduced' (65) (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32004L0035&from=EN).

The industry tries to convince us that the super high frequencies of 5G are so weak and its millimeter waves will penetrate only the outer surface of the skin. The opposite was proven in USSR research already in 1977 (https://www.cia.gov/library/reading-room/docs/CIA-RDP88B01125R000300120005-6.pdf). High frequencies (37-60 GHz), which will be used in 5G, caused several kinds of detrimental effects in experimental rats. The high frequencies seem to be worse than the lower frequencies. The USSR experiments were made more than 40 years ago - when we had no digital pulsed radiation - with a generator producing sinus curves. Peaks of pulsed radiation used in 5G with unpredictable intensity changes seem to be an important parameter for the bioactivity of RF radiation (29).

In conclusion, this article demonstrates that the EU has given mandate to a 13-member, non-governmental private group, the ICNIRP, to decide upon the RF radiation guidelines. The ICNIRP, as well as SCENIHR, are well shown not to use the sound evaluation of science on the detrimental effects of RF radiation, which is documented in the research which is discussed above (9,10,21-24,54,55). These two small organizations are producing reports which seem to deny the existence of scientific published reports on the related risks. It should perhaps be questioned whether it is in the realm of protecting human health and the environment by EU and whether the safety of EU citizens and the environment can be protected by not fully understanding the health-related risks.

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Availability of data and materials

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Authors' contributions

Both authors (LH and RN) participated in the conception, design and writing of the manuscript, and have read and approved the final version.

Ethics approval and consent to participate

Not applicable.

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Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, *et al*: EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health 31: 363-397, 2016.
2. BioInitiative: The BioInitiative Report 2012: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Fields (ELF and RF). https://bioinitiative.org/. Accessed August 21, 2019.
3. Hardell L, Koppel T, Carlberg M, Ahonen M and Hedendahl L: Radiofrequency radiation at Stockholm Central Railway Station in Sweden and some medical aspects on public exposure to RF fields. Int J Oncol 49: 1315-1324, 2016.
4. Hardell L, Carlberg M, Koppel T and Hedendahl L: High radiofrequency radiation at Stockholm Old Town: An exposimeter study including the Royal Castle, Supreme Court, three major squares and the Swedish Parliament. Mol Clin Oncol 6: 462-476, 2017.
5. Hardell L, Carlberg M and Hedendahl LK: Radiofrequency radiation from nearby base stations gives high levels in an apartment in Stockholm, Sweden: A case report. Oncol Lett 15: 7871-7883, 2018.
6. Hardell L, Carlberg M, Hedendahl LK, Koppel T and Ahonen M: Environmental radiofrequency radiation at the Järntorget Square in Stockholm Old Town, Sweden in May, 2018 compared with results on brain and heart tumour risks in rats exposed to 1.8 GHz base station environmental emissions. World Acad Sci J 1: 47-54, 2019.
7. Belpomme D, Hardell L, Belyaev I, Burgio E and Carpenter DO: Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective. Environ Pollut 242 (Pt A): 643-658, 2018.
8. Miller AB, Morgan LL, Udasin I and Davis DL: Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). Environ Res 167: 673-683, 2018.
9. Starkey SJ: Inaccurate official assessment of radiofrequency safety by the Advisory Group on Non-ionising Radiation. Rev Environ Health 31: 493-503, 2016.
10. Hardell L: World Health Organization, radiofrequency radiation and health - a hard nut to crack (Review). Int J Oncol 51: 405-413, 2017.
11. Baan R, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, Guha N, Islami F, Galichet L and Straif K; WHO International Agency for Research on Cancer Monograph Working Group: Carcinogenicity of radiofrequency electromagnetic fields. Lancet Oncol 12: 624-626, 2011.
12. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields, vol. 102. IARC, Lyon, 2013. http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf. Accessed August 21, 2019.
