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Commentary

Aspects on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 Guidelines on Radiofrequency Radiation

Lennart Hardell[1*], Mona Nilsson[2], Tarmo Koppel[3], Michael Carlberg[1]

[1]The Environment and Cancer Research Foundation, Studievägen 35, SE-702 17, Örebro, Sweden

[2]Swedish Radiation Protection Foundation, Gredby 14, SE-178 92 Adelsö, Sweden

[3]Tallinn University of Technology, SOC353 Ehitajate tee 5, 19086 Tallinn, Estonia

[*]**Corresponding Author:** Lennart Hardell, The Environment and Cancer Research Foundation, Studievägen 35, SE 702 17, Örebro, Sweden

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Abstract

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published 2020 updated guidelines on radiofrequency (RF) radiation in the frequency range 100 kHz to 300 GHz. Harmful effects on human health and the environment at levels below the guidelines are downplayed although evidence is steadily increasing. Only thermal (heating) effects are acknowledged and therefore form the basis for the guidelines. Despite the increasing scientific evidence of non-thermal effects, the new ICNIRP guidelines are not lower compared with the previous levels. Expert groups from the WHO, the EU Commission and Sweden are to a large extent made up of members from ICNIRP, with no representative from the many scientists who are critical of the ICNIRP standpoint.

Keywords: EU; WHO; ICNIRP; 5G; Microwave radiation

1. Introduction

Wireless technologies, such as mobile phones, cordless phones, base stations, WiFi, 2G, 3G, 4G and 5G emit radiofrequency (RF) radiation, also called microwave radiation. For a long time there has been concern among laymen and a large part of the scientific community that such radiation may be a health hazard and also have a negative effect on the environment including birds [1], insects [2] and plants [3,4].

The seminal first early warning on brain tumor risk associated with exposure to RF radiation from mobile phones was published some 20 years ago [5, 6]. In the following case-control studies by the Hardell group, in addition to mobile phones, also use of cordless phones (DECT) was assessed. These studies confirmed an increased risk for brain tumors, i.e. glioma, for both types of wireless phones [7]. Similar findings were reported for acoustic neuroma [8].

In May 2011 the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) evaluated RF radiation in the frequency range 30 kHz–300 GHz to be a possible human carcinogen, Group 2B [9, 10].The IARC decision on mobile phones was based mainly on two sets of case-control human studies: the Hardell group studies from Sweden [11-13] and the IARC Interphone study [14, 15]. Both provided supportive evidence of increased risk for brain and head tumors, i.e. glioma and acoustic neuroma. Later published studies by the Hardell group [7, 8] and the French CERENAT (CEREbral tumors: a NATional study) study on glioma and meningioma [16] supported an increased risk for brain tumors and use of mobile and cordless phones. However, risks associated with the use of cordless phones was assessed only by the Hardell group, although cordless phones emit RF radiation of similar type as mobile phones.

The increasing scientific evidence on cancer risks from RF radiation, as well as other health effects, has had little or mostly no effect on preventive measurements. This is due to scientific disagreements and controversies. Some influential organizations are downplaying the health risks, i.e. the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the World Health Organization (WHO), the European Union (EU) and the Swedish Radiation Safety Authority (SSM), see next section. It has been discussed that by now such exposure might be classified as carcinogenic to humans, Group 1, according to the IARC classification [17-19]. However, only an IARC evaluation can make that classification.

Because of the controversies and the lobbying by influential organizations, including the telecom industry, precautionary measures are not taken and the public is not informed about health risks [20, 21]. People in general are, as a consequence, not taking preventive measures when using the handheld wireless phone, WiFi, or when exposed to RF radiation from base stations. Increasing ambient RF radiation gives higher total human exposure [22, 23] in addition to the widespread use of mobile and cordless phones.

During the last decades, the scientific evidence on other health effects than cancer has also increased. By January 2021, 255 scientists from 44 nations and 15 supporting scientists from 11 nations concluded that these effects occur well below most international and national guidelines recommended by ICNIRP, (see next section).

"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 to both plant and animal life." [24].

The scientific evidence on the carcinogenic potential of RF radiation in laboratory studies has long been accumulating, but has mostly been ignored or dismissed by e.g., ICNIRP, the WHO, the EU and the SSM. The increased cancer risk in humans for RF radiation is clearly supported by recent animal studies [25-27] and mechanistic studies, both induction of reactive oxygen species (ROS) [28], and DNA damage [29-31]. The history on carcinogenic effects in laboratory studies started several decades ago.

Co-carcinogenic effects of RF radiation exposure and benzopyrene in mice were published already in 1982 [32]. The study showed that 2,450 MHz of RF radiation at either 50 or 150 W/m^2 promoted carcinogenesis. These levels exceed the ICNIRP guidelines, see below. The authors concluded that the resulting acceleration of development of spontaneous and chemically induced cancers indicated the carcinogenic potential of RF radiation.

Two studies published in 1990 demonstrated that 2,450 MHz continuous-wave RF radiation exerted a biphasic effect on glioma cells [33] and lymphocytes [34]. Cell proliferation was found at a specific absorption rate (SAR) of ≤50 W/kg, whereas a higher SAR suppressed DNA and RNA synthesis. These effects were reported to be non-thermal, i.e. not caused by heating.

A statistically significant increased incidence of primary malignant diseases was found in exposed animals compared with sham exposure in a study on 200 rats exposed to 2,450 MHz pulsed RF radiation for 21.5 h/day for 25 months compared with 200 controls. SAR ranged between 0.144 and 0.4 W/kg, depending on the rat's weight [35]. This was one of the first large scale studies to be conducted. Consequently the results in the U.S. National Toxicology Program (NTP) [25-26] and the Ramazzini Institute [27] studies are in line with these findings.

A study on mice carrying a lymphomagenic oncogene exposed to RF radiation showed a statistically significant increased risk for malignant lymphoma [36]. A total of 100 mice were sham-exposed and 101 were exposed for two 30-min periods per day for up to eighteen months to 900 MHz pulsed RF radiation with power densities of 2.6-13 W/m^2 (SAR 0.008-4.2 W/kg; mean, 0.13-1.4 W/kg). These results were not confirmed in the study by Utteridge et al. [37] which has been noted not to be a replication study [10, 38].

A co-carcinogenic effect was found in a study on mice exposed to a Universal Mobile Telecommunications System (UMTS) test signal from the fetal period for up to 24 months [39]. Animals were exposed to UMTS fields with intensities of 0 (sham), 4.8 and 48 W/m^2. The low-dose group was subjected to additional prenatal ethylnitrosourea (ENU) treatment. The group that was ENU-treated and UMTS-exposed at 4.8 W/m^2 exhibited an increased rate of lung tumors and an increased incidence of lung carcinomas as compared with the controls treated with ENU alone.

A tumor promoting effect was studied in another study on ENU-treated mice. The exposure levels were 0 (sham), 0.04, 0.4 and 2 W/kg SAR. The numbers of lung and liver tumors

in exposed animals were statistically significant higher compared with those in sham-exposed controls, as were the numbers of malignant lymphoma. A tumor-promoting effect of RF radiation was found at low to moderate levels (0.04 and 0.4 W/kg SAR), which were well below the exposure limits for users of mobile phones, 2 W/kg (of tissue) to the head [40].

Numerous published studies report effects or damage in terms of oxidative stress, damage to DNA, gene and protein expression, breakdown of the blood-brain barrier and damage to the brain and other organs of the body [41, 42]. There is also increasing evidence of adverse (chronic) health effects from long-term exposure. This was already reported as the "microwave syndrome" or "radiofrequency sickness" some fifty years ago. Reported health effects in scientific studies during the last decades from exposure to mobile phone towers, WiFi and mobile phones are consistent with the reported effects from RF radiation (microwaves) half a century ago [43, 44]. Furthermore, repeated studies show harmful effects from prenatal exposure, both in animal studies and in humans [45, 46].

