

German Mobile Telecommunication Research Programme Acute Health Effects

**International Workshop on Final Results of Projects
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**Rapporteur's Report
Mirjana Moser**

Welcome and Introduction

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

Dr. Axel Böttger welcomed the participants on behalf of the BMU and gave a short history of the Programme. Following an intensive discussion in the late 90's about possible health effects of electromagnetic fields (EMF), the BMU mandated the German Radiation Protection Commission (SSK) to evaluate the knowledge on EMF health effects below the valid limits. The Commission concluded that research should be largely intensified in this area. At the end of 2001 mobile phone network operators signed a declaration of self commitment granting support to the existing national research programme with an amount of 8.5 million Euro in addition to the 8.5 million Euro sponsored by the state. Dr. Böttger stressed that the main goal of the research on acute health effects is to look for an answer through a scientific approach to the public concern and case observations of some medical doctors. He thanked the Federal Office of Radiation Protection (BfS) for their dedicated work in running the Programme and organizing the workshops.

Federal Office for Radiation Protection (BfS)

Roger Matthes welcomed the participants on behalf of the BfS and received the apologies from Dr. Wolfgang Weiss, the head of the Department "Radiation Protection and Health", who could not participate in the workshop (because of urgent matters regarding the "polonium-case"). He welcomed all participants and in particular the representatives of the German Radiation Protection Commission (SSK), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the World Health Organization (WHO), the German Ministry of Environment and Mirjana Moser from the Swiss Federal Office of Public Health, rapporteur of the session. Mr. Matthes repeated that the motivation to conduct the present module of the research programme on acute health effects was triggered by public concern and therefore focussed on investigations of the end points that might have objective as well as subjective cause. The goals of the projects were to investigate unspecific end points like headache or sleep disturbance as well as to get a deep understanding of the issue of electrosensitivity in general and to investigate possible problems specific to children. Mr. Matthes formulated the main questions relevant to the final discussion:

- ♦ What are the achievements of the projects (German and international projects)?
- ♦ What lessons have been learned?

- ♦ Where do we still have gaps in knowledge? Do we need more research on hypersensitivity or more on epidemiology?
- ♦ Can minimum standards for future work be identified (in epidemiology or dosimetry)?
- ♦ Do the results have an impact on guidelines and regulations?

Session A: Epidemiological Studies

Chair: Michaela Kreuzer

A0: Exposure of the general public to RF electromagnetic fields Christian Bornkessel, IMST GmbH, Kamp-Lintfort

In his introductory lesson Dr. Bornkessel gave a very nice overview of RF sources and exposures of the general public in everyday life. He stressed that for testing the compliance with the limits the worst case exposure conditions have to be assessed, while for epidemiological studies real, everyday exposure conditions are of major interest.

RF EMF sources can be divided into two groups: mobile phone base stations, TV and radio broadcast transmitters are characterized by fixed, outdoor installation and far field exposure conditions, while mobile phones, cordless (DECT) phones and WLAN applications are mobile, preferentially indoor, household devices, worn close to the body whereby exposure takes place under near field conditions.

Results on different exposure measurements in everyday situations were presented for mobile phone base stations (GSM and UMTS), mobile phones, digital and analogue radio and TV broadcast, wireless LAN and DECT phones. The conclusions as well as some interesting points can be summarized as follows:

- ♦ In all situations the measured field strengths or SAR values in everyday life are below the ICNIRP limits.
- ♦ Comparing exposure values from different EMF sources by means of percentage of ICNIRP limits, exposure from apparatus worn close to the body is generally higher than from outdoor, far field, fixed installations.
- ♦ Most services exhibit strong time and space variations, causing a big challenge in exposure assessment for epidemiological studies.
- ♦ Exposure from highly mounted antennas is generally lower than from low mounted ones (in microcells).
- ♦ UMTS exposure is generally lower than GSM.
- ♦ DAB exhibits lower exposure compared to FM.
- ♦ DVB-T and Analogue TV exposure are almost the same.
- ♦ Long, medium and shortwave radio services might exceed mobile phone base station exposure – they are often underestimated in exposure assessment.

