

An analysis of Prof. Rössli's presentation of available studies on non-ionizing radiation and 5G

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Background: In its 10/2021 edition, the journal *Aktuelle Kardiologie* published the article "Gesundheitsrisiko Mobilfunkstrahlung? Was ändert sich mit 5G? [Radiation from Wireless Communication Technologies a Health Risk? What changes with 5G?]," perpetuating the message that the use of wireless technologies would not pose any health risk.¹ The main author is Prof. Martin Rössli, who, among other positions, is the chairman of BERENIS, an expert group on electromagnetic fields and non-ionizing radiation advising the Swiss government, and a member of ICNIRP (International Commission on Non-Ionizing Radiation Protection). From 2011 to 2018, he was a board member of the Swiss Research Foundation for Electricity and Mobile Communication. His article immediately served as the basis for other articles in online medical portals, such as "5G, 'Elektrosmog' und die Gesundheit: beruhigende Botschaften [5G, Electrosmog, and Health: Reassuring News]," with the key message: "A reassuring answer in a nutshell. So far there is no evidence that 5G technologies cause adverse health effects."¹ The analysis presented here will discuss the method and content of the article by Rössli et al.²

Keywords: mobile communications, wireless communication technologies, smartphone, 5G, non-ionizing radiation, health, study situation

Prof. Rössli's statements on the status of research

The article by Rössli makes three main statements that taken together give the "all clear" signal:

1. With the use of 5G, total exposure levels would not necessarily increase.
2. Since so far no adverse health effects could be proven for wireless radiation exposures to GSM, UMTS, and LTE, 5G would also be safe.
3. Though effects on the brain and oxidative status have been observed, they would be without health consequences.

None of the three statements corresponds to the facts, including the additional 5 statements Rössli derives from them. What Rössli tells medical doctors about the status of research is incomplete and misleading.

1. Statement I by Prof. Rössli: No increase in wireless radiation exposure for the public due to 5G!?

Rössli's first message: Wireless radiation exposure for the public would not "necessarily" increase due to 5G, even though the networks would be densified.

Rössli writes: "What overall impact the deployment of 5G will have on the exposure for the public depends on future applications that currently are still mostly unknown" (Rössli, p. 534).

Unknown, though, is next to nothing. As the digital transformation is being deployed, everything will be wirelessly connected to everything else.³ Rössli himself concedes a "rising demand for cell sites" that are expected to connect billions of devices across the Internet of Things, including autonomous cars, bus, tram, and train traffic, armed and public security forces, wireless payment systems, Wi-Fi at schools and government agencies, video streaming, and, last but not least, always-on smartphones. This will result in a massive increase in exposure. Rössli's

phrasing regarding 5G beamforming used for transmission is a belittling half-truth: "With this so-called 'beamforming,' local exposures can increase dramatically during heavy data use for a limited period" (p. 534). This exposure increase will not only occur during a limited period, but the intended operating mode of "always on" will lead to the opposite: an increasing permanent exposure. Beamforming, a focused high-energy beam, will become predominant. In real life, many people will use their smartphones in a main shopping area at the same time, all of them will have these beams following them, and those beams will not steer clear of nearby people.

Rössli's reassuring statement that "5G is more efficient than previous wireless communication technologies and that the emissions per transmitted amount of data will thus decrease," is another half-truth because we are dealing with a rebound effect here. This means that the transmission of individual data is more efficient, but the amount of data transmitted will explode and, in turn, lead to a higher electromagnetic radiation level – which has already been confirmed by first measurements. Koppel et al.⁴ published their measurements from an urban area in Stockholm where a cluster of cell antennas was mounted at low level close to the heads of pedestrians. They found that the spatial average across all cell antennas was 12.1 V/m (= 388,355 $\mu\text{W}/\text{m}^2$) and the maximum reading was 31.6 V/m (= 2,648,700 $\mu\text{W}/\text{m}^2$). The French government started a nationwide measurement program whose final results revealed an average exposure increase by 16% (for averaged values). It is expected "that the total exposure in areas where cell networks at the 3.5 GHz band are being used will see an exposure increase by about 20% in the long term."⁵ A series of measurements by the State of North Rhine-Westphalia in Germany showed maximum readings of 30.44 V/m (= 2,460,000 $\mu\text{W}/\text{m}^2$) in Dortmund, in Cologne 14.6 V/m (= 565,000 $\mu\text{W}/\text{m}^2$). These are extremely high exposure levels and 5G applications, owing to their new antenna technologies (at 3.6 GHz band), make up a disproportionately high percentage.⁶ For comparison, the environmental organization Friends of the Earth (BUND) demands a legally enforceable protective standard

