Bundesamt
für Strahlenschutz

**Spotlight on EMF Research**

# Spotlight on “Evaluation of oxidative stress and genetic instability among residents near mobile phone base stations in Germany” by Gulati et al. in Ecotoxicology and Environmental Safety (2024)

**Category [radiofrequency, epidemiology]**

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Competence Centre Electromagnetic Fields (KEMF)

## 1 Putting the paper into context by the BfS

People living close to mobile phone base stations are permanently exposed to weak radiofrequency electromagnetic fields (RF-EMF). Compliance with the limits for RF-EMF exposure ensures that no scientifically established adverse health effects of RF-EMF exposure occur. The limits protect against a potentially adverse increase in tissue temperature. The question of whether low-level RF-EMF exposure is associated with as yet undiscovered non-thermal effects with potential health consequences has been a subject of debate for decades, but no conclusive evidence for such effects has been presented yet.

## 2 Results and conclusions from the authors‘ perspective

To investigate whether long-term exposure to environmental RF-EMF from mobile phone base stations could cause effects that might increase cancer risk, Gulati et al. [1] examined human blood cells for oxidative stress, transient and permanent DNA damage, cytogenetic endpoints, and leukaemia-specific gene alterations.

The participants of this study have lived for more than five years either close to (75 – 160 m, exposed group, 12 individuals) or distant from (490 – 1,200 m, control group, 12 individuals) mobile phone base stations. Both groups were comparable with respect to sex, age, body weight and size. There were no statistically significant differences between the groups with regard to nutrition and food preferences, alcohol and nicotine consumption, as well as exposure to ionising radiation for medical reasons. Participants were mostly not taking any medication. There were no statistically significant differences between the groups in the proportion of self-reported electrohypersensitivity and the occurrence of symptoms (like headache, stress or disturbed sleep).

Electromagnetic fields of different frequency ranges were measured in the sleeping areas of participants' homes for up to seven days. In the exposed group, the "peak" as well as the "rms" (i.e. root mean square) power density values of the LTE and GSM base station signals were statistically significantly higher than in the control group. Exposure to RF-EMF fields from DECT and WLAN devices and exposure to low-frequency electric and magnetic fields at 50 Hz (AC mains power supply) were not statistically significantly different between the groups. The average exposure to low frequency magnetic fields at 16.7 Hz (railway power supply) was statistically significantly higher in the exposed group.

Each participant provided 12 ml of blood for biological testing. The probes were coded and the analysis was blinded. The thiobarbituric acid reactive substance (TBARS) assay was used to obtain an index of the level of oxidative stress in the blood samples. DNA damage was assessed by the comet assay. Micronuclei were counted in 1000 binucleated cells from each participant. Chromosomal aberrations were assessed in cell cultures in 1000 dividing peripheral blood lymphocytes from each participant. Double-strand DNA breaks were visualised by immunostaining (53BP1/gammaH2AX assay). Preleukaemic gene rearrangements were identified by fluorescent staining and RNA sequencing of the mixed lineage leukaemia (MLL) gene. Differences in the 19 biological markers between control and exposed groups were analysed by univariate analysis of variance (ANOVA) or Student's t-test.

Spearman's correlation analysis showed the highest correlation coefficients (meaning the strongest relationship) between chromosomal aberrations and both LTE and GSM exposure. In the group comparison of biological markers, only the results of ANOVA, and not of the t-test, were reported. DNA double strand breaks, micronuclei, MLL gene rearrangements, oxidative DNA lesions and the analysis of ring chromosomes and acentric chromosomes revealed no statistically significant differences between exposed and control group. DNA damage in the comet assay and the rate of total chromosomal aberrations as well as of three different types of chromosomal aberrations (i.e. dicentric chromosomes, chromatid gaps, and chromosomal fragments) was statistically significantly higher in the exposed group. After correction for multiple testing (Bonferroni correction), only the percentage of chromosomal fragments and the percentage of total chromosomal aberrations showed a statistically significant increase in the exposed group compared to the control group.

It was examined whether the occurrence of potential confounding factors such as gender, smoking, alcohol consumption, and medical use of ionizing radiation differed between the groups. This was not the case. Furthermore, bifactorial tests were conducted to determine whether the biological markers studied differ depending on the aforementioned confounding factors. The comet assay showed a dependence on alcohol consumption, double-strand breaks on alcohol, and X-rays. None of the confounders affected chromosomal aberrations.

Overall, no statistically significant changes in DNA damage, oxidative stress or specific gene parameters were detected in the study that would be attributable to RF-EMF exposure from mobile phone base stations. However, the authors report a statistically significant nearly two-fold elevated rate of some chromosomal aberrations in the group with higher exposure to GSM and LTE signals from mobile phone base stations in the bedroom. According to the authors, these findings may provide a biologically plausible mechanism for an increased risk of cancer in individuals long-term exposed to such signals.