In the second part of his presentation Dr. Bornkessel presented two personal dosimeters available on the market: "Maschek ESM-140", a German product and "Antennessa EME Spy 120", a French dosimeter. The two dosimeters had been tested

and compared. Both seemed to be very helpful for epidemiological studies, although their features need to be investigated in more detail.

Discussion

- ♦ On the question whether, based on his presentation, one could recommend using high antennas, Dr Bornkessel answered that the issue was not that simple and that many other factors had to be considered, too.
- ♦ He was also asked to comment on the recommendations in some German towns to put antennas on the top of hospitals, schools, etc because of apparent “umbrella” effect. The answer was that the EMFs in the rooms below an antenna were usually low but not zero and that the field attenuation strongly depended on the construction of the building.
- ♦ It was noted that in the future exposure from base stations would diminish as a whole because of the lower UMTS exposure compared to GSM.
- ♦ Dr. Rööslı noted that by comparing different levels of exposure not only the field strength, but also exposure time has to be taken into account.

A1: Cross-sectional study on subjective symptoms due to electromagnetic fields from mobile phone base stations among adults

Gabriele Berg, University of Bielefeld; Christian Bornkessel, IMST; Peter Potthoff, TNS-Healthcare, München

Dr. Berg started her presentation by giving a comprehensive review of the literature dealing with health disturbances in connection with mobile telecommunication and the problem of electrosensitivity. She concluded that there was missing epidemiological knowledge about association between EMF exposure from mobile phone base stations (BS) and health. That was the motivation to conduct the present large scale, multistage, cross sectional study.

Stage 1: Baseline study

The baseline study was conducted between August and November 2004. In a population based sample of 51'444 selected individuals (age 14 to 69) a written survey was conducted with the aim to assess the prevalence of persons living near a BS (closer than 500m) and the prevalence of concern and self reported complaints. 30'047 individuals responded (58.4% response rate). Geo-coordinates from the participant's household-addresses were merged with the technical data and geographic coordinates of about 51'000 locations of mobile phone base stations (BS) with 280'000 antennas (data provided by the Federal Network Agency). The prevalence of persons living in a 500m distance to a BS showed to be 48.7% in average and 53.5% for city categories. Prevalence of concern and self reported disturbances shows a north-south gradient, the highest rate being in Bavaria where about 35% of the population mentioned to be concerned or impaired by a BS. Health complaints could be explained by subjective and not objective distance to mobile phone base stations.

Stage 2: In depth study

The aim of the in depth study was to investigate whether there was a significant epidemiological association between: a) EMF exposure from BS and reported health

disturbances, b) concern about BS and reported health disturbances and c) if there was an interaction between the two. Based on the baseline study, candidates for additional surveys had been selected in 8 urban regions (mainly for logistic reasons), who agreed to take part in measurement procedure, computer assisted interview and dosimetric assessment of exposure levels in their households. 1500 individuals were selected. In an additional "consolidation survey" general state of health, physical and mental health, sleep and headache were assessed. Additional factors such as location of the bedroom, direction of the bedroom window, visibility of BS from the bedroom were assessed in a "complementary survey". A short questionnaire had been designed to check for headache on the day of the measurement and for sleep disturbances during the previous night. For the EMF dosimetry assessment 20 "Antennessa" dosimeters were used. Dr. Bornkessel presented the procedure assuring the quality of measurement during the field work. 19 out of 20 dosimeters provided stable and reproducible measurements. Dr. Potthoff presented the procedures for management and analysis of the huge amount of collected data. For 1390 subjects exposure and dosimetric data were linked to the health outcome surveys (out of the 1500 persons, 83 had been excluded due to a defect of the dosimeter and 28 due to problems in data collection). The analysis is going on; the results will be available in the course of 2007.

Discussion

- ♦ Regarding the question on the parameterization of exposure, an explanation was given that the percentiles of the exposure distribution would be used to define exposure categories.
- ♦ As an answer to the question whether noise had been included as a quality of life parameter Dr. Berg stated that noise could be assessed on the basis of geographical coordinates and it might be included in the analysis.