with a maximum permissible limit of 0.194 V/m (= 100 $\mu\text{W}/\text{m}^2$); the Austrian "Leitfaden Senderbau [Antenna System Siting Guideline]," coauthored by the Austrian Medical Association, calls for 0.6 V/m (= 1000 $\mu\text{W}/\text{m}^2$).⁷

The measurement results confirm the prediction made in the eighth mobile communications report of the German federal government:⁸ *"The digital transformation of society accelerates at a fast pace. This will lead to an enormous increase in wireless communication overall, including an increased use of electromagnetic fields and thus also an overall increased exposure level for the public."*

In Germany, NGOs dedicated to a safer use of technology provide precautionary concepts for minimizing overall exposure levels with which the threshold limits recommended by BUND can be met.^{9,10}

Conclusion: Rösli's message that wireless radiation exposures remain constant does not correspond to reality.

2. Statement II by Prof. Rösli: There is no evidence of risk from GSM, UMTS, and LTE below exposure limits?

Rösli's second message: To date, no adverse health effects have been demonstrated below exposure limits; consequently, 5G will also not be harmful to health.

Rösli writes: *"To date, no adverse health effects could be consistently demonstrated below guideline values." "5G is a further development of existing wireless communication technologies. There is no substantial evidence that 5G would have biological effects different from previously used wireless communication technologies"* (p. 532).

Rösli insinuates that there would be no evidence of adverse health effects from previously used technologies, such as GSM, UMTS, and LTE, below exposure limits. The applicable ICNIRP exposure limits, however, are based on the thermal dogma and only recognize damage caused by heating. Studies that demonstrate non-thermal effects of wireless radiation are therefore excluded from the risk assessment. Based on this dogma, Rösli withholds the studies and more than 110 reviews that have demonstrated non-thermal effects at those frequencies.^{11,12}

In 2021, the Panel for the Future of Science and Technology (STOA) of the European Parliament published a 198-page study on the *Health Impact of 5G* in which the authors covered almost the entire current body of knowledge on carcinogenic and reproductive hazards regarding GSM, UMTS, and LTE.¹³ The STOA study comes to the following conclusions:

- Based on the overarching findings from epidemiological, in vivo, and in vitro studies, we have evidence of a carcinogenic potential, especially for previously used frequency bands of GSM, UMTS, and LTE (FR1: 700 to 3800 MHz), as well as adverse effects on fertility.
- For the higher frequency range of 5G (FR2: 24.25 to 52.6 GHz), no appropriate studies are available. This is why the STOA study refers to 5G as an experiment on the population.

In the 5G review by Simkó/Mattson,¹⁴ sponsored by Deutsche Telekom (the largest wireless network provider in Europe), it says:

"The available studies do not provide sufficient and satisfactory information for a meaningful safety assessment or regarding the question of non-thermal effects." 5G is being deployed without a technology assessment. The chairman of the Office of Technology Assessment at the German Bundestag, Armin Grunwald, referred to this as a real-life experiment on humans.¹⁵ The STOA report by the EU therefore demands a moratorium on 5G, just like the report from the Netherlands, which is cited by Prof. Rösli to support safety claims, though he fails to mention the report's call for a moratorium.

Conclusion: There is consistent evidence of adverse health effects from GSM, UMTS, and LTE. Rösli misleads readers in two ways: He leaves out parts of the current body of knowledge and downplays the ongoing experiment of 5G. He presents everything we do not know about the toxicity of 5G as knowledge. First studies on 5G, however, have already pointed to its toxicity.^{16,17}

3. Statement III by Prof. Rösli: There are effects, but they have no adverse impact on human health!

Rösli's third message: Effects have been observed on the brain and oxidative status; however, without health risks.