Many countries around the world rely on guidelines for maximum allowed exposure from ICNIRP, supported and recommended by the WHO [47]. In Europe, most countries also follow the recommendations from the EU Commission that are based on ICNIRP and the EU expert group Scientific Committee on Emerging and Newly Identified Health Risk (SCENIHR). In 2020 ICNIRP published updated guidelines [48] based on the reviews and opinions from the WHO 2014 environmental health criteria public consultation report, SCENIHR 2015 [49] and the Scientific Council on Electromagnetic Fields at the Swedish Radiation Safety Authority (SSM) 2015, 2016, 2018 [50-52].

In this article we discuss how these organizations have evaluated the increasing evidence of harmful effects of RF radiation at levels below most national guidelines and limits for RF radiation exposure. The same individuals reappear in several of these organizations' expert groups, see Table 1, and there are no representatives in these groups from the many scientists that disagree with their conclusions [24]. We discuss primarily cancer risks in Appendix B of the ICNIRP updated guidelines [48].

WHO 2014 core group	**ICNIRP**	**IEEE**	**EU**	**SSM**	**EMF Scientist Appeal**	**The 5G Appeal EU**
Emilie van Deventer, project leader	X	X	-	X	-	-
Simon Mann	X	-	-	-	-	-
Maria Feychting	X	-	-	X	-	-
Gunnhild Oftedal	X	-	-	-	-	-
Eric van Rongen	X	X	X	X	-	-
Maria Rosaria Scarfi	X	-	X	X	-	-
Denis Zmirou	-	-	-	-	-	

SCENIHR 2015	ICNIRP	IEEE	WHO	SSM	EMF Scientist	5G Appeal EU
Theodoros Samaras	-	X	-	-	-	-
Norbert Leitgeb	-	-	-	-	-	-
Anssi Auvinen	X	-	-	-	-	-
Heidi Danker Hopfe	-	-	-	X	-	-
Kjell Hansson Mild	-	-	-	-	-	-
Mats Olof Mattsson	X	X	-	-	-	-
Hannu Norppa	-	-	-	-	-	-
James Rubin	-	-	X	-	-	-
Maria Rosaria Scarfi	X	-	X	X	-	-
Joachim Schüz	-	-	-	-	-	-
Zenon Sienkiewicz	X	-	-	-	-	-
Olga Zeni	-	-	X	-	-	-
SSM 2016	ICNIRP	IEEE	WHO	EU	EMF Scientist	5G Appeal EU
Anke Huss	From 2020	-	-	-	-	-
Clemens Dasenbrock	X	-	-	-	-	-
Emilie van Deventer	X	X	X	-	-	-
Eric van Rongen	X	X	X	X	-	-
Heidi Danker-Hopfe	-	-	-	X	-	-
Lars Klaeboe	-	-	-	-	-	-
Maria Rosaria Scarfi	X	-	X	X	-	-
Martin Röösli	X	-	X	-	-	-

Table 1: Many persons in expert groups at the WHO, the EU commission and in Sweden are current or former members in ICNIRP, and other expert groups, with no representative from the scientific community with opinions as expressed in EMF Scientist Appeal or 5G Appeal. For further details see ICNIRP [72,135,136,140,141,143-146], IEEE [137,145], EU [86,138,145], SSM [71,142], EMF Scientist Appeal [24], the 5G Appeal EU [139].

2. Evaluating Organizations

2.1. ICNIRP

ICNIRP is a non-governmental organization (NGO) based in Germany that has obtained major influence world-wide on health risks from RF radiation through its recommended guidelines for limiting RF radiation exposure [48, 53, 54]. These guidelines are recommended by the EU Commission, the WHO and are adopted by the majority of the countries around the globe.

ICNIRP was started in 1992 as an "independent commission". It is registered in Germany and located in Munich at the same address as the German Federal Office for Radiation Protection [55].

ICNIRP maintains the same attitude to health effects from RF-radiation as the Institute of Electrical and Electronics Engineers (IEEE) and its standards setting committee, the International Committee on Electromagnetic Safety (ICES). This committee and ICNIRP, are both standard setting organizations for frequencies between 0 Hz to 300 GHz.

ICES have many industry and military representatives among its members [56]. ICES within IEEE also sets limits for RF exposure which are in line with the ICNIRP opinion that there are only immediate thermal effects and no effects below those that cause immediate effects due to increased temperature. This perception was established in the 1950's and a decade later used when the first thermal based standard for radiofrequency radiation was set in the USA in 1966 [57]. Several members of ICNIRP are also present or former members of IEEE/ICES [58].

The biophysicist Michael Repacholi from Australia was ICNIRP's first chairman and he is since 1996 an emeritus member [59]. Experts from various countries constitute the "main commission" of ICNIRP; a chair, a vice chair and 11 other members. Further scientists are elected by this commission to the scientific expert group (SEG). New and continuing members to the commission are elected by the members of the main commission. Nominations can be submitted by the members of the Commission itself, the Executive Council of IRPA (the International Radiation Protection Association) or the IRPA Associate Societies. It seems as if no scientist that is critical to the thermal paradigm on RF radiation risks, advocated by ICNIRP, is elected as a member of the Commission.

ICNIRP published its first guidelines on RF radiation in 1998 [53]. These were updated in 2009 with no changes [54]. Only short-term thermal (heating) effects were acknowledged to form the basis for the exposure guidelines. Long-term exposure and non-thermal effects were considered not to be established, thus excluding a large number of peer-reviewed scientific studies on negative health and biological effects from RF-radiation below the ICNIRP guidelines. In 2020 ICNIRP [48] published new guidelines on health risks based on documents from: the WHO 2014 draft, the EU SCENIHR 2015 report and the Swedish SSM reports 2015, 2016 and 2018.

It should be noted that not one of these five reviews has been published after peer-review in a scientific journal. Critique from the scientific community has been expressed against several of these reviews but has been ignored. Furthermore, these older documents do not cover the most recent research. In the following comments are given to these three reviews

since the ICNIRP 2020 is based on these older evaluations with no new and further evaluation of its own [48].

2.2 The WHO Public Consultation Environmental Health Criteria Document, 2014

The WHO EMF Project, responsible for the 2014 document, was established in 1996. ICNIRP's chairman Michael Repacholi suggested in 1995 that WHO should start the EMF Project [60]. In 1995, while Repacholi still was chairman of ICNIRP, he became the head of the WHO International Electromagnetic Fields Project, and then head of the WHO EMF Project in 1996 [61], where he remained until 2006 [62]. A close colloboration between WHO and ICNIRP was initiated. In November 1998 the WHO EMF Project commenced a process aimed at the harmonization of EMF standards worldwide according to the ICNIRP guidelines [63]. Benefits to trade was given as one main argument to this specific project. The 100 times lower limits (compared to ICNIRP) in Eastern Europe were described as problematic [63].

The possibility of industry funding to the project was arranged already before the start of the project: "In 1995 WHO reached agreement consistent with these policies with Royal Adelaide Hospital (RAH), Australia to collect funds on behalf of the EMF Project. A memorandum of understanding allowed RAH to collect funds from government, professional associations and industry." [64]. This financial situation was ended in 2006 after disclosure by investigating journalists that showed that approximately half of the funding for the WHO EMF Project came from telecom industry organizations; GSM Association, Mobile Manufacturers Forum (MMF) and Forschungsgemeinschaft Funk e.V. (FGF) [65, 66].

Since 2006 the project leader of the WHO EMF project is Emilie van Deventer, an electrical engineer and longtime member of the industry organization IEEE [67]. She is the founder and former chairperson of the IEEE Joint Chapter on Electromagnetics and Radiation [68]. Her background is in "electromagnetic characterization of high-speed circuits for telecommunications applications, computationa electromagnetics (RF frequency and time domain techniques), electromagnetic compatibility, antenna modelling and design*"* and does not include medical training [69, 70]. She is the WHO EMF Project observer at the ICNIRP's main commission as well as a member of the SSM expert group from 2010 to 2017 [60, 71, 72].

The WHO EMF Project is in principle synonymous with ICNIRP. The same individuals that propose the ICNIRP guidelines are also acting as experts evaluating hazards from RF radiation on behalf of the WHO. This kind of double position situation is a potential conflict of interest according to the Ethical Board of the Karolinska Institute, Stockholm, Sweden 2008 (Dnr 3753-2008-609).