A2: Mobile phone exposure and well-being in children and adolescents

Katja Radon, Institute for Occupational and Environmental Medicine, Munich

As well as the previous study on adults, the present study on children was triggered mainly by public concern. Additional motivation came from the fact that 93% of the children aged 6 to 9 years use mobile phones and from the fear that children and adolescents might be more vulnerable towards EMF exposure. The aim of the study was to investigate a possible association between personal EMF exposure of children and adolescents and well-being. The study was designed as a population-based cross-sectional study.

A random sample of 1500 children (8-12 years) and 1500 adolescents (13-17 years) will be selected from 4 German towns. Among them EMF exposure is assessed by means of personal dosimeters worn on the arm during 24 hours. In parallel well-being (headache, stomach ache, back, neck and shoulder pain, nervousness, dizziness, anxiety and tiredness) and possible confounders (socio-demographics, mobile phone attitude, media consumption, environmental concern, school and family problems, social support and personal factors like extraversion, demands and emotionality) are assessed

by computer-assisted personal interview (CAPI). In addition, a symptom diary is kept by the participants over the measurement day.

To assess exposure a "Maschek" personal dosimeter was chosen. In comparison with the French "Antenna" it is better accepted by children since it is easier to wear attached on the arm. Overall exposure to frequencies between 800-2400 MHz is recorded every second over 24 hours. Frequency selection in 3 frequency bands is possible, allowing to distinguish between GSM and UMTS, but not between up and down link. A problem had emerged with regard to orientation sensitivity of the dosimeter - for proper measurement it has to be moved around. As this can not easily be done during the night, it was unclear whether night exposure data could be used in the study. The study started recently and is planned to be finished in 2008. Dr. Radon showed some preliminary data from Augsburg and Munich. The response in the field phase was about 50%. Mean daytime exposure was between 0.13% (detection limit) and 0.45% of the ICNIRP limit, being significantly higher in the bigger city. The own use of a mobile phone was not a major predictor of exposure over 24-h as children and teenagers only use their mobile phone on average for a few minutes per day.

Discussion

- ♦ Regarding the question whether the same questionnaires had been used for all age groups Dr. Radon explained, that they had used validated questionnaires for different age groups for children and for adolescents.
- ♦ Dr. Vogel commented the selection of the study population. She said that the exposure was generally higher in big cities. However, the four participating Bavarian cities were not representative for Bavaria where small cities dominate. Dr. Radon said that the study group was indeed not representative for Bavaria, but for the German population. Larger cities have been chosen for logistic reasons.
- ♦ A practical question considering working with children was posed: whether they really wear the dosimeter or not? This can be assessed based on the measurement output over 24-h as the measurement would be more or less constant if the dosimeter was not worn. Dr. Berg was surprised at the high response of 50%. The explanation was that both children and adolescents got a voucher of 20 Euro for participation which played a certain role for the adolescents; in addition they judged it to be "cool". As for smaller kids, the decision to participate was taken by their mothers.
- ♦ Mr. Matthes mentioned that the fact, by itself, that a subject participated in the study might have had influence on the health outcome and asked whether they had any idea on the baseline prevalence of investigated effects. Dr. Radon answered that they don't have.
- ♦ There was a query on possible selection bias since kids would recommend one another to participate. Dr. Radon answered that this had not been a problem since the candidates had been selected from the population registry and the response rate was rather high, but anyhow there could always be a selection bias.

Lots of questions and comments were raised considering exposure assessment and it's relation to health outcomes. The following points were addressed:

- ♦ Dosimetric measurements represent rather whole body than head exposure (as dosimeters were worn on the arm), though head exposure would be more relevant for outcomes such as cognitive functions.