Rösli writes: *"Biological effects that have been observed within the range of exposure guideline levels, for example, on the electrical activity of the brain or oxidative status during high local exposure events do not represent a health risk according to the current body of knowledge"* (Rösli p. 531).

3.1. Effects on the brain, cognitive performance, headaches, and sleep

Rösli's claim that effects would not have adverse effects on brain metabolism is incomprehensible. The Swiss government confirmed in 2015 that the impact on brain currents by non-thermal effects *"has been sufficiently demonstrated according to scientific criteria," "clearly below international exposure limits."*¹⁸ Rösli himself coauthored an important study with 700 adolescents that showed that radio-frequency electromagnetic fields from cell phones adversely affect the development of cognitive functions, especially in figural memory scores.¹⁹

The review on the 2.45 GHz Wi-Fi frequency by Wilke²⁰ alone documents 12 studies with adverse effects on EEG and brain function and 22 studies on cognition, learning, attention, and behavior. More than a dozen studies from recent years, which are well known among experts, confirm effects on the brain. The studies by Volkow et al.²¹ and Wardzinski et al.²² show effects on glucose metabolism; studies by Akakin et al.,²³ Delen et al.,²⁴ Gökçek-Saraç et al.,²⁵ Hasan et al.,²⁶ Karimi et al.,²⁷ Kumar et al.,²⁸ Tohidi et al.,²⁹ Shahin et al.^{30,31} on the hippocampus; studies by Alkis et al.,³² Singh et al.,³³ Yang et al.³⁴ on ROS formation; research by Chen et al.,³⁵ Kim et al.,^{36,37,38} Li et al.³⁹ on neurons, neurite growth, and cell division; and Othman et al.⁴⁰ demonstrated cell stress caused by Wi-Fi.

Rösli also leaves out the studies of the Swedish research group led by oncologist Prof. Leif Salford (Lund University) on the permeability of the blood-brain barrier (BBB), which revealed neuronal damage,⁴¹ as well as the follow-up studies by Orendacova et al.,⁴² Sirav et al.,^{43,44} and Tang et al.,⁴⁵ which confirmed these results.

A meta-study by Farashi et al.⁴⁶ supports the observation that heavy cell phone use triggers headaches due to radio-frequency radiation exposure. Studies on Wi-Fi show a significant relationship with headaches and fatigue.^{47, 48, 49, 50} As an example for a study that demonstrates a correlation, we quote here the one by Chongchitpaisan et al.⁵¹ from 2021: "SOP (smartphone output power), which is smartphone electromagnetic radiation, has a non-linear correlation with migraine headaches which has been called a window effect response."

Röösli himself was a coauthor of the Schwarzenburg study in Switzerland that found that radio-frequency radiation exposure caused sleep disturbances, which ultimately led to the short-wave broadcast transmitter at Schwarzenburg being shut down.⁵² There is a wealth of studies that demonstrate effects on sleep, such as Arnetz et al.⁵³ with the partial outcome: "[In exposed subjects,] there was a prolonged latency to reach the first cycle of deep sleep (stage 3). The amount of stage 4 sleep was also decreased in exposed subjects." This finding is in contrast to studies that did not find any effect. A review that covers the endpoint sleep, however, is still pending.

Conclusion: Röösli does concede that radio-frequency radiation has measurable effects on the brain and sleep; yet his statement that these effects would have no health impact is not supported by the available research.

3.2. Oxidative cell stress, nothing to be concerned about!? Or are there "long-term harmful effects" after all!?

Röösli writes: "In vitro and in vivo studies, various exposure levels of radio-frequency electromagnetic fields have been observed to trigger the formation of reactive oxygen species (ROS). It is possible that at least part of these results can be traced to thermal effects of radio-frequency electromagnetic fields, as has also been observed for infrared radiation. The production of ROS, of course, could theoretically also be an indicator of long-term harmful effects" (p. 534).

Röösli does not mention the actual results of studies regarding this mechanism of action. A first such review was presented by Naziroglu M, Akman H⁵⁴ in the Springer reference book on ROS, including evidence of oxidative stress caused by Wi-Fi. In the review "Oxidative Mechanisms of Biological Activity of Low-intensity Radiofrequency Radiation," Yakymenko et al.⁵⁵ evaluated 100 studies. Ninety-three of those studies showed an EMF-related overproduction of reactive oxygen species (ROS): "In turn, a broad biological potential of ROS and other free radicals, including both their mutagenic effects and their signaling regulatory potential, makes RFR a potentially hazardous factor for human health."

