Summaries and assessments of selected studies

In the period from beginning of May to mid of July 2023, 75 new publications have been identified, and six of these were discussed in depth by BERENIS. Based on the selection criteria, four of these publications were selected as the most relevant ones. Their summaries and assessments are provided below.

1) Experimental animal and cell studies

Effects of 5G-modulated radiofrequency electromagnetic fields on molecular mechanisms of skin cells (Joushomme et al. *2023)*

The study of Joushomme *et al.* (2023) is among the first ones applying a 5G-modulated 3.5 GHz RF-EMF signal of the new C-band for mobile communication to cultured cells. In order to investigate the influence of acute exposure on signalling pathways and stress mechanisms, the authors used a novel analytical approach ("BRET", bioluminescence resonance energy transfer) that enables real-time observations. For this purpose, four new molecular biosensors were developed that allow to monitor various stress conditions (HSF1: marker for heat, oxidative and proteotoxic stress; PML aggregates in the cell nucleus: marker for oxidative stress, cell ageing...) or the activation of MAP kinase signalling pathways (RAS and ERK). The activity measurements of the biomarkers were performed in skin fibroblasts obtained from a *xeroderma pigmentosum* group D patient ("XP-D" with sunlight sensitivity) and in HaCaT cells derived from healthy human skin keratinocytes. Measurements were performed after 24 hours of continuous or intermittent (5/10 min on/off) RF-EMF exposure at 0.25, 1 or 4 W/kg SAR. In comparison to sham control conditions, either the basal activities by exposure to RF-EMF or the sensitivity and excitability to known stimuli (MG132 for HSF1, PMA for RAS and ERK, arsenic for PML) were analysed.

On the one hand, the study by Joushomme *et al.* (2023) is interesting because of the use of 5G-modulated 3.5 GHz signals and on the other hand because of the application of a novel methodology, although the sensitivity and reliability need to be more thoroughly demonstrated. The authors report about some exposure-dependent changes in cellular stress mechanisms (HSF1 and PML), which occurred primarily in the fibroblasts of XP-D patients, but not in keratinocytes. It thus remains to be investigated to what extent these observations can be generalised and also apply to "healthy" fibroblasts. Independent replications and confirmations by other molecular analyses are required. It should be noted that a large number of experimental conditions were tested in this study. As the authors also pointed out, the number of significant effects is only slightly above the expected rate of false positive findings. In addition, the use of the incubator as a reverberation chamber for the RF-EMF exposure implies a certain variability of the SAR values, which could have an effect on the dose-response correlation.

2) Epidemiological studies

Mobile phone use, genetic predisposition, and risk of hypertension: results of the UK Biobank study (Ye et al. *2023)*

Few studies have addressed a potential relationship between mobile phone use and risk for hypertension. Ye *et al.* (2023) used data from 212,046 participants of the UK Biobank study who did

not have hypertension at the start of the study. At baseline, participants were asked since how many years they use a mobile phone at least once a week to make or receive calls. Further, participants were asked how much time they spent talking on a mobile phone on average for the last three months including the proportion of using hands-free devices or speakers. Statistical analyses were adjusted for several confounders such as age, sex, BMI, socioeconomic status, family history of hypertension and numerous biomarkers. During a median follow-up of 12.0 years, 13,984 participants developed new-onset of hypertension. No association was found for new-onset of hypertension with the number of years of mobile phone use or proportion of hands-free use. However, risk of developing hypertension significantly increased with weekly calling time. Those with at least 30 minutes weekly calling time had a 12% increased risk compared to people using a mobile phone less often. This correlation was seen in people with an age of less than 60 years but not in older ones. The strongest correlation was found for participants with a high genetic risk for hypertension and long weekly calling time.

This is a prospective cohort study with a large sample size, and thus the gold standard for this research question. If causal, even the relatively small risk increase would be of high public health relevance, given the high prevalence of hypertension in the population. A weakness of the study are self-reported mobile phone use data without any update during the long follow-up time. It is thus unclear how well typical usage at baseline is correlated with actual use during the whole study period. Further, no distress indicator was considered in the statistical analysis. It is thus conceivable that observed associations are due to other factors than RF-EMF exposure. For instance, amount of mobile phone usage may be an indicator for a stressful lifestyle. The large difference between basic and fully adjusted analysis is an indication that co-factors play an important role for this research question.