- ♦ The biological relevance of the chosen exposure variable - the mean dose value averaged over 24 hours - is not clear. Which health outcomes should correlate with this exposure parameter?
- ♦ There are a number of problems considering the aim of the study to investigate health effects caused by mobile phone exposure: the dosimeters can not differentiate between mobile phone and base stations. Moreover EMF exposure from own phone calls could not be recorded; instead the use of a mobile phone is assessed by a questionnaire. On average children use their mobile phone for less than 10 minutes per day only and no correlation between the own use of a mobile phone and exposure could be detected.
- ♦ One should distinguish between mobile phone exposure and mobile phone use. Possible confounders and other side effects related to the use of mobile phones should be considered.
- ♦ It was suggested to look for a correlation to other exposure parameters i.e. exposure above certain level, or excessive use of a mobile phone.

Answering all these questions Dr. Radon stressed, that the focus of this study is overall exposure to the fields of mobile telecommunication and not only exposure to the use of mobile phones and that the data analysis had not yet started. A lot of data and information had been collected and would be analyzed in different ways. The comments and suggestions would be considered. Dr. Rööslü additionally defended the exposure assessment arguing that the combined exposure from mobile phone and base station was a more stable parameter than the mobile phone alone as it shows bigger variation (for example on their birthday children use mobile phones much more than on other days).

General Discussion on Session A

In this chapter only general issues are summarised. Specific questions and discussions considering each study are attached to the relevant study.

- ♦ Dr. Kreuzer asked Dr. Rööslü to comment the present studies in respect to the recommendations given in his paper on the feasibility of studies on base stations. Dr. Rööslü answered, that the studies comply very well with two particular points in the recommendations namely: not only base stations but all other sources have been assessed and short term effects were chosen for health outcome, which can be better investigated than long term effects.
- ♦ The question was raised whether TV-frequencies were considered in the exposure measurements. The answer was that, in both studies, study locations were chosen far away from TV-emitters.
- ♦ There was some discussion triggered by a provocative question on “negative effects” in assessment of well-being like language enrichment by children using mobile phones (“positive effects” being for example headache or concentration problems). It was commented that it might be interesting to investigate “negative effects”, but the counter question arose on what would be the endpoints and how they could be connected to exposure. It was also felt that these end-points should be taken apart from the present ones.
- ♦ There was a suggestion to conduct follow-up studies. As the exposure will change with the appearance of new technologies, it would be interesting to look whether symptoms will also change.

- ♦ There was again some discussion on which exposure parameter would suit best epidemiological studies: what averaging in space and time should be taken? How to handle maxima, etc.? It was admitted that both studies were susceptible for misclassifications - the BS study somewhat less because EMFs were more homogeneous in that case.
- ♦ Dr. Kreuzer gave some polemic input on possible end points: what would be the best strategy - to look for many different endpoints (like in the study of Dr. Berg where 36 items were quoted as potential end-points) or to concentrate on headache and sleep disorders? Dr. Hillert warned of making general validation for many different items; she suggested validating the analysis for every single item separately. Dr. Frick suggested to use validated, empirical psychological methods. Dr. Berg explained that in her study validated and sophisticated methods were used to assess different endpoints, (for example there were at least 6 questions related to headache) and that they concentrated on 4 items: sleep disorder, headache, complaint list and quality of life.

Session B: Experimental Studies

Chair: Blanka Pophof

This session was entirely given by Prof. Danker-Hopfe. She started her presentation by giving a very interesting and instructive lesson on the basics of sleep research (especially the meaning of different sleep parameters) and the motivation to study sleep in the context of electromagnetic fields. Then she presented two sleep studies conducted by research groups of the Department of Psychiatry and Psychotherapy of the Charité University of Medicine in Berlin.

B1: Laboratory study: Studies of the effects of exposure to electromagnetic fields emitted from mobile phones on volunteers **Heidi Danker-Hopfe and Hans Dorn, Charité Berlin**

Background

Starting in 1996 a number of different sleep laboratory studies were performed showing contradictory results. In their first study Mann and Röschke found some effect, which could not be reproduced in later studies. In different studies the group at the Zürich University (Achermann et al.) consistently found an effect on the power of the NREM-EEG in the spindle frequency range. A study at the University of Magdeburg (Hinrichs et al. 2005) did not show any effects, while another study at the University of Swinburne (Loughran et al. 2005) did show some effects. The aim of the present study was to contribute to a clarification of the situation.