13. Hardell L and Carlberg M: Mobile phone and cordless phone use and the risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009. Pathophysiology 22: 1-13, 2015.
14. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in B6C3F1/N mice exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP TR 596, March 26-28, 2018. https://ntp.niehs.nih.gov/ntp/about_ntp/trpanel/2018/march/tr596peerdraft.pdf. Accessed August 29, 2019.
15. National Toxicology Program: NTP technical report on the toxicology and carcinogenesis studies in Hsd:Sprague Dawley sd rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP TR 595, March 26-28, 2018. https://ntp.niehs.nih.gov/ntp/about_ntp/trpanel/2018/march/tr595peerdraft.pdf. Accessed August 29, 2019.
16. Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, Mandrioli D, Manservigi M, Manservisi F, Manzoli I, *et al*: Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Environ Res 165: 496-503, 2018.
17. Carlberg M and Hardell L: Evaluation of mobile phone and cordless phone use and glioma risk using the Bradford Hill viewpoints from 1965 on association or causation. BioMed Res Int 2017: 9218486, 2017.
18. International Commission on Non-Ionizing Radiation Protection: Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74: 494-522, 1998.
19. International Commission on Non-Ionizing Radiation Protection: ICNIRP statement on the 'Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)'. Health Phys 97: 257-258, 2009.
20. Törnevik C: Impact of EMF limits on 5G network roll-out. EMF and Health Ericsson Research, Stockholm. ITU Workshop on 5G, EMF & Health Warsaw, December 5, 2017. https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20171205/Documents/S3_Christer_Tornevik.pdf. Accessed August 29, 2019.
21. Pall M: Response to 2018 ICNIRP darft guidelines and appendices on limiting exposure to time varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz). http://www.5gappeal.eu/wp-content/uploads/2018/10/icnirp_2018_pall.pdf. Accessed October 8, 2018.
22. Hansson-Mild K and Hardell L: Response to 2018 ICNIRP darft guidelines and appendices on limiting exposure to time varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz). https://www.environmentandcancer.com/comments-icnirp-hansson-mild-hardell/.
23. Redmayne M: Response to 2018 ICNIRP darft guidelines and appendices on limiting exposure to time varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz). https://www.environmentandcancer.com/comments-icnirp-redmayne/.
24. Favre D: Response to 2018 ICNIRP darft guidelines and appendices on limiting exposure to time varying electric, magnetic and electromagnetic fields (100 kHz to 300 GHz). https://www.environmentandcancer.com/comments-icnirp-favre/.
25. Melnick RL: Commentary on the utility of the National Toxicology Program study on cell phone radiofrequency radiation data for assessing human health risks despite unfounded criticisms aimed at minimizing the findings of adverse health effects. Environ Res 168: 1-6, 2019.
26. Hardell L and Carlberg M: Comments on the US National Toxicology Program technical reports on toxicology and carcinogenesis study in rats exposed to whole-body radiofrequency radiation at 900 MHz and in mice exposed to whole-body radiofrequency radiation at 1,900 MHz. Int J Oncol 54: 111-127, 2019.
27. International Commission on Non-Ionizing Radiation Protection (ICNIRP): ICNIRP Note: Critical evaluation of two radiofrequency electromagnetic field animal carcinogenicity studies published in 2019. Health Phys: Aug 27, 2019 (Epub ahead of print).
28. Yakymenko I, Tsybulin O, Sidorik E, Henshel D, Kyrylenko O and Kyrylenko S: Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. Electromagn Biol Med 35: 186-202, 2016.
29. Panagopoulos DJ: Comparing DNA damage induced by mobile telephony and other types of man-made electromagnetic fields. Mutat Res 781: 53-62, 2019.
30. Michaels D: Doubt is Their Product. How Industry's Assault on Science Threatens Your Health. Oxford University Press, New York, NY, 2008.
31. Walker MJ: Corporate Ties that Bind. An Examination of Corporate Manipulation and Vested Interest in Public Health. Skyhorse Publishing, New York, NY, 2017.
32. Puranen L: Altistumisen mittaus ja laskentamallit, pp457-458, 2018 (In Finnish). https://www.stuk.fi/documents/12547/494524/6_10.pdf/588055cc-7672-446a-a12a-570df87b3599.