The EMF-related increase in oxidative damage, according to Yakymenko et al., already occurs at levels thousand times below the exposure limits in the non-thermal range, at a power density of 0.1 $\mu\text{W}/\text{cm}^2$ (= 1000 $\mu\text{W}/\text{m}^2$) and at a specific absorption rate of (SAR) 3 $\mu\text{W}/\text{kg}$.⁵⁵

In the conclusion of the largest review on ROS to date by Schürmann/Mevissen,⁵⁶ the authors conclude after the assessment of 223 papers:

"In summary, indications for increased oxidative stress caused by RF-EMF and ELF-MF were reported in the majority of the animal studies and in more than half of the cell studies. ... Certainly, some studies were subject to methodological uncertainties or weaknesses ... A trend is emerging, which becomes clear even when taking these methodological weaknesses into account, i.e., that EMF exposure, even in the low dose range, may well lead to changes in cellular oxidative balance. ... Adverse conditions, such as diseases (diabetes, neurodegenerative diseases), compromise the body's defense mechanisms, including antioxidant protection mechanisms, and individuals with such pre-existing conditions are more likely to experience health effects" (p. 23).

Conclusion: These ROS studies answer Röösli's suggestion: "The production of ROS, of course, could theoretically also be an indicator of long-term harmful effects." This correct statement contradicts his general message of safety because this identifies a causal mechanism of action that forms the basis for inflammatory diseases. Yet the risk is certainly not theoretical. Even if biological effects of exposures will turn out to be partially reversible, they still can lead to manifestations of effects in the case of chronic exposures.

4. Statement IV by Prof. Röösli: No cancer risk – no increase in brain tumors!?

Röösli's fourth message: The "majority" of studies did not show an increased risk of brain tumors; statistics would also speak against this.

Röösli writes: "Epidemiological studies of malignant brain tumors in connection with cell phone use, however, show mostly no increased tumor risk. Isolated observations of an increased risk in case-control studies are probably due to issues of methodology" (Röösli, p. 534).

Once again, Röösli does not cite the actual research results that demonstrate effects, but he suggests that the "majority" – a dubious criterion that can quickly be met by the industry with sponsored studies – would not demonstrate any risk and that the studies that do demonstrate a risk "probably" could be attributed to issues of methodology or improved diagnostics.

With this undocumented claim, he uses doubt to cast a veil over the studies that do document cancer risks. According to the analysis by Prof. Henry Lai, the latter are even in the majority. Of 125 comet assay studies, 78 (65%) show an effect and 47 (35%) show no effect; of 346 genetic effects studies, 224 (65%) show an effect and 122 (35%) show no effect.⁵⁷

In 2011, IARC, the cancer agency of the WHO, classified non-ionizing radiation as "possibly carcinogenic" in Group 2B. The classification was based on the findings of the Interphone study⁵⁸ for heavy users (more than 1640 hours/cumulative) and the studies by the oncologist and epidemiologist Lennart Hardell that demonstrated an up to 5 times higher tumor risk in heavy users for the same type of tumor that the exposed animals in the NTP and Ramazzini studies also had developed.^{59, 60, 61, 62}

The finding of the NTP study^{63, 64} from the US shows that cell phone radiation can result in tumors. In the exposed group of male rats, tumors (schwannomas, gliomas) were found and an

additional number of rats showed precancerous cell changes (hyperplasia of glial cells). In the control group, no tumors were found. Falcioni et al.⁶⁵ at the Ramazzini Institute (Italy) exposed 2500 male and female rats for their entire lives with radiation representative of a 1800 MHz cell site and found increased rates of schwannomas in the heart and gliomas, thereby confirming the NTP study. The studies commissioned by the Austrian AUVA insurance company⁶⁶ also confirmed the cancer risk. The scientists involved in these studies and their reviews vehemently reject any doubts regarding the relevance of their findings to human health.^{67, 68, 69} The studies by Sadetzki et al.⁷⁰ and Czerninski et al.⁷¹ show a significantly increased risk of parotid gland tumors. The Federal Office for Radiation Protection in Germany considers the cancer promoting effect in animal studies a reliable finding.⁷²

Study findings on cancer – no relevance to real life?