Study design

In a very comprehensive selection procedure 30 healthy young men (age of 18 - 30) were selected out of 293 candidates, according to a long list of inclusion and exclusion criteria. This selection procedure, done by telephone contact, written questionnaires and

invited screening visits, aimed at excluding possible confounders and giving a homogeneous study sample.

During 20 consecutive weeks the subjects spent 10 days and 10 nights in the laboratory (one day or night per week alternating). The first visits served for adaptation. During the following 9 visits the subjects were exposed to sham, GSM and UMTS fields (three days and nights, respectively, for each exposure situation) in a double-blind, randomised, cross-over and placebo-controlled design. The radiation was applied continuously (8 hours during the night) by an antenna attached to the head in a way to simulate the spatial field distribution of a common dual band cell phone with SAR distribution being close to, but not exceeding, 2 W/kg. Uplink signals from UMTS and GSM (900 MHz, 217) were simulated. Exposure assessment was realised by IMST GmbH, Kamp-Lintfort.

During the day-visits, two test sessions were performed, one starting at 11 am and another starting at 4 pm. The following tests were performed in each session: pupillography, acoustic choice reaction test, contingent negative variation, oddball paradigm, sustained attention, alpha-attenuation-test, visual monitoring test, working memory test, divided attention and vigilance test. During the night-sessions participants spent 8 hours in bed. Among others the following sleep parameters were calculated: sleep period time, total sleep time, REM sleep latency, sleep efficiency index, number of stage shifts, wake after sleep onset, REM sleep and stages 1 to 4 of NREM sleep. During all sessions EEG was recorded continuously.

Results

The normal distribution hypothesis was tested by the Shapiro-Wilk test and the Kolmogorov-Smirnov test respectively. Depending on the results of this test, Student's-test or Wilcoxon's signed rank test for paired observations were used to test the null hypothesis that there was no difference between the pair-groups. At the moment the data evaluation is in progress, only those parameters based on visual expert scorings related to the macrostructure of sleep have been analysed. For none of the investigated sleep parameters a significant effect could be found neither for GSM nor for UMTS exposure. Compared to the previous studies the present has the highest exposure, exposure was continuous and more constant (as the antenna was fixed to the ear).

Discussion

- ♦ A question on the meaning of positive controls was answered by Dr. Achermann. He explained that fortunately a lot is known about factors, which might influence sleep. Based on that knowledge it is possible to investigate sleep in a standardized way.
- ♦ As possible explanations for discrepancies in sleep studies Prof. Danker-Hopfe mentioned different exposure conditions and different study designs. Considering UMTS exposure and sleep this is the only study.

B2: Field Study: Investigation of sleep quality in persons living near a mobile base station – Experimental study on the evaluation of possible psychological and physiological effects under residential conditions

Heidi Danker-Hopfe and Hans Dorn, Charité, Berlin

History and background

The present study has its roots in a feasibility study that was conducted in 2002 in the small village Flachsmeer in the north-eastern part of Germany (Ostfriesland). 47 men and 58 women participated in the study designed in a similar way as the present one. Apart from the fact, that the study attracted enormous media attention, it showed that such studies were feasible. Immediately after presentation of the results a proposal for the present study was submitted to the DMF. In 2005 a pilot study was conducted in order to: review the literature, get a vote of the Ethics Committee and achieve an agreement with the network providers. After all requirements had been fulfilled the main study could start in March 2006 and is planned to be finished by September 2007.

Design

The main focus of the study is the investigation of subjective and objective sleep quality and possible psychological effects on subjects living near mobile telecommunication base station under residential conditions. In order to “disentangle” possible psychological effects from the investigated physiological effects study sites were selected where no mobile service is available, only weak fields from other RF sources (like TV) exist and where no emotional EMF discussion is going on during the study period. Three study sites could already be determined and a fourth one was scheduled.