In 2005-2006 the personnel at the WHO EMF Project were Michael Repacholi, Emilie van Deventer, Chiyoi Ohkubo [62], Richard Saunders [73], Eric van Rongen and Lisa Ravenscroft [60]. All except Ravenscroft are current or former members of ICNIRP. In fact, at a meeting at WHO, Geneva in March 2017, Dr Maria Neira, at that time Director for Public Health and Environment at WHO, stated that ICNIRP is an Non-Governmental organization (NGO) with an official relationship with WHO that "helps us a lot in our analyses" and their members work as WHO's experts [74]. The WHO EMF Project has for many years been criticized for its collaboration with the industry; electrical, military and telecom [75].

A draft of a Monograph on health effects of electromagnetic field (EMF) exposure was released by WHO in 2014 [76]. It was open for public consultation until December 31, 2014, but has never been published as a final version and it is unclear why it was never finalized.

Out of the six experts in the WHO core group responsible for the draft, four were active members and one was a former member of ICNIRP [74], a fact that illustrates that WHO continues to be almost identical with ICNIRP, see Table 1. Many critical comments were sent to the WHO. One example is the "No confidence" letter sent by The BioInitiative Working Group in December 2016 to the WHO EMF Program Manager that concluded that the experts writing the WHO draft were to a large extent ICNIRP members.

"The BioInitiative Working Group urges the World Health Organization to make changes to the WHO RF EHC [Environmental Health Criteria] Core Group membership to more fairly reflect membership and expertise of the 2011 IARC RF Working Group. At present the WHO RF EHC Core Group is indistinguishable from ICNIRP (1, 2) undermining credibility of the process and ensuring doubt about conclusions." [77].

This letter was followed by another letter from the BioInitiative Working Group in January 2017 including suggestion of experts to replace present persons in the Core Group as well as Additional Experts [78].

A call for Protection from Non-ionizing Electromagnetic Field Exposure was made by the International EMF Scientist Appeal.

"By not taking action, the WHO is failing to fulfil its role as the preeminent international public health agency…. The WHO is calling for all nations to adopt the ICNIRP guidelines to encourage international harmonization of standards… It is our opinion that, because the ICNIRP guidelines do not cover long-term exposure and low-intensity effects, they are insufficient to protect public health." [24].

In total forty-seven NGOs also submitted a critical statement regarding the WHO draft on December 15, 2014. The WHO draft was criticized for the absence of pluralism among the selected experts, for biased reporting of scientific results and the "promiscuity between the WHO and ICNIRP." [79].

A press release was furthermore issued on February 24, 2017 by the European coordination of organizations for an EMF exposure regulation which truly protects public health. They stated that "The Conflict of Interest Scandal is repeating itself in the WHO" [80].

In a letter of concern dated March 1, 2017 the Russian National Committee on Non-Ionizing Radiation Protection wrote to the WHO: "It has just come to our attention that the WHO RF Working group consists mainly from present and past ICNIRP members…..the private self-elected organization ICNIRP, similar as majority of the current WHO RF WG [Working Group] members, does not recognize the non-thermal RF effects,…" [81].

In 2016 at a seminar at SSM in Stockholm Emilie van Deventer said that they had received 700 comments on the draft including references to "at least 300 papers that we had missed" [82].

It is unclear how WHO reacted to the critique. The Monograph is still unfinished. Instead the WHO has called for a new systematic review of this topic.

It should be noted that WHO in 2014 issued the following statement: "THIS IS A DRAFT DOCUMENT FOR PUBLIC CONSULTATION. PLEASE DO NOT QUOTE OR CITE." Nevertheless, this WHO Monograph draft from 2014, issued by a group dominated by ICNIRP members, was used as a basis for the ICNIRP guidelines 2020.

2.3. The European Commission SCENIHR opinion 2015

In 2015 the European Commission's expert group on electromagnetic fields, SCENIHR, released its report "Opinion on potential health effects of exposure to electromagnetic fields (EMF)" [49]. It was an update of the previous SCENIHR Opinions of 19 January 2009 "Health effects of exposure to EMF" and 6 July 2009 "Research needs and methodology to address the remaining knowledge gaps on the potential health effects of EMF" [83].

SCENIHR is one of three "Independent Scientific Committees" that provide the EU Commission, and through the Commission the other European institutions, with scientific advice regarding consumer safety, public health and the environment [84]. The Committee is also supposed to "…draw the Commission's attention to the new or emerging problems which may pose an actual or potential threat".

According to the Commission decision 2008, article 15 [85], the experts "…shall undertake to act independently of any external influence" and "shall make a declaration of commitment to act in the public interest and a declaration of interests indicating either the absence or existence of any direct or indirect interest which might be considered prejudicial to their independence". However, this committee has a history of being unbalanced in terms of representation from both sides of the scientific controversy on RF radiation. No representatives from the scientific community that are of the opinion that there is increasing evidence of harmful effects have participated; at least no person has declared other opinion than the ICNIRP view.

The 2007 SCENIHR [86] working group's chair was Anders Ahlbom from Sweden, ICNIRP commission member 1996-2008 and contributing to the ICNIRP guidelines 1998. Mats-Olof Mattsson, from Sweden, was one of the groups' three experts.

The 2009 SCENIHR [87] working group was identical to the 2007 group, but Mats-Olof Mattsson, from 2013 member of ICNIRP SEG, replaced Ahlbom as chair [88]. Eric van Rongen, member of ICNIRP and ICES as well as working with the WHO EMF Project, was now among the external experts [87].

The 2015 SCENIHR working group was made up of Theodoros Samaras and Norbert Leitgeb (retired) and ten additional external experts [89]. Of the ten external experts, four are former or present members of ICNIRP main commission or SEG (Anssi Auvinen, Mats-Olof Mattsson, Maria Rosaria Scarfi and Zenon Sienkiewicz). Both Mattsson and Samaras are members of ICES/ IEEE [56].

2.3.1 Main conclusions 2015

The quotes in this section are from the SCENIHR report 2015 [49]:

"Overall, the epidemiological studies on mobile phone RF EMF exposure do not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region.…The results of cohort and incidence time trend studies do not support an increased risk for glioma while the possibility of an association with acoustic neuroma remains open."

Other effects from RF-radiation such as different health symptoms, also known as the microwave syndrome [43], neurological diseases and other health outcomes, were also dismissed with various arguments. The conclusion of no brain tumor risks from RF radiation relied upon several studies with methodological shortcomings resulting in underestimated risks, for instance the Danish cohort study [90, 91], the UK Benson study [92] as well as the Cefalo study [93], see below. Joachim Schüz, who was a member of SCENIHR 2015 working group that drafted SCENIHR 2015, was also coauthor of these three studies [94].

Increased cancer risks in other epidemiological studies [7, 8, 14, 15, 16] were downplayed by SCENIHR [49] with reference to a few brain tumor incidence trend reports, the Danish cohort and a UK cohort:

"The fact that incidence rates of glioma and meningioma do not rise in the age groups of highest mobile phone prevalence provides evidence that common use of mobile phones is unlikely to be associated with an increased risk of those brain tumours. This is confirmed by the Danish cohort study that rules out risks that would affect large segments of the population. Evidence against an association also arises from the large-scale UK million women study."

2.3.2. Methodological issues

2.3.2.1. The Danish Cohort (2001, 2006, 2011): This study, funded by Danish telecom operators, first published in 2001 [90] and last updated in 2011 [91], reported no increased risks of tumors in the central nervous system. It was based on 420,095 mobile phone private subscribers. This group's incidence of brain tumors was compared with the incidence within the rest of the Danish population (control group). However, there are severe methodological faults that led to erroneous results:

- Inclusion only of mobile phone private subscribers in Denmark between 1982 and 1995 in the exposure group.
- Exclusion of the most exposed group, consisting of 200,507 corporate users of mobile phones [90]. They were instead included in the unexposed control group if not private subscribers.
- Users with mobile phone subscription after 1995 were not included in the exposed group and were thus treated as unexposed: "individuals with a subscription in 1996 or later were classified as non-users" [91].
- Actual exposure data is unknown and no analysis by laterality (the side were the phone is hold in relation to the position of the tumor) was performed.
- All users of cordless (DECT) phones were treated as unexposed for that exposure although they were also exposed to the same kind of RF radiation as from mobile phone use. The Hardell group has shown that use of cordless phones increases risk of glioma and acoustic neuroma tumors [7, 8].