With cancer statistics, Rösli tries to take the wind out of the sails of these study findings. His argument: Cancer statistics would not show an increased incidence. Once again, he leaves out essential research.

The most aggressive form of glioma is the rare glioblastoma whose incidence has rapidly increased in recent years. A statistics for Metropolitan France counts 823 histologically confirmed new cases of glioblastoma in 1990 and 3481 in 2018.⁷³ Official cancer statistics from Great Britain make this even clearer because the data distinguish between individual brain regions. The frontal and temporal lobes are right next to the cell phone during calling and receive a particularly high amount of radiation. This is why one study compared the increase in glioblastomas in the frontal and temporal lobe regions to those in the remaining brain regions. While in the latter regions no significant increase was seen, the number of glioblastomas in heavily exposed regions of the brain more than tripled. The figure from this study shows that many other causes, such as chemical burdens, can be ruled out for the increase in glioblastomas because they would affect all regions of the brain equally (Figure 1). Hardell and Carlberg⁷⁵

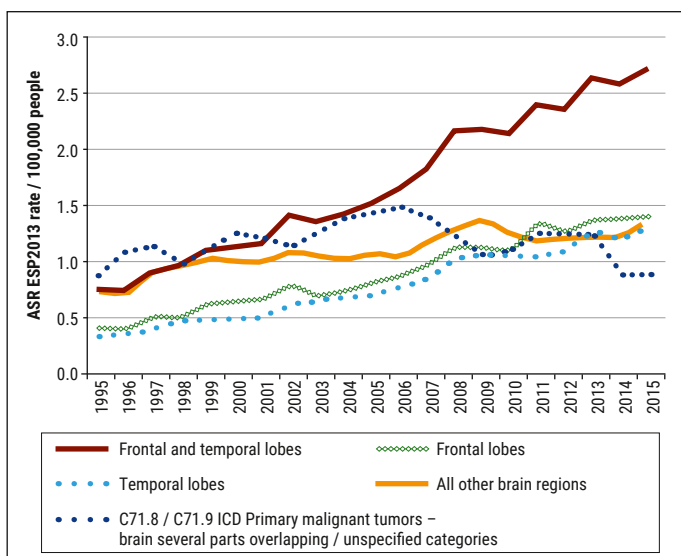


Figure 1: Change in age-standardized incidence rates of glioblastomas in different brain regions 1995–2015, Philips et al.⁷⁴

could demonstrate that gliomas occur more frequently on the side on which the cell phone is held during calling. An analysis of data from England between 1985 and 2014 shows that new cases of glioblastoma in frontal and temporal lobes have increased since about 1992.⁷⁶ Analyses of cancer statistics from the US by Gittleman et al.⁷⁷ and Ostrom et al.⁷⁸ also show this trend. The analysis of US cancer statistics between 2000 and 2010 by Gittleman et al.⁷⁷ (p. 111) finds: "The incidence of NMCNST [non-malignant central nervous system tumors] increased significantly. In comparison, adolescents had increasing rates of MCNST [malignant central nervous system tumors] and NMCNST, and children had increasing rates of AML [acute myeloid leukemia], NHL [non-Hodgkin lymphoma], and MCNST."

The analysis by Ostrom et al.⁷⁸ (p. 26) revealed: "In children (0–14 years old), there have been significant increases in incidence of primary malignant brain and CNS tumors between 2000–2010, with an annual percentage change (APC) of 0.6%. In adolescents (15–19 years old), there was a significant increase in incidence of primary malignant brain and CNS tumors between 2000–2008, with an APC of 1.0%. Adolescents also experienced an increase in non-malignant brain and CNS tumors from 2004–2010, with an APC of 3.9%." In the meta-analysis by Bortkiewicz et al.,⁷⁹ it says: "The results support the hypothesis that long-term use of mobile phones increases the risk of intracranial tumors, especially in the case of ipsilateral exposure." Analyses by Burkhamer et al.⁸⁰ confirm this trend. Gliomas are on the rise in the Netherlands, glioblastomas increase in Australia and England, and all brain tumors are on the rise in Spain and Sweden⁸¹ (Belpomme, p. 653). Lim et al.⁸² and the Robert Koch Institute have documented an increase in thyroid cancer. The Robert Koch Institute documents for all malignant tumors in children an increase of ca. 25% between 1994 and 2012.⁸³ The IARC of the WHO reports a worldwide increase in cancer of 13% in children from 2001 to 2010.