Selection of the study sites and construction and operation of the special transportable base station is done in close cooperation with the network providers and the German Federal Network Agency. A container, originally used for disaster recovery, containing GSM900 and GSM1800 base stations (BS), was modified in order to meet the need of the study. The BS delivers generic GSM signals using a test mode without net service, so it is not displayed on the mobile phone (enabling double blind design of the study). Additional 6/8 pulsed GSM signals simulate a BS transmission close to full capacity. Outdoor exposure measurements and single measurements of signals at the pillow of each participant’s bed are done by the IMST GmbH. Exposure from the test BS and external background exposure are assessed using frequency selective and isotropic methods. Signals of the various transmitting services are measured individually. DECT phones are replaced for the time of the study.

Selection of participants is done by inviting all inhabitants to an information meeting at the study site. Participating subjects have to be older than 17 years, able to give an informed consent and live closer than 500m to a site suitable for placing the experimental base station. At a second meeting with subjects who were willing to participate “entrance” questionnaires concerning sleep and well-being have to be filled in aiming at identifying possible psychological components. The experimental period lasts 2 weeks (12 nights). The type of exposure is randomly assigned to the study nights (sham and verum) allowing for double-blind, cross-over and sham-controlled design of the study. There is no exposure during days and no exposure during the weekend. During the experiment the quality of sleep at home is studied at subjective (questionnaires) and objective (EEG) level. The questionnaire, recommended by the

German Society for Sleep Research and Sleep Medicine, has to be filled in every morning and evening. Two questions were added to assess problems met with the handling of the EEG-devices and telephone use after 10 pm. Frontally recorded bipolar sleep EEG data were registered and automatically analysed as objective data.

Status of the project

The first three study sites have been chosen and meetings to inform the inhabitants of the respective villages about the study were held. At one of the sites, the village Frebershausen (Hessen), data collection was finished in December 2006. 34 persons (20.5% of the eligible population) were included in the study – 17 men and 17 women. The “entrance” questionnaire shows the characteristics of the study group. All the investigated sleep parameters (like quality of sleep, morning or evening type, excessive daytime sleepiness and poor sleepers) as well as psychological characteristics show no deviations from the population distributions. 31 individuals participated in more than 10 experimental nights; the drop out rate was 11.8 %. In November 2006 the experiment at the second site started with 56 subjects enclosed. Altogether it is planned to recruit about 300 subjects.

Discussion

- ♦ A question was posed whether endocrinological parameters like melatonin level might have an influence on sleep. Prof. Danker-Hopf said that they had considered this parameter, but these investigations would have been too complicated and costly. In addition the previous studies had shown that one did not get the expected information.
- ♦ There was a question on how and why the experimental sites had been chosen. The answer was that the sites were indeed very hard to find, so they just took what they got.
- ♦ The question whether participants started to be more concerned about EMF after being enclosed into the study, Prof. Danker-Hopf answered that they were very relaxed. In some study sites neither emotions for nor against EMF could be observed. There were some indications, that the participants were more educated than average population and that they wanted to support science, but the relevant data have still to be analysed.
- ♦ The question was also posed on "double blindness" of the experiment. Could it be figured out whether there was a real signal or sham? Prof Danker explained, that participants were not informed what was going on – so they did not know, that there was real and sham exposure and no exposure during the day. In addition, by looking at the registered parameters it can be figured out whether a person was awake or not.
- ♦ Dr. Radon noted that the prevalence of persons with sleep disorder was higher than in the general population. She wondered whether these persons were more motivated to participate in the study. Prof. Danker-Hopf answered that one of the aims of the study was to assess the prevalence of sleep complaints in the general public. The prevalence of real sleep disorders in the general population is known from sleep medicine studies, but not the prevalence of sleep complaints.
- ♦ A critical question was raised: why was the field study performed after the laboratory study had shown no positive results? The answer was that in the laboratory study only the correlation between real EMF exposure from mobile

phone and sleep was investigated, whereas in the field study it was also investigated whether concern about BS might cause sleep disturbances.

- ♦ Dr. Frick commented that in the present study, being double blind, concern is a covariate but not a variable measured as an exposure condition. In their study, they openly announced exposure and then they measured concern.

General Discussion on Session B

There was no general discussion on session B. Specific questions regarding one or the other study are summarised in the corresponding discussion chapter.

