Ten Years Experience with Epidemiological Research in the Vicinity of the Short-Wave Broadcasting Area Schwarzenburg: What does the Story Tell Us?*

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Background

In 1939 the short-wave broadcasting station in Schwarzenburg started operation. 1954 the main star-shaped antenna has been installed by the former PTT (today SWISSCOM). Broadcasting frequencies were between 6.1 and 21.8 MHz. Maximum power was three times 150 kW, but only 300 kW were really used. The broadcasting direction changed every two hours. The beam had an inclination of 11° above horizontal and was directed towards the receiving area. The destination was reached by reflection at the ionosphere and at the earth surface. Broadcasting was scheduled according to the local time at the destination. This resulted in broadcasting around the clock. 1971 an additional log periodic antenna with a power of 250 kW was installed to provide broadcasting in case of a breakdown. However, this antenna has seldom been used.

The short-wave broadcasting facility Schwarzenburg aired mainly Radio International Switzerland and had clearly a political mandate: To provide information for Swiss citizens abroad and to inform foreign countries about political issues in Switzerland and Europe. It had a central importance for the spirit of defense during world war II. Despite the development of satellite broadcasting in later decades, short-wave transmission has been kept up mainly for financial reasons.

Starting with the 70ies health complaints within the population of residents were expressed, blaming the broadcasting station Schwarzenburg. Primarily, PTT has been addressed. The persons concerned requested an epidemiological clarification of the issue. However, PTT felt itself not as the competent authority. In 1990 the residents submitted a petition for a referendum to the government, the Bundesrat. After this petition went its way through the different bodies of the government, the Bundesamt für Energiewirtschaft (Federal Department for Energy) declared itself in charge of the agenda, because it is the authority granting the license. Headed by this federal authority an ad-hoc working group was installed comprising delegates from the canton physician's office of Bern (Kantonsarztamt), of the canton department of industry, trade and occupation, the former federal department for environment, forestry and landscape, the federal department of health and the institute of social and preventive medicine from the University of Bern. This institute was closest to the broadcasting area, had the necessary expertise for planning, conducting and evaluating a study of that type.

The primary task of that working group was to assess the feasibility of a study to answer the following questions: Are health disturbances in the vicinity of the broadcasting station more frequent as compared to socio-economically comparable non-exposed regions? If so, is there a biophysical mechanism explaining the complaints? Is the population at risk big enough to additionally investigate

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cancer frequency? Are the exposures with RFR below the guideline levels of IRPA? There was agreement that these questions, with the exception of cancer incidence, could be answered, and the decision was drawn to do this study.

Setup and Methods of the Study

Several types of investigation were applied: two cross-sectional studies (1992, 1996), three short cohort studies, two of them including determination of melatonin (diary investigations 1992, 1993 and 1998) and two studies in cows (1993 and 1998).
Within the cross-sectional studies the area of the affected local communities was divided into three (1992) or four (1996) sections: one zone with very low exposure (zone C, 1992, 1996), one with low exposure (zone R, 1996), one zone with moderately high exposure (zone B, 1992, 1996), and one zone with high exposure (zone A, 1992, 1996). In 1992 a health inventory with a broad scope has been used, because the complaints which may be involved were unclear. Because after the first investigation sleep problems became a focus of interest, in 1996 a second survey was conducted which included a more specific investigation on sleep disturbances. In 1992 extensive measurements of exposure were carried out at 56 sites, and in 1996 on 10 specifically selected sites. Measurements were carried out by PTT (Post-Telefon-Telegraf, now SWISSCOM). In 1992 a survey in volunteers was carried out using a personality questionnaire (Freiburger Personality Inventory), demonstrating that there were no differences in personality traits between zones A, B and C, but prevailing physical complaints within zone A.

In 1992 a first short cohort study during three times a period of 10 days was conducted. A symptoms diary was filled in by volunteers during these periods. Different symptoms were put down on an hourly basis. During these periods broadcasting followed a randomized scheme: If under normal conditions broadcasting would be northwards it was changed to south, hence the direction was reversed such that it was impossible near the antenna to differentiate normal and special broadcasting conditions. A drawback was, however, that the whereabouts of the participants were not recorded. As mentioned previously, during this investigation extensive measurements were carried out. In 1993 another short cohort study was carried out which included ceasing of broadcasts during three days within a 10 days observation period in humans and cows. In humans, sleep quality and melatonin in morning urine samples (by measurement of 6-hydroxy-melatonin-sulfate, the main metabolite of melatonin) were determined. In cows, melatonin was obtained during nights from saliva samples in 5 exposed and 5 not exposed animals. In 1998 we took advantage of the economically motivated shutdown of the broadcasting station Schwarzenburg. One week preceding and one week following disconnection of the transmitter sleep quality (using the standardized questionnaire VIS-M) and melatonin in saliva samples were determined in humans, and in cows salivary melatonin and milk production were analysed (13 exposed and 12 not exposed animals). For financial reasons only the exposed cowshed could be monitored for exposure. A 24-hour measurement in the not exposed control cowshed demonstrated that it was in fact not exposed to EMF in the shortwave range.

