

Summaries and assessments of selected studies

In the period from February to April 2019, 112 new publications have been identified, and nine 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. In addition, this newsletter issue presents a number of studies that investigate the relationship between mobile phone use and radiation-independent symptoms in adolescents.

1) *Experimental animal and cell studies*

Radiofrequency electromagnetic fields and fertility in male rats (Shahin et al. 2019)

Shahin *et al.* (2019) have investigated effects of RF-EMF (GSM 900 MHz, 1.075 W/kg whole-body SAR) on the fertility of male rats. The animals were RF-EMF- or sham exposed for 2 hours per day for a total of 8 weeks. The polyamine spermine was used to prevent possible effects of RF-EMF on functional, morphological or biochemical markers, and thus strengthen the evidence. [*Spermine is essential for spermatogenesis, which has been demonstrated in transgenic mice by a mutation in the enzyme spermine synthase. Spermatogenesis was impaired and the animals were infertile. Polyamines including spermine also protect sperm from DNA damage, and antioxidant, anti-inflammatory as well as anti-apoptotic effects have been described*]. Besides quantitative histomorphology, function of the sperm and testicular activity, various hormones and biochemical parameters as well as testicular DNA damage were investigated.

The findings showed significantly decreased sperm counts, viability and motility as well as increased sperm deformities. Serum inhibin B levels, a marker of spermatogenesis, were significantly reduced, as was the concentration of testosterone. Concentrations of hormones such as follicle-stimulating hormone, luteinizing hormone and estradiol were significantly increased. The regulatory protein involved in steroid genesis (StAR), c-kit mRNA expression and activities of key androgenic enzymes 3β - and 17β -hydroxysteroid dehydrogenases were significantly attenuated following exposure to RF-EMF. Various biochemical parameters related to lipid peroxidation, inflammation, apoptosis and oxidative stress were also investigated. These results indicate that RF-EMF promotes these parameters and initiates testicular DNA damage. Spermine administration for 8 weeks prevented RF-EMF-induced alterations in the sperm and hormone profiles, StAR and c-kit expression and androgenic enzyme activities. Spermine also partly prevented RF-EMF-induced oxidative, inflammatory, apoptotic and DNA perturbations.

The fact that histological analyses of the testes were supported by all biochemical findings, as well as the protective effect of spermine provide evidence at various levels that RF-EMF exposure damages sperm of rats in their morphology and function, and impairs hormone profiles via steroidogenesis and spermatogenesis. The exposure setup is not described in detail and therefore cannot be assessed. The reported whole-body exposure of 1.075 W/kg is well above the regulatory limit (0.08 W/kg).

2) Human experimental studies

Radiofrequency electromagnetic fields and resting EEG: Thermal effect? (Loughran et al. 2019)

It is an ongoing controversy whether the observed effects of RF-EMF exposure on the resting state wake electroencephalogram (EEG) are merely thermal, or if there is an underlying biological mechanism that is yet unknown. This question is relevant with regard to the debate on regulatory limit values. In the study by Loughran *et al.* (2019) 36 volunteers (18 females, 18 males) were exposed to a GSM-like signal (920 MHz; sham (SAR 0 W/kg); low (maximum SAR: 1 W/kg); high (2 W/kg)). The study participants had to wear a water-perfusion suit (water temperature 34 °C) in order to keep the surface temperature of the skin constant during the experiment, and to minimize the impact of ambient temperature. The suit covered the whole body except head, hands and feet. A 16-minute control measurement (baseline) was followed by 30 minutes of exposure. The three conditions were tested at weekly intervals (randomized and double-blind). Following high exposure, alpha activity in the EEG was increased. In order to assess thermoregulatory responses, the temperature of the left middle finger was measured. After the baseline, finger temperature slightly decreased at first. Following low exposure, finger temperature was significantly higher than in the sham condition. The authors have interpreted this as a clear thermoregulatory response. Exposure might have increased the temperature of brain regions responsible for thermoregulation, resulting in dilatation of peripheral blood vessels (finger).

The authors interpret their findings as a clear indication of a thermal mechanism. However, this is an over-interpretation of the results. The statistics are partly questionable, and the results are inconsistent, since only the low exposure was associated with a significant temperature increase. In contrast, the EEG effect was observed at high exposure, and a correlation between the temperature change and the EEG effect was not shown.

3) Epidemiological studies

Maternal proximity to extremely low frequency electromagnetic fields and risk of birth defects (Auger et al. 2019)

In a large-scale study conducted in Canada, Auger *et al.* (2019) investigated births registered in hospitals in the province of Quebec between 1989 and 2016 with regard to maternal low-frequency magnetic field exposure. Residential proximity to the nearest high-voltage transmission line (≥ 120 kV) or transformer station was used as a proxy for ELF-MF exposure. A total of 2,164,246 children were included in the analysis. In total, 123,575 birth defects were observed, the most common being clubfeet (29,192), noncritical heart defects (19,718) and disorders of the urogenital system (15,853). The analyses were adjusted for age and diseases of the mother, sex of the infant, number of siblings of the infant, multiple birth, urbanity, socio-economic status and time period. Mothers who lived within 200 meters from a transmission line or transformer station at the time of birth had a 2% or 5% higher risk for a child with a birth defect. Compared with 200 m, the risk within a distance of 50 m from a transmission line was not increased.