Session C: Electrohypersensitivity

Chair: Anne Dehos

C1: Investigation of sleep quality of electrohypersensitive persons living near base stations under residential conditions

Norbert Leitgeb, Technical University of Graz

Study design

This very original field study might be described as an inverse provocation study. For “verum” condition EMF shielding curtains able to reduce the EMF exposure to a negligible value were placed around the bed of the test person. During 10 nights test persons spent 3 nights under “verum” condition (with real shielding curtains), sham (non shielding curtains) and control (no curtains) respectively in a double-blind cross-over design (the first night was used for accommodation). EMF exposure in the “tent” was measured continuously (80 MHz – 3GHz, frequency selective). As objective parameters polysomnographic recordings were performed during the night (EEG, EOG, ECG, movement), while subjective sleep quality was assessed by means of a validated Subjective Sleep Quality (SSA) questionnaire in the morning.

Study population

44 volunteers were selected out of 600 interested candidates: 17 men, 26 women and one girl. Although electrosensitivity (ES) was not an acceptance criterion, a significant shift towards ES could be observed by comparing the perception ability of contact currents in the test group with the distribution in the representative population (done in a previous study). According to their subjective judgement, the sleep quality of the test population was also worse than in the average population.

Results

Following the unusual study design Dr. Leitgeb showed as well an unusual sleep analysis. Differences in sleep parameters were shown in a 4-field plot representing: “positive effect” if the sleep was better under “verum” condition compared to sham, and

“negative effect” if the sleep was worse, “placebo effect” if the sleep was better under “verum” or sham condition compared to control (better sleep with curtains) and “impairment” for vice versa situation - better sleep without curtains. Generally, no effect could be observed. In some participants placebo effect, based on subjective sleep parameters, could be observed. The total immission was low – less than 4% of the ICNIRP limits.

Discussion

- ♦ Dr. Achermann commented that the observed difference between subjective and objective sleep judgement was not surprising; it is well known from other studies. However, Dr. Leitgeb clarified, that what was surprising was the difference in the judgement between the sham and the “verum” condition.
- ♦ There was a question on sleep stage scoring, whether it was done automatically or not? The answer was that they had both: automatic scoring and another run where they had visual observation as they did not want to rely only on the automatic scoring. Dr. Achermann confirmed that automatic scoring was not always reliable.
- ♦ A question was posed whether consecutiveness of recorded nights has been taken into account; for example, if a test person slept poorly one night, the consecutive night should be better. The answer was that this was taken into account in the rank analysis. Other factors like menstrual cycle, temperature etc. had been taken into account, too.
- ♦ On the question about possible causes for Electrohypersensitivity (EHS) problems Dr. Leitgeb answered, that problems were multidimensional, but mostly related to mobile phone antennas.
- ♦ Some criticism was expressed, that in the “4-field” presentation of data each point meant a different significance test.
- ♦ Some doubt was expressed considering double-blinding of the experiment, but Dr. Leitgeb said, that if somebody had got a mobile phone into the “tent” this would have been noted in the registered exposure– but he can’t be 100% sure.
- ♦ The question was raised whether EHS persons wanted to use the shields in their home. The answer was “Yes”, but the curtains used in the experiment were better than the commercial ones (they had double layers).

C2: Investigation of the phenomenon of 'electromagnetic hypersensitivity' using an epidemiological study on 'electrosensitive' patients including the determination of clinical parameters

Ulrich Frick and Michael Landgrebe, Psychiatric University Hospital, Regensburg

Aim and study design

The aim of the study was to analyse potential disposing factors for subjective electromagnetic hypersensitivity (EHS). For that reason 89 EHS “cases” and 107 controls, matched for age, sex, place of residence and working place, were compared in respect to a large number of parameters. Simple conservative statistical analysis was independently performed on the two groups.