Exposure was measured by PTT (SWISSCOM) under the surveillance of the Eidgenössische Technische Hochschulen of Zurich and Lausanne (1992, 1993). In 1992 a loop antenna from Rhode & Schwarz HFH-Z2 was used. This system covers the range of 100 kHz to 30 MHz, the precision is approx. ±1.5 dB. In 1993, 1996 and 1998 an isotropic antenna EH30KW (EMC Baden Ltd., Dättwil, Switzerland) was employed, measuring within the range of 2 to 30 MHz. This antenna was newly developed by order of PTT. It was calibrated by the National Institute of Standards and Technology (Boulder, CO, USA). While the loop antenna has to be turned into three orthogonal directions manually, the isotropic antenna could be used for 24-hour automatic measurements. This was the basis for the measurements in the sleeping rooms of the participants during the investigation in 1993.

Measurement of 6-hydroxy-melatonin-sulfate from urine samples (1993) and of salivary melatonin was carried out by IBL (Hamburg). Salivary samples were analyzed by RIA and urine samples by ELISA methods.

Results

In the study conducted in 1992 an increased prevalence of sleep disturbances (problems of sleeping through) in the vicinity of the transmitter were demonstrated. The short time series analysis (three-times 10 days) pointed in the same direction, however, these results, due to missing one-to-one exposure measurements, were difficult to interpret. We were not able to do person oriented measurements of exposure at that time and we still couldn't do it today because of the unwieldy measurement equipment.

In 1993 neither an acute nor a chronic effect on sleep quality or 6-OHMS could be demonstrated in humans. In cows no chronic effects were obtained either. However, with a delay following the reconnection of the transmitter variations in salivary melatonin were observed, compatible with a short-term compensation of melatonin suppression.

In 1996 during another cross-sectional study it has been confirmed that sleep disturbances in the vicinity of the transmitter are more frequent as compared to the non-exposed control area. Furthermore, it could be shown that the exposed population applied coping measures by avoiding heavy meals and coffee consumption in the evening. There was a tendency for higher uptake of sleeping pills within the exposed area.

The results of the study conducted in 1998 are not released until publication and could not be reported here.

Discussion

The investigations conducted in the area around the short-wave transmitter Schwarzenburg are an instructive example of environmental epidemiology. Repeatedly it was demonstrated that in exposed subjects sleep disturbances are more frequent than in non-exposed. This association in space could also be found in short time series. The validity of the latter observation has to determined with caution due to the impossibility of person oriented exposure measurements. This problem leads to a possible exposure misclassification and we can not say whether the results of the sample measurements are over- or underestimating actual exposure. Another problem arises from not knowing which component of the electromagnetic field is hazardous to organisms: the magnetic field, the electric field, the induced field, frequency ranges, type of modulation, gradients? This difficulty leads to problems in formulation and enacting of regulations for protection in legislation.

Research is needed in the area of exposure measurement, and this is also true for measurement of clinically relevant aspects. In the area of sleep research we can rely on a variety of instruments and techniques: sleep EEG, 24-hour EEG, standardized questionnaires etc. However, especially concerning sleep a number of physical, psychological and social factors play a role. An association between sleep disturbances and EMF is therefore open to a number of explanations. A simple unidirectional cause-effect relationship is unlikely.