Professor Michael Kundi of the Medical University of Vienna expressed the opinion that the Danish study is "the

most severely biased study among all studies published so far" [95]. Certainly, there were severe methodological flaws. The study [90, 91, 96] was regarded by IARC in the 2011 evaluation [9, 10] to be uninformative regarding cancer risks due to serious exposure misclassification. However, it is included by SCENIHR [49], WHO [76], SSM [97] and ICNIRP as evidence of no risk [98, 99]. The statement by SSM 2013 [97] that: "The Danish cohort studies make an important contribution to the total assessment in the field." is remarkable taking the critique of the study that should have been well known to the SSM expert panel. The many shortcomings in the study were discussed in a peer-reviewed article [100] concluding that: "After reviewing the four publications on the Danish cohort study, one might rightly wonder whether this cohort was initially set up to show no increased risk."

2.3.2.2. The Benson UK study (2013): This cohort study of 791,710 women in the Million Women Study was started during 1996-2001 [92]. Data on mobile phone use was collected at one time between 1999 and 2005, without questions separating heavy users from light users. Mobile phone use was based on the answers to a few questions posed at the time when the women were recruited to the study: "About how often do you use a mobile phone?", "Never, less than once a day, or every day?" Those who did use a mobile phone were also asked "for how long?". At the end of the study in 2009, a random sample of participants were asked two more questions about their mobile phone use, but these answers were never used in the analyses. Use of cordless (DECT) phone was not assessed. Due to limitations in the study design, such as no comprehensive assessment of life-time mobile phone use, the study is uninformative and should not be used as scientific evidence of lack of cancer risk. In fact the authors concluded that:

"The main limitation of the study is that mobile phone use was reported at baseline and may have changed subsequently. Almost all women who reported daily use of mobile phones at baseline were still using a mobile phone at least once a week when asked again 8.8 years later. However, some women who reported not using a mobile phone at baseline began use subsequently; and this might dilute our estimates of relative risk towards the null" [92].

2.3.2.3. The CEFALO Study (2011): The CEFALO study on brain tumor risk for children aged 7-19 using mobile phones [93] is claimed in the SCENIHR 2015 report [49] to have found no increased risk. The children in the study were diagnosed with a brain tumor during 2004-2008. The study showed several statistically non-significant increased odds ratios (ORs). However, a press release issued by one of the authors, Maria Feychting at the Karolinska Institute in Stockholm, stated that "Reassuring results from first study on young mobile users and cancer risk…The so called CEFALO study does not show an increased brain tumor risk for young mobile users." [101]. She was vice chair of ICNIRP 2012-2020, member of ICNIRP SEG 2000-2012, and is currently SEG member since 2020. Maria Feychting was also member of the WHO core group responsible for the WHO 2014 draft. Martin Röösli, member of ICNIRP Commission since 2016, the SSM expert group since 2010, as well as member of the WHO 2014 external expert group, was also coauthor of this study (corresponding author). Martin Röösli also claimed in a press-release that the results were reassuring of no risk [102].

The study has several shortcomings and one major shortcoming is the assessment of RF exposure from cordless phones that was not included in the total RF radiation exposure. Furthermore, the scientists did not assess total

exposure from cordless phones (DECT). Instead the authors analyzed "…ever used cordless phones, and the cumulative duration and number of calls with cordless phones in the first 3 years of use." This is a scientifically invalid method to study risk associated with an agent [103]. Thereby four to sixteen years of potential exposure were disregarded in the study age group 7-19 years. It is most questionable since use of the cordless phone increases by age.

This is more startling since no such time limit was made in the questionnaire sent to the Ethical Board at Karolinska Institute, Stockholm (DNR2005/1562-3). There were four questions on use of a cordless phone (summary): 1. When did you first start using a cordless phone? 2. How often did [child] answer the cordless phone? 3. How often does [child] speak on the cordless phone? 4. When [child] talks on the cordless phone, which phrase fits the best? (about 1 min, about 3 min, about 6 min, about 10 min or more).

No doubt even with these few questions it would have been possible to assess lifetime cumulative use of the cordless phones. According to the questions there is no reason or possibility to limit to only the first three years of use. Furthermore, it is not probable that a child would only use the cordless phone for three years and then stop the habit. To note is also an e-mail (personal communication) from Martin Röösli to one of the authors (MN) on August 17, 2011 in which he regarding cordless phones stated that "We also asked about ever using it and we requested the age range that they have used the phone". No doubt with that information, which was not given in the article, it would have been possible to calculate whole lifetime cumulative exposure.
Thus, it is evident that limiting use to only first three years would bias the results towards unity, particularly as children tend to increase their phone use with increasing age, which is also shown in the CEFALO study. In spite of this, SCENIHR [49] gave the impression that all cordless phone use was included by claiming that "Use of cordless phones showed no increased OR (1.09; CI 0.81-1.45), not even in the group of highest cumulative use." This claim is most misleading. Highest group for cumulative use available in the study was only 70+ hours. Further, the authors intentionally omitted the real highest users by limiting the exposure to the first three years of use. It is remarkable that this misleading claim in the SCENIHR report was written by one of the authors of CEFALO (Joachim Schüz), who also was coauthor of the Danish cohort and the Benson study.

In a comment, the Hardell group wrote [103]:

"Further support of a true association was found in the results based on operator-recorded use [of mobile phones] for 62 cases and 101 controls, which for time since first subscription > 2.8 years yielded [odds ratio] OR 2.15 (95% [confidence interval] CI 1.07-4.29) with a statistically significant trend (P = 0.001)….. We consider that the data contain several indications of increased risk, despite low exposure, short latency period, and limitations in the study design, analyses and interpretation".

In fact, all ORs on mobile phone use were >1.0 according to Table 2 in the article [93]. For both ipsilateral and contralateral mobile phone use statistically significant increased risks were obtained for highest group of cumulative numbers of calls; OR = 2.91, 95% CI = 1.09-7.76 and OR = 4.82, 95 % CI = 1.21-19.24, respectively. For central or unknown location a statistically significant decreased risk was found based on low numbers. It should be noted that there are missing numbers of cases and controls in different strata in e.g. Table 5 in the article [93], no

explanation is given as we have discussed [103]. The anatomical distribution for brain tumors in children differs from adults [104]. Thus, there are more central and brain stem tumors, facts not considered by Aydin et al. [93] In children the distribution of RF radiation differs from adults with larger part of the brain more exposed due to e.g. smaller head and thinner bone [105]. Thus, the laterality analysis should be interpreted with caution.

2.3.3. Critical comments on SCENIHR [49]

There were in total 186 critical comments submitted to EU by different persons and organizations [106]. Less than 30 percent of these comments were taken into account, a few yielding minor clarifications in the text but without changes of the SCENIHR major conclusions. The BioInitiative Group was among many others that expressed critical comments to the SCENIHR: "In summary, the preliminary SCENIHR conclusion that glioma risk is weaker now is not scientifically justified. The only way that conclusion could be reached by SCENIHR is to exclude critical studies that present evidence to the contrary, i.e. studies that report the risk of glioma (and acoustic neuroma) is stronger now than in 2009" [107].

2.4. The reports from the Swedish Radiation Safety Authority (SSM) 2015, 2016 and 2018 [50-52]

The expert group on electromagnetic fields at SSM was created in June 2002. Between 2003 and 2010 it was called the "Independent Expert Group on Electromagnetic Fields". During that period Anders Ahlbom, member of ICNIRP main commission 1996-2008, and SCENIHR member 2007-2009, was the head of the expert group and his colleague Maria Feychting, longtime member of ICNIRP and member of the WHO 2014 core group, was the group's secretary. From 2013 and until today, the expert group was renamed as the "Scientific Council on Electromagnetic Fields".