Meanwhile, calls are growing louder for international commissions to revise their previous assessments because they underestimate the risk. Prof. James C. Lin (from 2004 to 2016 ICNIRP commissioner and from 2008 to 2012 chairman of the Standing Committee on Physics and Technology of ICNIRP), for example, states in a conclusion of a National Institute of Environmental Health Sciences (US) conference that the findings of the cancer study by the National Toxicology Program (NTP) suggest that the current safety guidelines are insufficient because he considers the available studies as "clear evidence of cell-phone RF radiation cancer risk."^{85, 86} The Hardell research group from Sweden demands to have radio-frequency radiation classified as "carcinogenic."^{59, 75, 87}

Conclusion: The risk that radiation from wireless communication technologies can initiate and promote cancer is supported by study findings. Rösli makes no attempt to refute these studies, but simply withholds them from readers. This is unscientific.

5. Statement V by Prof. Rösli: Sperm quality – not at risk!?

Rösli's risky fifth message: Mobile devices can be worn and used close to reproductive organs without hesitation.

Rösli writes: "Until recently we have not had an epidemiological study of sufficient quality about the impact of radiation from wireless communication technologies on sperm quality, even though

it is a matter of public controversy. In a recently published prospective cohort study with about 3000 subjects, no effect was observed for the use of cell phones in the front pockets of pants on sperm quality and the period until a pregnancy is confirmed" (Röösli p. 535).

Röösli bypasses an overall analysis of the current body of knowledge from in vivo, in vitro, and epidemiological studies by pointing to an anecdotal note in a single (!) epidemiological study by Hatch et al.⁸⁸ Furthermore, Röösli misinterprets this study. It supposedly proves that the use of cell phones has "no effect" on sperm quality. This is not what the study says. It presents a differentiated result with suggestions of a possible risk for persons with a normal body weight and a BMI below 25.

This finding by itself would justify the implementation of the precautionary principle. All studies with positive findings, Röösli generally disregards as having "insufficient quality." The STOA study¹³ (see above) analyzes in its review more than 60 studies, concluding that the risk to fertility has been proven. This has been confirmed by the currently most important meta-study by Kim et al.⁸⁹ This risk is also supported by 16 reviews that demonstrated damage to sperm and embryos in cell and animal studies.¹¹

Conclusion: Röösli's citation and misinterpretation of only a single epidemiological study distracts from the entire body of available studies. With this risky message, Röösli falls behind recommendations in instruction manuals not to use mobile devices too close to the user's body, but to keep a certain distance.

No conflict of interest?!

Röösli's method of presenting the current status of studies is remarkable. He works with a mix of half-truths, qualifiers, and omissions of knowledge. Röösli's role across politics, industry,

and science has been analyzed in reports by Members of the European Parliament (Buchner/Rivasi⁹⁰) and the network of investigative journalists at Investigate Europe (Schumann/Simantke⁹¹), especially also the lobbying efforts of ICNIRP, the organization Röösli is a member of and on whose behalf he acts. That the journal *Aktuelle Kardiologie* and Thieme Medical Publishers accepted Röösli's publication unchecked is negligent. Under "Conflict of Interest," Röösli writes about himself in the journal *Aktuelle Kardiologie*: "From 2011 to 2018, M.R. was an unpaid board member of the Swiss Research Foundation for Electricity and Mobile Communication, a non-profit research foundation at ETH Zurich. Industry or NGOs are not represented in the scientific board of the foundation."

With this statement, Röösli betrays the journal and its readers. He gives the impression as if the foundation would be a department at ETH Zurich. Yet, in reality, the foundation only uses rooms at the Swiss Federal Institute of Technology in Zurich (ETH). And most of all, the founders, among others, include Swiss telecommunication companies Swisscom, Salt, and Sunrise; the current sponsors are Swisscom, Salt, Sunrise, Ericsson, and Huawei.⁹²

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