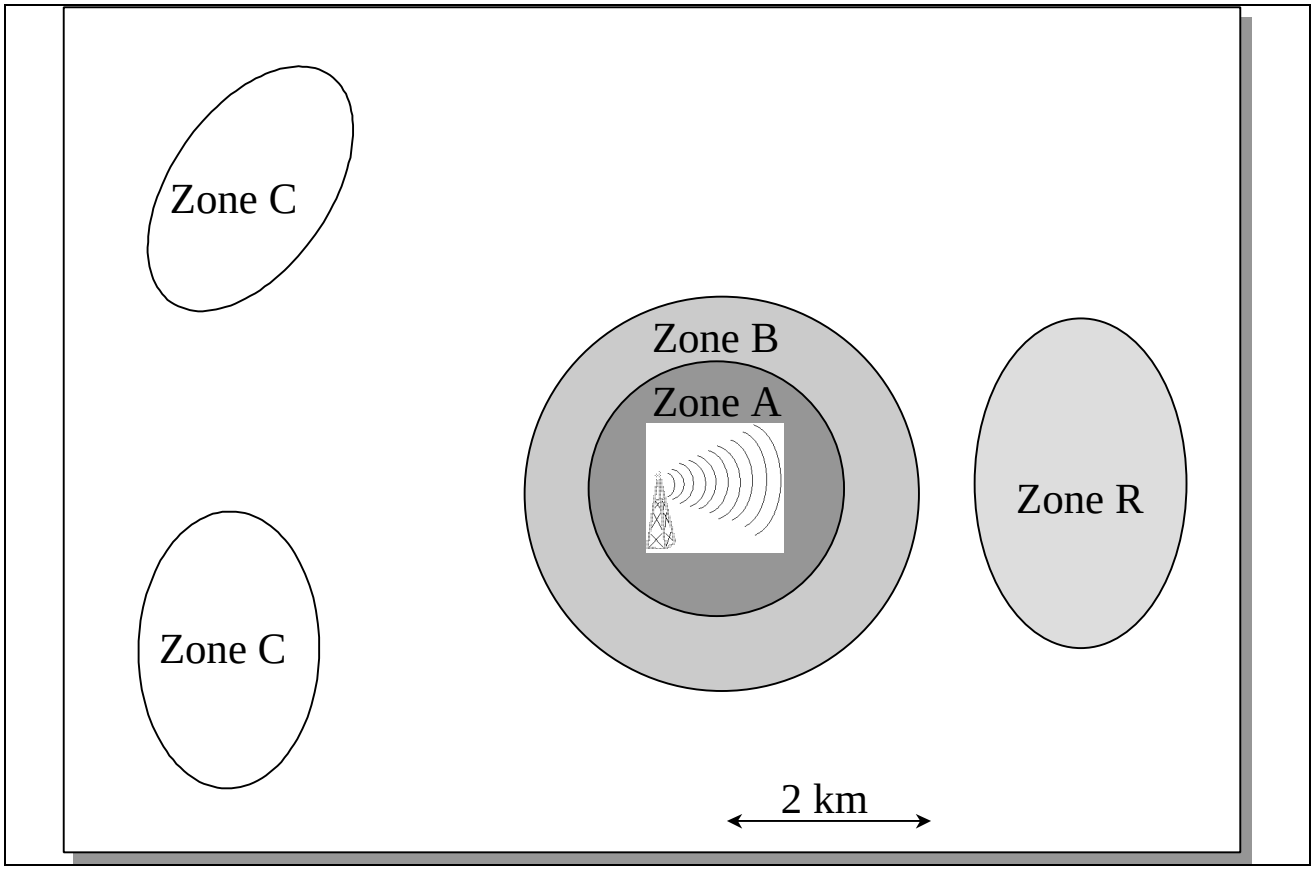
We are especially interested in the chain H-field -> melatonin -> sleep disturbances, because this series of observables could be investigated in epidemiological studies. While already in our first study in cows clues for a delayed acute effect were present, we had no such signs in humans. The reasons for this failure are manifold: Are morning urinary samples sufficient? Do we need morning and evening samples? How practical is it to use urinary samples in women? For that reason we have conducted another study in 1998 in humans and cows. We have learned from mistakes of the past and made new ones. It is therefore our intention to discuss these technical details without disclosure of preliminary findings.