3) Impacts on the environment

Exposure of honey bee colonies to simulated RF-EMF (Treder et al. *2023)*

Eight honey bee colonies were exposed to a combined RF-EMF (2.4 and 5.8 GHz; WiFi) for 12 to 14 weeks (for 7 weeks prior to testing; long-term exposure) or 40 minutes (short-term exposure) in July to September 2020 and July to October 2021, respectively. Another eight colonies were used as controls without exposure. The effect of exposure on brood development, longevity and homing ability under open field conditions was investigated. Long-term exposure reduced the ability of honey bees to fly back to the hive (78.6% compared to 95.2%) while there was no effect on brood development and longevity of adult worker bees. There was no effect of short-term exposure. According to the authors, this indicates that foragers from colonies that have not been exposed long-term can still to successfully return to the hive, even if their foraging trajectories pass through areas with RF-EMF radiation for a short time.

The study provides interesting first indications of possible effects of RF-EMF on honey bees. However, further clarification is required, as it is unclear to what extent RF-EMF is shielded by the honeycombs. Conducting corresponding dosimetry would be helpful in this respect. As the variability between colonies is very high, the study should be repeated with substantially more colonies and at different locations.

Do RF-EMF, as used in mobile communications, affect wild plant species? (Czerwinski et al. *2023)*

The effects of long-term RF-EMF exposure over 4 months on wild plants were investigated under controlled experimental field conditions. Pulsed RF-EMF (4 frequency bands; 866-868 MHz; 12.4 mW/m^2 (2.16 V/m) and 16.7 mW/m^2 at 20 and 40 cm height) were applied. Ten common herbaceous plant species were analysed over the entire generation phase from germination to seed maturation.

The plant species belong to different families with different functional and morphological characteristics. In most species, a response to RF-EMF exposure was not or hardly detectable, mainly limited to a single feature. Effects were only observed in hare's-foot clover (Trifolium arvense) at different developmental stages of the plant and regarding different features. These effects were permanent. The consequences of environmental exposure to human-induced RF-EMF appear to be limited to certain plant species. Trifolium species could be considered as candidates for future ecological studies.

We consider this as an interesting pilot study. Follow-up studies should be conducted at different sites, as a contribution of other environmental factors or masking of an effect in the other plant species by such other environmental factors cannot be excluded.

References

Czerwiński M, Vian A, Woodcock BA, Goliński P, Recuero Virto L, Januszkiewicz Ł (2023): **Do electromagnetic fields used in telecommunications affect wild plant species? A control impact study conducted in the field.** Ecological Indicators 2023; 150: 110267. https://doi.org/10.1016/j.ecolind.2023.110267

Joushomme A, Orlacchio R, Patrignoni L, Canovi A, Chappe YL, Poulletier De Gannes F, Hurtier A, Garenne A, Lagroye I, Moisan F, Cario M, Lévêque P, Arnaud-Cormos D, Percherancier Y (2023): **Effects of 5G-modulated 3.5 GHz radiofrequency field exposures on HSF1, RAS, ERK, and PML activation in live fibroblasts and keratinocytes cells.** Scientific Reports. 2023 May 23;13(1):8305. https://doi.org/10.1038/s41598-023-35397-w

Treder M, Müller M, Fellner L, Traynor K, Rosenkranz P (2023): **Defined exposure of honey bee colonies to simulated radiofrequency electromagnetic fields (RF-EMF): Negative effects on the homing ability, but not on brood development or longevity.** Science of The Total Environment. 2023 Jun 28;896:165211. https://doi.org/10.1016/j.scitotenv.2023.165211

Ye Z, Zhang Y, Zhang Y, Yang S, Liu M, Wu Q, Zhou C, He P, Gan X, Qin X (2023): **Mobile phone calls, genetic susceptibility, and new-onset hypertension: results from 212 046 UK Biobank participants.** European Heart Journal - Digital Health. 2023 May 4;4(3):165-174. https://doi.org/10.1093/ehjdh/ztad024

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BERENIS - Swiss expert group on electromagnetic fields and non-ionising radiation

List of abbreviations (pdf)