Between 2003 and 2019 the SSM group has published thirteen reports in English on its webpage [71]. All reports since 2003 have consistently refuted or ignored evidence of health risks from non-thermal exposure in line with the views by ICNIRP, the WHO and the SCENIHR.

Since the first report in 2003 until today around half of the group's members have also been present or previous ICNIRP members. In consequence the conclusions have generally been that there are no health risks below the limits recommended by ICNIRP. No scientist critical to the ICNIRP view has ever been part of this group. Here are some examples of conclusions from the SSM reports (2015 – 2018) that are included as basis for the present ICNIRP guidelines.

2.4.1. SSM 2015

"In terms of exposure from mobile phone base stations or other RF-EMF transmitters, no new evidence has become available indicating a causal link between exposure and symptoms or Electromagnetic Hypersensitivity (EHS)…. New studies on mobile phone use and tumours in the brain using retrospective exposure assessment are in line with previous research, which means that increased risks were observed in some of the most extreme exposure categories. However, it is not clear to what extent these risk estimates are affected by recall bias… New studies on associations between sperm quality and mobile phone use are of low quality and cannot be used to evaluate a potential association with RF-EMF exposure" [50].

The 2015 SSM report raised the issue that recall bias might have affected brain cancer risk estimates. However the study by Momoli et al. [108] showed that recall bias did not affect the risk of glioma in the Canadian component of the Interphone study [14]. In addition, it should be noted that the 2020 ICNIRP guidelines [48] refer to recall bias in the case-control studies of the Interphone study but do not mention the analysis by Momoli et al. Also, as displayed below, recall bias cannot explain the results in the Hardell group studies.

2.4.2. SSM 2016

"Most research in the past decade has been done into a possible relation between mobile phone use and brain tumours. Epidemiological studies have provided weak indications for an association between frequent and long-term use of a mobile phone and gliomas (malign tumours of the brain tissue) and vestibular schwannomas (also called acoustic neuromas, a benign tumour of the vestibulocochlear nerve that connects the ear to the inner brain). The evidence is not very clear and unequivocal, however. Altogether it provides no or at most little indications for a risk for up to approximately 15 years of mobile phone use" [51].

In a press release, at the time of the publication of the 2016 report, this Swedish authority claimed that the suspicion that mobile phones or wireless networks could be a health risk to humans or to the environment had become weaker during the past 13 years since the first of the group's report [109]. This contrasted with the increasing scientific evidence of the opposite [24]. In Table 2 results for meta-analysis of highest cumulative use in hours of mobile phone use in case-control studies is given and the results for acoustic neuroma are given in Table 3. Clearly these results from the different studies available in 2016 are in contrast to the statement by SSM.

	All			Ipsilateral		
	Ca/Co	OR	95 % CI	Ca/Co	OR	95 % CI
Interphone 2010 [14]						
Cumulative use ≥1,640 h	210/154	1.40	1.03 – 1.89	100/62	1.96	1.22 – 3.16
Coureau et al 2014 [16]						
Cumulative use ≥896 h	24/22	2.89	1.41 – 5.93	9/7	2.11	0.73 – 6.08
Hardell, Carlberg 2015 [7]						
Cumulative use ≥1,640 h	211/301	2.13	1.61 – 2.82	138/133	3.11	2.18 – 4.44
Meta-analysis						
Cumulative use ≥1,640 h*	445/477	1.90	1.31 – 2.76	247/202	2.54	1.83 – 3.52

*≥896 h used for Coureau et al.

Table 2: Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95 % confidence interval (CI) for glioma in case-control studies in the highest category of cumulative use in hours for mobile phone use, for further details see [42].

	All			Ipsilateral		
	Ca/Co	OR	95 % CI	Ca/Co	OR	95 % CI
Interphone 2010 [15]						
Cumulative use ≥1,640 h	77/107	1.32	0.88 – 1.97	47/46	2.33	1.23 – 4.40
Hardell et al. 2013 [8]						
Cumulative use ≥1,640 h	27/301	2.40	1.39 – 4.16	19/133	3.18	1.65 – 6.12
Meta-analysis						
Cumulative use ≥1,640 h	104/408	1.73	0.96 – 3.09	66/179	2.71	1.72 – 4.28

Table 3: Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95 % confidence interval (CI) for acoustic neuroma in case-control studies in the highest category of cumulative use in hours for mobile phone use, for further details see [42].

2.4.3. SSM 2018

This annual report was the twelfth in this series and covered studies published from October 2015 up to and including March 2017. Oxidative stress effects reported below ICNIRP guidelines was discussed but the relevance for human "direct health effects" was claimed to be "unclear". The conclusion was that "No new health risks have been identified." [52].

It is clear that the SSM expert group has not made a sound and objective scientific evaluation of health risks associated with RF radiation exposure. We note that SSM in April 2020 published a new report from the SSM expert group which concluded: "The results of the research review give no reason to change any reference levels [ICNIRP's] or recommendations in the field". Of the ten members in the scientific group five were present or past members of ICNIRP [110].

3. ICNIRP 2020 Evaluation

Eric van Rongen, chair of the ICNIRP Commission 2016-2020, claimed in a press release regarding the new ICNIRP guidelines 2020 that the 1998 version was "conservative in most cases" and "still provide adequate protection for current technologies". He also argued that: "The most important thing for people to remember is that 5G technologies will not be able to cause harm when these new guidelines are adhered to" [111].

Many other incorrect statements were made in the recent ICNIRP paper [48] contrary to an objective evaluation of the available scientific evidence. In the following the section on cancer is reviewed. That section claims:

"There is a large body of literature concerning cellular and molecular processes that are of particular relevance to cancer. Although there are reports of effects of radiofrequency EMFs on a number of these endpoints, there is no substantiated evidence of health-relevant effects (Vijayalaxmi and Prihoda 2019)".

Already in the first paragraph in the report evidence on biological effects from RF radiation is dismissed without

scientific foundation. This continues regarding cancer risks. Mostly not even references are given to the discussed studies, or with erroneous references. The uninformed reader may take the statements at face value and not understand that they are, in fact, not correct.

3.1. Animal studies

Regarding animal studies yielding a promoting effect from RF radiation [39, 40] ICNIRP states that "…interpretation of these results and their applicability to human health [is] difficult, and, therefore, there is a need for further research to better understand these results". In the next paragraph the recent animal NTP studies [25, 26] and Ramazzini Institute results [27] are disregarded, stating that "…no consistency was seen across these two studies" and "within the context of other animal and human carcinogenicity research (HCN 2014, 2016), their findings do not provide evidence that radiofrequency EMFs are carcinogenic".

On the contrary, as discussed above, animal studies indicate that RF radiation may both promote and initiate cancer. In a review, the Hardell group concluded that:

"There is clear evidence that RF radiation causes cancer/tumor at multiple sites, primarily in the brain (glioma) and head (acoustic neuroma). There is also evidence of an increased risk of developing other tumor types. The results are similar in both the NTP studies (19, 20) and the Ramazzini Institute findings (34). Based on the IARC preamble to the monographs, RF radiation should be classified as Group 1: The agent is carcinogenic to humans" [19].

In a note published by ICNIRP in 2018 it was claimed that the histopathological evaluation in the NTP study was not blinded as to exposure status [112]. This was rebutted by one of those responsible for the NTP study [113]. However, it seems to have had no impact on the ICNIRP evaluation [48]. ICNIRP claims that the animal studies "do not provide evidence that radiofrequency EMFs are carcinogenic," while an independent peer review of the NTP data concluded that this study provided 'clear evidence of carcinogenic activity', see Table 4 in a comment on the NTP study [19]. A comprehensive discussion of the ICNIRP evaluation was published by Melnick as a correspondence with "focuses on ICNIRP's false claims about the methodology, interpretation, and relevance of the National Toxicology Program studies on cell phone radiation" [114]. This included misleading statements by ICNIRP on e.g., the pathology review procedure, rat survival rates, multiple comparisons, but also excluding discussion of other end points such as DNA strand breaks in the brain cells, and increased incidence of cardiomyopathy. Melnick concluded that "ICNIRP should promote precautionary advice for the general public rather than trying to justify their decision to dismiss findings of adverse health effects caused by RF-EMFs and thereby retain their 20+ y-old exposure guidelines that are based on protection against thermal effects from acute exposure". In the response, ICNIRP seemed not to make a serious scientific rebuttal of the statements by Melnick "except for one minor issue", i.e., the description of the NTP study as "whole of life" rather than "most of life" [115].