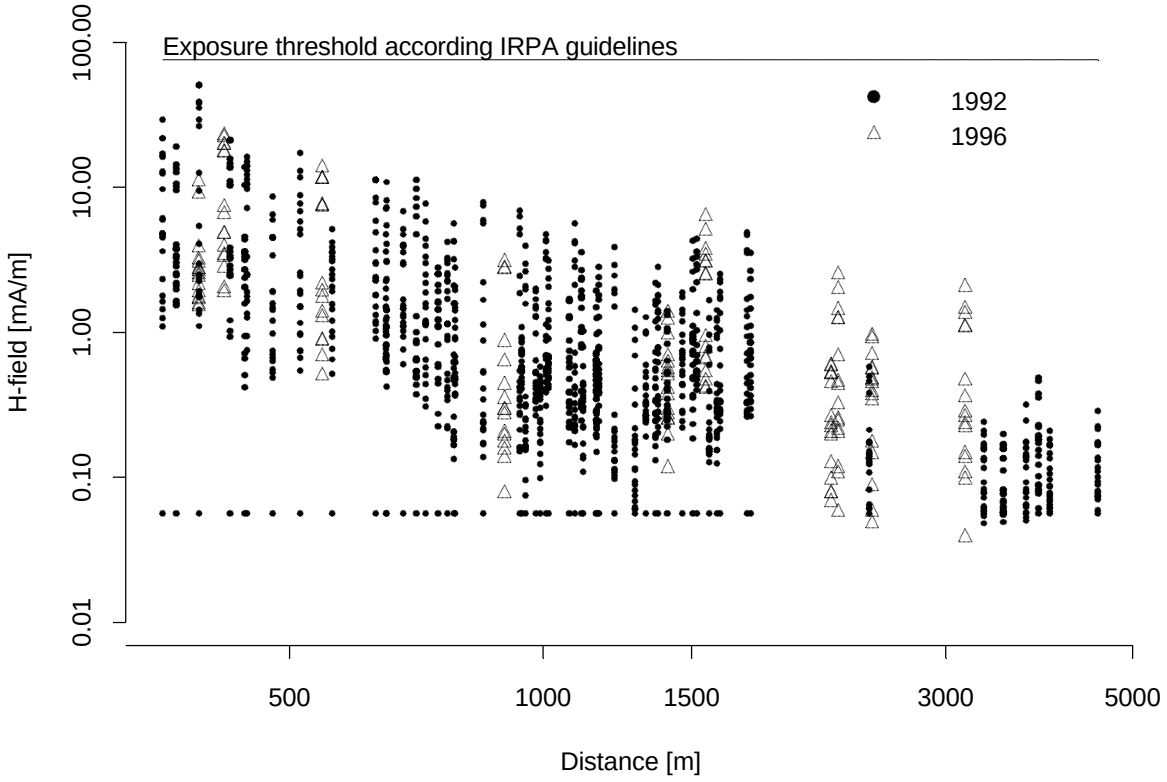
In 1998 we have confined ourselves to five sampling times: before breakfast, before lunch, before tee-time (approx. 16:00), before dinner (approx. 19:00) and before bedtime. We have taken no samples during nights because this would have severely disturbed the melatonin rhythm during the 14-days period. The sample times were deliberately chosen to conform to everyday life in Switzer-

land, to minimize administration errors and increase compliance. The sampling times were, however, recorded and considered in the evaluation. With this regimen we created undoubtedly a problem: time series with not equally spaced sampling points and systematically missing data. We solved this problem by application of the model of Lerchl and Patsch. It is a complex cosinor method including two frequencies: a 12-hour and a 24-hour component. By application of this model we were able to investigate the suppression hypothesis as well as the phase-response hypothesis. While the application of the model in humans revealed no severe problems, in cows it did. Therefore further research is needed concerning melatonin: What is the most straightforward method to describe melatonin rhythms in different species? And in general: What mechanisms testable in epidemiological studies might be responsible for the sleep disturbances, if there is in fact a biophysical association?

After 10 years of research in the area of short-wave electromagnetic fields we identify the following research issues:

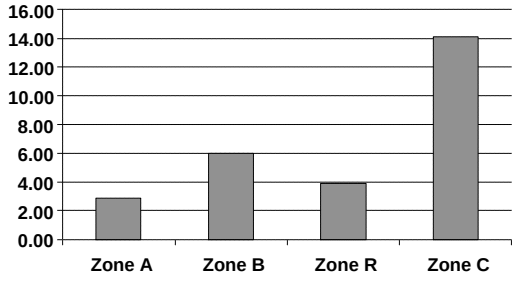
- Measurement of clinically relevant endpoints
- Determination of the biologically active component of EMFs
- Personal samplers for this component
- Improved statistical models.





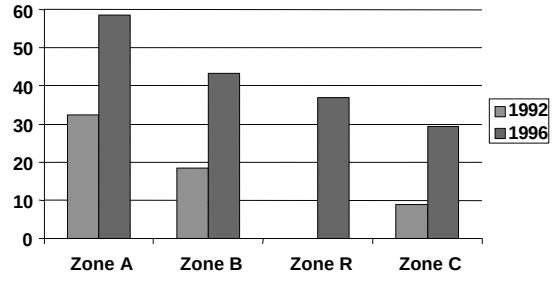
Drinking coffee at night?