33. Jackson JD: Classical electrodynamics. John Wiley & Sons, Inc., New York, NY, 1975.
34. Neufeld E and Kuster N: Systematic derivation of safety limits for time-varying 5G radiofrequency exposure based on analytical models and thermal dose. Health Phys 115: 705-711, 2018.
35. Hedendahl L, Carlberg M and Hardell L: Electromagnetic hypersensitivity - an increasing challenge to the medical profession. Rev Environ Health 30: 209-215, 2015.
36. Mills MP: The Internet Of Things Won't Be Big It'll Be Huge. Forbes, 2016. https://www.forbes.com/sites/markpmills/2016/09/28/the-internet-of-things-wont-be-big-itll-be-huge/. Accessed August 20, 2019.
37. EMFscientist.org: International Appeal Scientists call for Protection from Non-ionizing Electromagnetic Field Exposure. https://emfscientist.org/index.php/emf-scientist-appeal. Accessed August 21, 2019.
38. Nittby H, Brun A, Strömblad S, Moghadam MK, Sun W, Malmgren L, Eberhardt J, Persson BR and Salford LG: Nonthermal GSM RF and ELF EMF effects upon rat BBB permeability. Environmentalist 31: 140-148, 2011.
39. Waldmann-Selsam C, Balmori-de la Puente A, Breunig H and Balmori A: Radiofrequency radiation injures trees around mobile phone base stations. Sci Total Environ 572: 554-569, 2016.
40. Balmori A: Electromagnetic pollution from phone masts. Effects on wildlife. Pathophysiology 16: 191-199, 2009.
41. National Toxicology Program: Report of Partial Findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposures). Draft 5-19-2016. https://www.biorxiv.org/content/biorxiv/early/2016/05/26/055699.full.pdf. Accessed August 21, 2019.
42. IARC: IARC classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans. Press release no 208, May 31, 2011. https://www.iarc.fr/wp-content/uploads/2018/07/pr208_E.pdf. Accessed August 21, 2019.
43. International Scientific Declaration on EHS & MCS: 2015, Brussels International Scientific Declaration on Electromagnetic Hypersensitivity and Multiple Chemical Sensitivity. http://www.ehs-mcs.org/fichiers/1441982143_Statement_EN_DEFINITIF.pdf. Accessed August 21, 2019.
44. EUR-Lex: Access to European Union law. Precautionary Principle. https://eur-lex.europa.eu/summary/glossary/precautionary_principle.html. Accessed August 21, 2019.
45. The Precautionary Principle website. http://www.precautionaryprinciple.eu/. Accessed August 21, 2019.
46. Council of Europe: The potential dangers of electromagnetic fields and their effect on the environment. Resolution 1815, 2011. http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994. Accessed August 21, 2019.
47. Nuernberg Military Tribunals: Trials of War Criminals before the Nuernberg Military Tribunals under Control Council Law. No. 10. Vol 2. U.S. Government Printing Office, Washington, DC, pp181-182, 1949.
48. European Environment Agency: Radiation risk from everyday devices assessed. https://www.eea.europa.eu/highlights/radiation-risk-from-everyday-devices-assessed. Accessed August 21, 2019.
49. Sheean O: World Health Organization. Setting the standard for a wireless world of harm. A call for action and accountability. https://olgasheean.com/wp-content/uploads/2017/02/WHO-setting-the-standard-for-a-wireless-world-of-harm.pdf. Accessed August 21, 2019.
50. Pall ML: Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75 (Pt B): 43-51, 2016.
51. International Commission on Non-Ionizing Radiation Protection (ICNIRP): High Frequency 100 kHz - 300 GHz. https://www.icnirp.org/en/frequencies/high-frequency/index.html. Accessed August 21, 2019.
52. BioInitiative: The BioInitiative Report 2012: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Fields (ELF and RF). Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure. https://bioinitiative.org/rf-color-charts/. Accessed August 21, 2019.
53. Maisch D: Spin in the antipodes - A history of industry involvement in telecommunications health research. In: Corporate Ties That Bind. An Examination of Corporate Manipulation and Vested Interest in Public Health. Walker MJ (ed). Skyhorse Publishing, New York, NY, pp292-321, 2017.
54. Nicola Wright N: Downplaying radiation risk. In: Corporate Ties That Bind. An Examination of Corporate Manipulation and Vested Interest in Public Health. Walker MJ (ed). Skyhorse Publishing, New York, NY, pp420-446, 2017.
55. Sage C, Carpenter D and Hardell L: Comments on SCENIHR: Opinion on potential health effects of exposure to electromagnetic fields, Bioelectromagnetics 36:480-484 (2015). Bioelectromagnetics 37: 190-192, 2016.
56. EUR-Lex: Access to European Union law. The Precautionary Principle. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:l32042. Accessed August 28, 2019.
57. InfoCuria: Judgement of the Court 5 May 1998 in Case C-157/96. http://curia.europa.eu/juris/document/document.jsf?text=&docid=43817&doclang=EN. Accessed August 28, 2019.
58. International appeal. Stop 5G on Earth and in Space. https://www.5gspaceappeal.org/. Accessed August 28, 2019.
59. European Commission: Commission adopts Communication on Precautionary Principle. Brussels, 2 February 2000. http://europa.eu/rapid/press-release_IP-00-96_en.htm. Accessed August 28, 2019.
60. Blackman C and Forge S: 5G Deployment. State of Play in Europe, USA and Asia. European Parliament, 2019. http://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL_IDA(2019)631060_EN.pdf. Accessed August 28, 2019.
61. European Commission: Right of access to documents. https://ec.europa.eu/info/aid-development-cooperation-fundamental-rights/your-rights-eu/know-your-rights/citizens-rights/right-access-documents_en. Accessed August 28, 2019.
62. Hardell L: Notes on parliament hearing in Tallinn, Estonia June 4, 2019 as regards the deployment of the fifth generation, 5G, of wireless communication. World Acad Sci J 1: 275-282, 2019.
63. Mallia P: The precautionary principle. In: Corporate Ties That Bind. An Examination of Corporate Manipulation and Vested Interest in Public Health. Walker MJ (ed). Skyhorse Publishing, New York, NY, pp363-378, 2017.
64. Greene G: The woman who knew too much. In: Alice Stewart and the Secrets of Radiation. University of Michigan Press, 2017.
65. EUR-Lex: Consolidated version of the Treaty on the Functioning of the European Union. Part three - Union Policies and Internal Actions. Official Journal of the European Union, Article 191, 2016. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:12016E191. Accessed August 28, 2019.

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