3.2. Brain tumor risks from mobile phone use

Regarding epidemiological studies first a study by Martin Röösli et al. [116] is cited by ICNIRP. Röösli is, as mentioned earlier, both member of the ICNIRP commission, the WHO 2014 external experts and the SSM experts. The

article has several limitations. The results on use of cordless phones as risk factor for brain tumors are not discussed. Regarding glioma risk all results on cumulative use of wireless phones were not discussed and ipsilateral or contralateral use in relation to tumor localization in the brain were omitted from the meta-analyses. These results are important and have shown a consistent pattern of increased risk.

There were several other limitations in the article [116], such as including the Danish cohort study [90] in the meta-analyses. As discussed above, the study has severe errors of exposure classification and was therefore evaluated to be uninformative regarding carcinogenesis in the IARC 2011 evaluation [10] including Martin Röösli as one participating member.

Regarding the thirteen country Interphone study on glioma [14] and acoustic neuroma [15] ICNIRP concludes that the studies do "…not provide evidence of an increased risk", which is not correct [48]. On the contrary regarding glioma cumulative call-time of mobile phones ≥1,640 h resulted in OR = 1.40, 95 % CI = 1.03–1.89, increasing to OR = 1.87, 95% CI = 1.09–3.22 for glioma in the temporal lobe, the most exposed part of the brain. Ipsilateral mobile phone use yielded OR = 1.96, 95% CI = 1.22–3.16 for all glioma, cumulative use ≥1,640 h. Furthermore, a statistically significant increased risk for glioma was seen in the group 2–4 years for regular use, with 1–1.9 years use as reference category, OR = 1.68, 95% CI = 1.16–2.41, see Appendix 2 [14]. The highest OR was seen in the 10+ years category for regular use, OR = 2.18, 95% CI = 1.43–3.31.

In parts of Interphone, RF radiation dose was estimated as total cumulative specific energy (TCSE; J/kg) absorbed at the tumor's estimated center [117]. The risk increased with increasing TCSE 7+ years before diagnosis, OR = 1.91, 95% CI = 1.05 - 3.47 (p-trend = 0.01) in the highest quintile. Comparing with glioma in other parts of the brain, increased ORs were found for tumors in the most exposed part of the brain in those with 10+ years of mobile phone use, OR = 2.80, 95% CI = 1.13 - 6.94.

Similar results were reported by Grell et al. [118]:

"we found a statistically significant association between the intracranial distribution of gliomas and the self-reported location of the phone…Taken together, our results suggest that ever using a mobile phone regularly is associated with glioma localization in the sense that more gliomas occurred closer to the ear on the side of the head where the mobile phone was reported to have been used the most".

Canadian data from the Interphone Study were evaluated separately [108]. For glioma, when comparing those in the highest quartile of use (>558 lifetime hours) to those who were no regular users, the OR was 2.0, 95% CI = 1.2 - 3.4. After adjustment for selection and recall biases somewhat higher OR was found, 2.2, 95 % CI = 95% CI = 1.3 - 4.1, indicating that such bias did not cause the results.

Also for acoustic neuroma, the Interphone study yielded statistically significant increased risk. Thus, ipsilateral cumulative mobile phone use > 1,640 hours gave OR = 2.33, 95 % CI = 1.23-4.40 [15].

Regarding the Hardell group studies ICNIRP [48] writes: "…a set of case-control studies from the Hardell group in Sweden report significantly increased risks of both acoustic neuroma and malignant brain tumors already after less than

five years since the start of mobile phone use, and at quite low levels of cumulative call time." No reference is given to the studies, indicating they have not been seriously evaluated. ICNIRP's writing is not consistent with what the studies reported. In the shortest latency time >1- 5 years period overall mobile phone use yielded for glioma OR = 1.2, 95 % CI = 0.98-1.5 increasing to OR = 2.3, 95 % CI = 1.6-3.4 in the latency period > 20 years (p trend = 0.01). Similar results were found for cordless phones although based on low numbers in the longest latency period. The lowest quartile of cumulative wireless phone use gave OR = 1.2, 95 % CI = 0.9-1.4 increasing to OR = 2.0, 95 % CI = 1.6-2.6 in the fourth quartile (p trend < 0.0001) [7]. Thus, as the published results show no statistically significant increased risk was found in total in the shortest latency group contrary to what ICNIRP stated, although somewhat higher risk was found for ipsilateral use.

For acoustic neuroma, the Hardell group reported use of wireless phone (mobile and/or cordless phone) with latency time >1-5 years in total OR = 1.2, 95 % CI = 0.8-1.6 increasing to OR = 4.4, 95 % CI = 2.2-9.0 (p trend = 0.003) for latency > 20 years [8]. The risk increased with cumulative use of wireless phone; first quartile OR = 1.2, 95 % CI = 0.8-1.7 and fourth quartile OR = 2.2, 95 % CI =1.5 – 3.4, p trend = 0.03. Thus, the results were similar as for glioma. These results were dismissed by ICNIRP.

In addition, ICNIRP claims that the Hardell group results may be caused by recall bias. For meningioma no statistically significant increased risk was found in the same study. Using meningioma cases as "controls" (the comparison entity) still yielded statistically significant increased risk for glioma and mobile phone use; ipsilateral use OR = 1.4, 95 % CI = 1.1-1.8, contralateral OR = 1.0, 94 % CI = 0.7-1.4 and for cordless phone use ipsilateral OR = 1.4, 95 % CI = 1.1-1.9, contralateral OR = 1.1, 95 % CI = 0.8-1.6 [7]. Similar results were found for acoustic neuroma using meningioma cases as the comparison group [8]. These results clearly show that the increased risks for glioma and acoustic neuroma were not caused by recall bias.

The CERENAT study by Coureau et al. [16] was omitted by ICNIRP. The study strengthened the evidence of increased risk for glioma associated with mobile phone use. Life-long cumulative duration ≥896 h gave OR=2.89, 95% CI 1.41 - 5.93 for glioma. Number of calls ≥18,360 gave OR=2.10, 95% CI 1.03 - 4.31. Higher risks were obtained for the highest exposed area, (temporal tumor), as well as occupational and urban mobile phone use. The Danish cohort study on mobile phone use with serious methodological limitations was however discussed in ICNIRP 2020, adding to the no-risk paradigm.

Furthermore, ICNIRP claims that "Studies of other types of tumors have also not provided evidence of an increased tumor risk in relation to mobile phone use. Only one study is available on mobile phone use in children and brain tumor risk. No increased risk of brain tumors was observed." This is yet another incorrect statement [93]. The CEFALO study, as discussed previously, showed increased risks in spite of methodological shortcomings.

3.3. Thyroid cancer

In 2016 the Hardell group published increasing incidence of thyroid cancer in the Nordic countries especially during the last two decades [119]. The thyroid gland is a target organ for RF radiation from smartphones, which was discussed as an etiologic factor. A case-control study on mobile phone use suggested an increased risk for thyroid cancer associated

with long-term use [120]. The same material was used to study genotype-environment interaction between single nucleotide polymorphism (SNPs) and mobile phone use [121]. The study showed that mobile phone use increased the risk for thyroid cancer when genetic variants were present within some genes. It was concluded that pathways related to DNA repair may be involved in the increased risk. The study was published online 6 December 2019, that is well before the ICNIRP 2020 publication. ICNIRP omitted completely to discuss the increasing incidence of thyroid cancer and the association with mobile phone use. The statement by ICNIRP of no risk for other tumor types is not correct. The increasing incidence of thyroid cancer in the Nordic countries is confirmed in our recent publication [122].