This is a very large study on a topic that has hardly been investigated so far. Strengths of the study are that virtually all births in Quebec were included, and that objective data from hospital discharge reports were used. However, distance to a high-voltage transmission line or transformer station is a suboptimal proxy for exposure. ELF-MF exposure is mainly increased within a distance of 50 m of highest voltage transmission line (≥ 220 kV). Unfortunately, no such analysis was done for the

corresponding group, and thus the exposure misclassification is considerable. However, the fact that the risk was not increased within a radius of 50 m of a transmission line compared to a radius of 200 m may indicate that other factors than ELF-MF are relevant. The slightly increased individual risks within 200 m could also be attributable to confounders that were not taken into account. Transformer stations in this study probably refer to power substations, but this has not been described clearly. The authors also have not described whether the analysis included underground transmission lines. If yes, this would result in exposure misclassification, as ELF-MF near underground transmission lines are relatively small even in close proximity.

Associations of maternal mobile phone use during pregnancy with pregnancy duration and fetal growth (Tsarna et al. 2019)

Using data from four cohort studies from Denmark (1996-2002), the Netherlands (2003-2004), Spain (2003-2008), and South Korea (2006-2011), Tsarna *et al.* (2019) investigated whether maternal mobile phone use during pregnancy was associated with pregnancy duration and fetal growth. The study included data from a total of 55,507 pregnant women. In their analysis, the authors compared 'no mobile phone use' (30,433 mothers), 'low use' with a maximum of one call per day (12,930), 'intermediate use' with 1-3 calls per day (8,270) and 'high use' with at least 4 calls per day (3,874). The analyses were adjusted for age, height, weight and marital status of the mother, alcohol consumption, active and passive smoking and number of pregnancies. Statistically significant exposure-response relationships were found for shorter duration of pregnancy and preterm birth, defined as birth before the 36th completed week of pregnancy. The corresponding risk increases were 2% and 28% for mothers with high use compared to mothers with low use. No associations were found regarding fetal growth and birth weight. The authors state that mobile phone use during pregnancy could be an indicator for the stress of the mother, and therefore the observed associations might also be due to this rather than mobile phone radiation.

Strengths of this study are the large number of mothers included, and the multitude of factors adjusted for in the analysis. However, the study also has some limitations. For 94% of mothers, the number of mobile phone calls per day was reported retrospectively 7 years after birth. Fetal exposure during a phone call of the mother is very low and it is unclear how such low levels of mobile phone radiation can affect the fetus. Regarding exposure of the fetus, it is probably more relevant how long and how frequently a mobile phone is carried near the belly. However, these data were not available. Nevertheless, it cannot be excluded that exposure has an impact on the maternal organism, and might thus indirectly affect the fetus.

Mobile phone use and radiation-independent symptoms in adolescents

In general, digital media use may influence the health of children and adolescents in many ways. Thus, apart from potential effects of RF-EMF, e-media use may also have other impacts. Examples include the consequences of waking up at night because of the own mobile phone, blue light from the screen, and the consequences of extensive time spent at the screen or in social media. In principle, studies on these topics are not a priority for the BERENIS based on its mandate, and have thus never been selected for a newsletter. However, recently a number of good quality studies have been published on this topic and therefore a selection these studies is briefly presented below to provide an overview of this research area.

A prospective cohort study conducted in California with 2,587 adolescents aged 15-16 years without ADHD symptoms (attention deficit hyperactivity disorder) found that the probability of developing

ADHD symptoms within two years significantly depended on the extent of digital media use. Study participants with the highest digital media usage developed ADHD symptoms about twice as often than adolescents with low digital media usage (Ra *et al.* 2018).

In a Spanish cross-sectional study of 226 adolescents aged 17-18, a statistically significant correlation was observed between problematic mobile phone use (using a standardized questionnaire) and reduced subjective and objective sleep quality. Objective sleep quality was measured using actigraphy. Furthermore, it was found that increased tablet use was associated with decreased sleep efficiency and increased duration of wake time after sleep onset (Cabr -Riera *et al.* 2019).

A prospective cohort study of 4,333 Chinese college students showed that students who reported using a mobile phone for at least four hours per day developed significantly more sleep disturbances and mental distress within 8 months (Liu *et al.* 2019).

In a prospective cohort study of 843 adolescents aged 12-15 in Switzerland, it was observed that nocturnal awakenings from the own mobile phone led to an increase in sleep and concentration problems. In addition, it was found that adolescents with above-average screen time had a 2.5 times higher risk of developing problems in falling asleep, and were more likely to develop a number of other non-specific health symptoms (Foerster *et al.* 2019).

In an Irish study with 1,626 participants aged 6-7 years and 12-13 years, children with more than 3 hours of screen time per day had a 3.7-fold increased risk of short-sightedness (Harrington *et al.* 2019).

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Additional information:

[BERENIS - Swiss expert group on electromagnetic fields and non-ionising radiation](#)

[List of abbreviations \(pdf\)](#)