# 3 Comments by the BfS

The authors used a broad spectrum of methods for analysing possible effects of RF-EMF exposure from mobile phone base stations on human blood cells. However, from a radiation and health protection point of view, there are some aspects that limit the significance of the results: the small group size, possible spurious relationships, biologically inconsistent results, exposure misclassification and imprecise exposure assessment.

The study is based on very few participants (only 12 per group), which limits its statistical power and prevents generalisation of the results. An underpowered study typically runs the risk of missing true effects, but it also has a reduced likelihood that a statistically significant result reflects a true effect [2].

Whether spurious associations due to potential confounding factors, which may differ between the two groups, have occurred remains unclear. Although bifactorial tests with potential confounding factors were conducted, differences may go undetected due to the small group size. Additionally, some confounding factors were only roughly captured or not at all (e.g., socioeconomic status). Furthermore, no regression analyses were conducted, meaning that the simultaneous investigation of RF-EMF exposure and each confounding factor, and their impact on the biological endpoint, was not performed. Again, the small sample size of the study is a significant limiting factor, as it does not allow for such analysis.

The main finding of the study was a statistically significant elevated rate of the total number of chromosomal aberrations in the exposed group compared to the control group, which remained statistically significant after correction for multiple testing. On the other hand, no difference was detected in the micronucleus test. This inconsistency is only briefly discussed by the authors with reference to different mechanisms of formation of micronuclei and chromosomal aberrations. However, micronuclei contain chromosome fragments (acentric fragments) or whole chromosomes, which are not distributed to the daughter cells during cell division. While the number of micronuclei is determined after cell division, the analysis of structural chromosome aberrations occurs already during cell division. From a technical point of view, the higher rate of chromosomal aberrations found in the study should also be reflected in a higher rate of micronuclei.

Another problem is that the statistical test used for comparing exposed and control group is not conclusive. The ANOVA test can only be used if the data being analysed are normally distributed. It was not specified whether the data were tested for the assumption of normality. Specifically, in the case of data from studies of dicentric chromosomes as part of biological dosimetry, one usually does not assume a normal distribution [3]. If the analysis is based on an inappropriate statistical distribution, this could lead to false-positive results.

The authors hypothesise that the observed elevation in the rate of chromosomal aberrations of the exposed group might be due to the years long exposure to LTE and GSM signals in their homes. However, the reliable quantitative recording of the actual total exposure of people over very long periods of time is very challenging. RF-EMF exposure is subject to strong local and temporal variations, and people spend time in different places during their lifetime. The data presented does not contain sufficient information on the level to which the subjects were exposed during the rest of the day when they were not in their bedroom. The subjects' mobile phone use was also not recorded, although it is often the primary source of personal RF-EMF exposure, especially when using second-generation mobile telephony standards (GSM). Therefore, it remains uncertain whether the total exposure of the test groups actually differed to a sufficient extent.

Even assuming that only the nighttime exposure in the bedroom would be relevant for the endpoint under consideration, the data and descriptions presented in the publication are not suitable for an assessment of the level of the actual nighttime exposure of the test groups over the period in which the persons lived in their homes. For example, it is unclear exactly how the radiofrequency electromagnetic fields from the base stations were measured and how the radio technology-resolved measurement results presented in the publication were determined. It is also unclear how strong the exposure contribution of other radio services and far- and nearfield sources was and whether the data is also meaningful for previous years.

In addition, in health or radiation protection research, there is no generally accepted scientific exposure measure for the total exposure to weak radiofrequency electromagnetic fields accumulated over longer

periods of time because no plausible non-thermal mechanism of action has yet been identified. Any observed correlations between changes in biologically relevant endpoints and the level of various exposure measures of low-level exposures over long periods of time can therefore at best only be regarded as hypothesis-generating. Due to the limited significance of the data and descriptions presented, the results of the study by Gulati et al. are also not suitable for deriving a plausible hypothesis.

Due to the aforementioned limitations, the present study does not provide evidence of an association between chromosomal damage and exposure of the general public to RF-EMF from mobile phone base stations. In addition, the findings are not sufficient to initiate further research on the subject.

# References

[1] Gulati S, Mosgoeller W, Moldan D, et al. Evaluation of oxidative stress and genetic instability among residents near mobile phone base stations in Germany. *Ecotoxicol Environ Saf*. 2024;279:116486. doi:10.1016/j.ecoenv.2024.116486

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[3] Ainsbury EA, Vinnikov VA, Maznyk NA, Lloyd DC, Rothkamm K. A comparison of six statistical distributions for analysis of chromosome aberration data for radiation biodosimetry. *Radiat Prot Dosimetry.* 2013;155(3):253-267. doi:10.1093/rpd/ncs335

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