3.4. Brain tumor incidence

Another example by ICNIRP that misguides the reader is the statement "trends in brain cancer incidence rates from a large number of countries or regions…have not found any increase in the incidence since mobile phones were introduced." This is not correct. Philips et al. [123] reported a statistically significant increasing incidence of glioblastoma multiforme in UK during 1995-2015. Similar results were published from USA [124]. In Sweden, the Hardell group published increasing rates of brain tumors based on the Swedish National Inpatient Register and the Causes of Death Register [125]. The same group also published an increasing incidence of brain tumors in the Swedish Cancer Register [126]. ICNIRP seems to have overlooked facts that would contradict their claim that the results showing brain tumor risk are "not consistent with trends in brain cancer trends".

3.5. Transmitters, base stations and cancer

According to ICNIRP, studies on exposure to environmental RF radiation "have not provided evidence of an increased cancer risk either in children or in adults". No references to that statement are given. In a review by Khurana et al. [127] two of three studies reported increased incidence of cancer at a distance < 350 m [128] or < 400 m [129] from a base station. Dode et al. [130] reported increased cancer mortality in an area within 500 m from a base station in Belo Horizonte, Brazil. A study from Taiwan found a statistically significant increased risk of all neoplasms in children with higher-than-median RF radiation exposure to mobile phone base stations [131]. A cause-effect relationship between RF radiation in occupational and military settings, mainly communication equipment and radar, and hematolymphatic malignancies was reported by Peleg et al. [18]. They concluded that available research "make a coherent case for a cause-effect relationship and classifying RFR exposure as a human carcinogen (IARC group 1)". DNA damage and oxidative stress were associated with living in a vicinity of base stations in a study from India which is also of interest in this context [132]. It would have been pertinent for ICNIRP to review the literature.

There are also studies showing increased risk for childhood leukemia from RF transmitters. One of the authors of the ICNIRP 2020 guidelines, commission member Martin Röösli, stated at a seminar organized by SSM in 2016 that until 2003 all but one results on transmitters had shown increased risk for childhood leukemia: "it was quite impressive that [for] almost all the studies for different type of leukemias basically they reported significantly increased risk. So it was not a random sample of risk estimates. All but one risk estimates were above 1" [133]. This is in obvious contrast to the claim in ICNIRP 2020.

4. Conflicts of Interests

The conclusion by ICNIRP is not objective and lacks scientific credibility according to a research report that investigated ICNIRP commissioned by two European Parliament Members published in June 2020 [58]. Industry funding has been found to influence the results on research on RF radiation and health effects. However, ICNIRP does not take this into account although ICNIRP members themselves have reported that industry-funded scientific research seems to influence the results by reporting less findings showing adverse health effects of EMF compared to independent research [134].

The composition of ICNIRP is very one-sided according to the EU report [58]:

"ICNIRP has been, and is still, dominated by physical scientists… ..As one can read in the 45 portraits of the members of the ICNIRP commission and of the Scientific Expert Group (SEG), they all share the same position on the safety issues: non-ionising radiation poses no health threats and the only effects it has are thermal".

The EU report [58] pointed to the fact that ICNIRP's chairman Eric van Rongen, in 2016 invited the industry organization ICES to comment and thereby influence the upcoming ICNIRP 2020 guidelines [48]. The report concludes that it is:

"clear from ICES minutes that ICNIRP worked very closely with IEEE/ICES on the creation of the new RF safety guidelines that were published in March 2020. And this implies that large telecom-companies such as Motorola and others, as well as US military, had a direct influence on the ICNIRP guidelines, which are still the basis for EU-policies in this domain".

The EU report [58] also highlights several ICNIRP experts' financial ties to the industry. As described in that report, it should be noted that for example the European Food and Safety Authority (EFSA) considers conflict of interests as "any situation where an individual has an interest that may compromise or be reasonably perceived to compromise his or her capacity to act independently and in the public interest in relation to the subject of the work performed at EFSA". Apart from the telecom industry funding of the WHO EMF project, while it was led by ICNIRP's first chairman Michael Repacholi [74] (1996-2006), the EU report documents that "the majority of ICNIRP-scientists did perform research partly funded by industry".

As cited in the EU Report [58], Professor David Carpenter, Environmental Health Sciences at the University of Albany, USA, considers the "perversion that can result due to conflicts of interests" to be "one of the greatest problems in scientific discovery…When funding for scientists comes from an organization or corporation with desires to present a clean bill of health to the public, there is strong motivation to give the funder what they want, if only to continue receipt of funding."

To act both on behalf of ICNIRP to set guidelines supposed to protect against harmful health effects of RF radiation, and at the same time evaluate the health risks representing other organizations, may constitute a conflict of interest, i.e. according to the opinion of the Ethical board of the Karolinska Institute, Stockholm, Sweden. Many of the ICNIRP commission and SEG members act on behalf of several organizations thereby evaluating their own ICNIRP

guidelines validity on behalf of other organizations. This kind of conflict of interest adds to those in terms of telecom funding and connection to ICES, see Table 1 [24, 71, 72, 86, 135-146].

5. Guidelines for RF Radiation Exposure

The new ICNIRP 2020 guidelines were developed with 5G in mind, especially considering frequencies that are higher to the presently used mobile phone communications. ICNIRP recognizes citizens' concerns regarding safety of 5G, however the new guidelines show no reduction of safety limits. The premise for safeguarding human health has remained the same – to avoid thermal effects. ICNIRP's 2020 guidelines [48] are based, like in 1998 [53], only on thermal effects, i.e. the RF radiation from mobile communications devices can be high as long as it causes no tissue heating. This may be problematic for mm waves as the radiation can cause heating effects on the surface of the skin. A systematic review on 5G safety limits based on thermal dose concluded that: "The results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines" [147]. Furthermore, some organs are more susceptible to RF radiation damage so local dosimetry is more appropriate for characterizing organ-specific risk [10].

Currently the mobile communications reside on frequencies up to 2,600 MHz band, with some minor exceptions beyond that frequency. 5G frequencies are expected to be using bands all over the higher radiofrequency spectrum, including previous 2G and 3G bands. Main 5G frequencies, however, will be at 3.4 to 4.2 GHz. Later, millimeter waves will also be deployed to provide 5G services, these are expected to reside at frequencies of 24-28 and 39 GHz. Millimeter wave base stations are expected to cover mainly high public density areas, such as city squares, transportation hubs, business and shopping centers and other public areas.

With the new reference levels [48] ICNIRP differentiates whole body exposure and exposure to small areas of the body introducing two separate classes of reference levels. ICNIRP grants higher exposure when assessing compliance by reference values; basic restrictions however have remained the same. ICNIRP claims, that this is because of better scientific understanding with respect to the 1998 guidelines. In Table 4 we compare ICNIRP reference levels between the 1998 [53] and the 2020 guidelines [48]. The calculated values are for arbitrary frequencies per each designated band; mobile communications frequency bands differ from region to region. Table 4 characterizes bands used in most European countries.

In their 1998 guidelines, at frequencies over 10 MHz, the reference levels are based on electric and magnetic field strengths for the whole-body SAR basic restrictions, derived by computer simulations and experimental data [53]. The 2020 guidelines introduce reference levels for local exposure [48]. In 2020 whole body reference levels, the averaging time has been increased from 6 min to 30 min, which ICNIRP argues is to better match the time taken for body core temperature to rise [48].

Frequency (MHz)	Example usage	ICNIPR 1998 [53] reference level, 6 min	ICNIPR 2020 [48] reference levels, whole body exposure, 30 min	ICNIPR 2020 [48] reference levels, local exposure, 6 min
800	LTE	4	4	18.2
900	GSM, UMTS	4.5	4.5	20.1
1,800	GSM	9	9	36.6
1,900	DECT	9.5	9.5	38.3
2,100	UMTS	10	10	40
2,400	WiFi 2G	10	10	40
2,600	LTE	10	10	40
3,500	5G, WiMax	10	10	40
5,500	WiFi 5G	10	10	40
26,000	5G	10	10	30.9

Table 4: Comparison of ICNIRP 1998 and 2020 reference levels across common mobile communication frequencies, time averaged (W/m²).