(p<0.01)



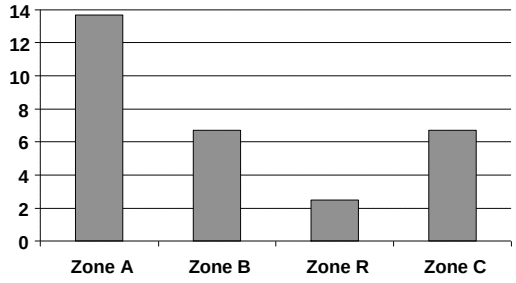
Sleep disturbance

(p<0.01)



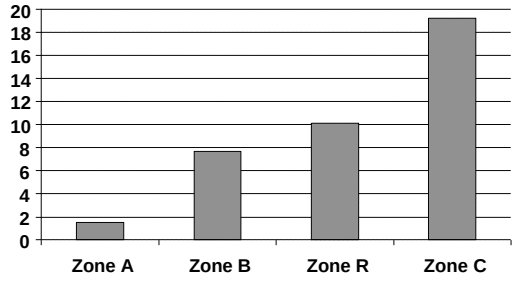
Taking medication against sleep disorders

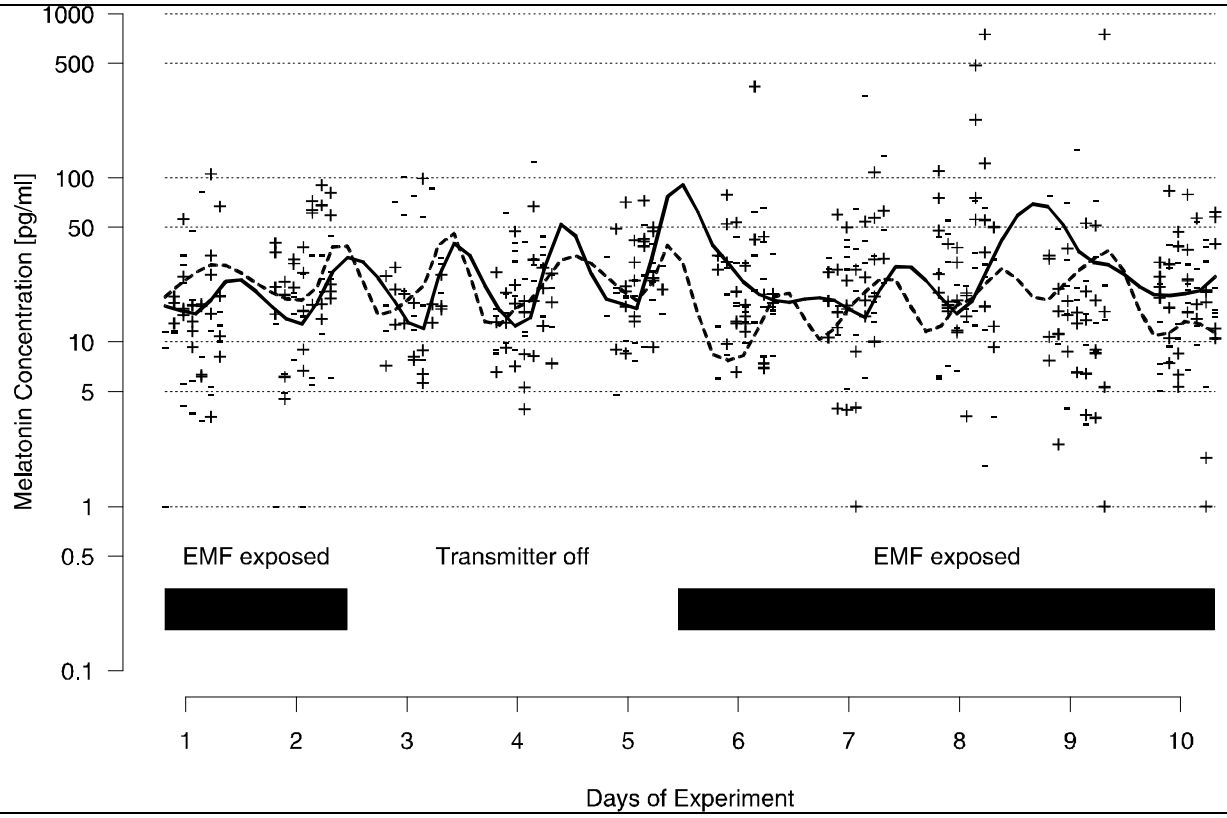
(p=0.01)



Having a heavy meal at night...?

(p<0.01)





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