The ICNIRP 2020 [48] reference levels are based on time averaged exposure over 6 min or 30 min, see Table 4. However, supra-additive effects between pulses from different RF radiation sources may give much higher peak radiation from short time pulses than the power density average. Using time averaging in reference values, as in the ICNIRP guidelines, definitely underestimates the risk.

Year	Power Density Limit ($\mu W/m^2$)	Name	Description
1966	100,000,000	ANSI C95.1 [149]	Based on thermal effects and 0.1-hour (or 6 minute) averaging time.
1991	10,000,000	ANSI/IEEE C95.1-1991 [150]	Based on thermal effects.
1996	10,000,000 5,800,000	FCC [151]	USA: 5,800,000 averaged over a 30-minute period (869 MHz), previously recommended in 1986 by NCRP; 10,000,000 for PCS frequencies (1.85-1.99 GHz).
1998	10,000,000 9,000,000 4,500,000	ICNIRP [53]	10,000,000 for 2–300 GHz 9,000,000 for 1800 MHz and 4,500,000 for 900 MHz averaged over 6 min.

2001	1,000	Salzburg Resolution [152]	
2001	100	EU Parliament STOA 2001 [153]	
2002	1	New Salzburg Precautionary Exposure Limit Indoor [154]	Maximum indoor exposure recommendation for GSM base stations proposed by the Public Health Office of the Government of Salzburg.
2009	See 1998	ICNIRP [54]	Confirmation of ICNIRP 1998.
2012	3-6	Bioinitiative 2012 Recommendation [44]	
2016	0,1-100	Europa EM EMF Guidelines [41]	For frequencies between GSM 900 to WiFi 5,6 GHz depending on sensitivity, night time or daytime exposure.
2020	400 MHz: 10,000,000 800 MHz: 18,200,000 1,800 MHz: 36,600,000 2,000 MHz: 40,000,000 6 GHz: 40,000,000 60 GHz: 26,600,000 300 GHz: 20,000,000	ICNIRP 2020 [48]	General public, local exposure, averaged over 6 min. For whole body exposure see Table 4.

Table 5: Guidelines by different organizations for radiofrequency radiation in $\mu W/m^2$.

In a recent review, average exposure limit was suggested to be considerably lower, 0.1 V/m; 26.5 $\mu W/m^2$ [148]. This guideline is comparable with the BioInitative Report from 2012 [44] with a scientific benchmark of 30-60 $\mu W/m^2$, and for chronic exposure to sensitive persons and children 3-6 $\mu W/m^2$. The EUROPAEM EMF guidelines published daytime RF radiation exposure to be 10-1,000 $\mu W/m^2$, nighttime 1-100 $\mu W/m^2$, and for sensitive persons 0.1-10 $\mu W/m^2$ [41]. All these guidelines by independent research groups without conflicts of interest are very much lower than the ICNIRP guidelines. These lower guidelines are aimed at preventing health effects and hazards, Table 5 [41, 44, 48, 53, 54, 149-154].

6. Discussion

As a general rule ICNIRP, WHO, SCENIHR and SSM have for many years dismissed available studies showing harmful effects from non-thermal RF exposure and have based their conclusions mainly on studies showing no effects. Results showing risk are criticized, disregarded or not even cited while studies showing no risks are accepted as evidence of no risk in spite of severe methodological problems. Many statements by these agencies are misleading and not correct. They are easily rebutted by reading the relevant publications.

In fact, these activities are not in line with prevention of health hazards. Previously the precautionary principle in

cancer prevention was discussed exemplified by e.g. asbestos, certain pesticides and RF radiation [155, 156]. It was noted that cancer prevention is usually very cost-effective. In a recent article we gave historical examples on lost opportunities based on early warnings with RF radiation as one more recent example [157].

In 2018 there was a call to dismantle ICNIRP and replace the organization with independent scientists [158]: "ICNIRP's mandate to issue exposure guidelines needs to be seriously questioned. ICNIRP is not independent of industry ties as it claims… Its opinions are not objective, not representative of the body of scientific evidence, but are biased in favor of industry."

The EU report investigating ICNIRP concluded in June 2020 that "for really independent scientific advice we cannot rely on ICNIRP." [58].

Our review reveals, with focus on cancer risks, an almost systematic downplaying of health risks from RF radiation by a group of persons that dominate the expert evaluations, see Table 1. Many of them reappear in several of these organizations' expert groups and also in other groups not described in this paper. One striking example is ICNIRP's chairman Eric van Rongen who also appeared in the WHO core group of six experts 2014 as well as one of SSM's eight experts and SCENIHR's nine experts in 2009 as well as secretary of the Health Council of the Netherlands expert group [159]. Another example is Maria Feychting, ICNIRP member since 2000, who was one of WHO's six core group experts behind the WHO 2014 draft, secretary of the SSM expert group evaluations 2003-2010, on the AGNIR (UK) expert group from 2009 and a Norwegian expert group in 2012 [160]. A third example is Martin Röösli, member of ICNIRP, the WHO external experts for the WHO draft 2014, the SSM expert group since 2010 and a Swiss expert group [99].

Our review also notes that there is a clear relationship between ICNIRP and ICES, which is dominated by industry representatives. Eric van Rongen, has been a member of ICES since 2000, ICNIRP member since 2001 and elected chair of ICNIRP in 2016, vice chair since 2020. From ICES annual report 2016 it was reported that:

"The new ICNIRP Chairman and one of the new members of the 14 member committee are also ICES members and ICNIRP is now willing to discuss harmonization of the exposure limits found in IEEE Stds C95.1TM-2005 and C95.6TM-2002 and the ICNIRP Guidelines. At a June 2016 Mobile Manufacturers Forum Workshop in Ghent, Belgium, the new ICNIRP Chairman, Dr. van Rongen, presented "ICNIRP's proposed HF guidelines" and extended an invitation to ICES to comment on the proposed guidelines. TC95 formed a 19 member task group to draft a document to comment on the ICNIRP proposed guidelines. The document was circulated to the TC95 membership for comment and a final document submitted to ICNIRP in time for discussion at the ICNIRP September meeting." [56].

The TC 95 committee's objective is "Development of standards for the safe use of electromagnetic energy in the range of 0 Hz to 300 GHz". These standards are based on the same scientifically invalid approach as the ICNIRP guidelines. In this TC95 committee, in which many members come from the military or the telecom industry, or are consultants to them, ICNIRP's chairman Eric van Rongen, Michael Repacholi, ICNIRP's first chairman and leader of the WHO EMF project 1996-2006, Theodoros Samaras

(chairman SCENIHR) and Mats-Olof Mattson, Chairman SCENIHR 2009 and member of ICNIRP, are also found.

All these expert groups dominated by ICNIRP consequently reach similar conclusions that there are no health effects below ICNIRP guidelines. No representative from the scientific community that is of the opinion that there is increasing evidence of health risks below the ICNIRP guidelines, e.g. as expressed in the EMF Scientists Appeal [24], has ever been a member of the expert groups at the WHO, the EU, the SSM or ICNIRP. Certainly scientists who do not discount evidence of health effects from exposure to RF radiation that are observed at exposures below guideline levels should be represented.

The resistance to the abundant and growing scientific evidence on health risks is remarkable and not within the realm of public health. This behavior, due to the ICNIRP influence and dominant role in several other expert groups, is detrimental to human health and leads to suffering and even premature death that could have been prevented. Furthermore, it must be stressed that in general there is lack of persons with medical education and competence not only in the evaluating bodies but also in several research teams producing questionable results as exemplified in this text.

ICNIRP is not representative of the scientific community since it does not include representatives from scientists that agree there is evidence of harmful effects at levels well below ICNIRPs limits although these scientists are in majority in the scientific community [24].

7. Conclusion

ICNIRP's conclusion [48] on cancer risks is: "In summary, no effects of radiofrequency EMFs on the induction or development of cancer have been substantiated." This conclusion is not correct and is contradicted by scientific evidence. Abundant and convincing evidence of increased cancer risks and other negative health effects are today available. The ICNIRP 2020 guidelines allow exposure at levels known to be harmful. In the interest of public health, the ICNIRP 2020 guidelines should be immediately replaced by truly protective guidelines produced by independent scientists.

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