Results

Based on descriptive parameters, the EHS group, compared to controls, can be described as follows:

- ♦ Worse employment status
- ♦ Worse perceived health status
- ♦ Larger number of physicians visits
- ♦ Larger number of days being sick
- ♦ Worse quality of sleep, measured by PSQI (Pittsburgh sleep quality index)
- ♦ Higher values for WHO CIDI (Composite International Diagnostic Interview) on major depression and general anxiety disorder and also for somatic disorder
- ♦ Less use of electrical equipment in sleeping room
- ♦ Higher EMF complaint score

No differences could be observed in the following descriptive parameters:

- ♦ Educational level
- ♦ BMI (Body Mass Index)
- ♦ Hospitalisation
- ♦ Use of electrical equipment in living room and kitchen
- ♦ Possession of a mobile phone
- ♦ Smoking
- ♦ disturbance by air pollution
- ♦ disturbance by noise
- ♦ amount of last mobile phone invoice (in Euro)

The comparison of further investigated parameters can be summarised as follows:

- ♦ *Perception of singular magnetic pulses from Transcranial Magnetic Stimulation (TMS):* no differences for acting and resting motor threshold, but EHS group shows diminished ability to discriminate between verum and sham stimulation (due to their high false alarm rate).
- ♦ *Cortical excitability measured by paired-pulse paradigm* shows to be diminished in younger EHS subjects and increased in older ones.
- ♦ *Genetic predisposition* with respect to 5-HTTLPR (serotonin transport promoter gene) and D4 receptor polymorphism (dopamine receptor gene) showed no differences.
- ♦ *Allostatic load* (as a marker of chronic stress) showed no differences
- ♦ *Dysfunctional cognitions:* the EHS subjects show higher level of rumination, intolerance towards complaints and other cognitions (exaggerated self attentiveness)

MRI Study

In a sub-study (presented by Dr. Landgrebe) 15 EHS subjects and 15 healthy controls underwent an MRI examination in order to test whether anticipation, known by chronic pain patients, plays a role in subjective EHS. Brain imaging was performed during thermal stimulation and placebo EMF exposure. While thermal stimulation of the left lower arm led in both groups to cortical activation in right primary somatosensory cortex, there was no activation in healthy controls during placebo EMF stimulation, but

activation of rACC and Insula in EHS patients. In addition they reported various sensations like prickling of the skin. These results point to a possible contribution of anticipation to symptoms generation in EHS subjects. Therefore a cognitive behavioural therapy, aiming at correcting dysfunctional cognitive strategies appears to be a promising approach to help the subjects suffering from EHS.

Discussion

- ♦ There were some questions considering the MRI test: whether the EHS patients felt more stress and were more anxious because of the examination and whether they were aware of HF exposure in MRI. The answer was that they were very relaxed, probably because they were taking MRI, being a diagnostic device, for something good. No side effects could be observed. They were not aware of HF fields of MRI and they really did believe that one could take the mobile phone into the MRI. But, since in the MRI study only 15 out of 89 EHS participants were included, one can not generalise.
- ♦ Dr. Frick additionally commented that in the whole study, there was no indication, that the EHS subjects were more stressed. Dr. Hillert mentioned that this had not been the case in her studies.
- ♦ It was queried whether the differences between the two groups could be explained just by anticipation. It was also mentioned, that similar results (using Positron emission tomography, PET) had been observed in patients suffering from Multiple Chemical Sensitivity.

C3: Investigation of electrosensitive persons with regard to accompanying factors or diseases, such as allergies and increased exposure or sensitivity to heavy metals and chemicals **Norbert Dahmen , University of Mainz, Department for Psychiatry**

The aim of the case-control study performed at the University of Mainz in collaboration with the University of Regensburg and self-help groups was to give clinical information about persons suffering from electrohypersensitivity (EHS) and to look whether the results fit into different disorder models and, if so, if EHS could be diagnosed and treated.

130 cases older than 18 years with severe EHS symptoms were selected from self-help groups, Mainz “EMF-Watchdog” and recruited by the University of Regensburg. 101 controls were recruited through advertisement. A large list of different parameters were tested by means of different standardized questionnaires (EHS symptoms, multiple chemical sensitivity, somatic and psychiatric comorbidity, depression, sleep quality, anxiety, life satisfaction etc.) and by laboratory investigation (routine blood sample, heart rate, genetically defined aspects of liver detoxification, infection and fatigue risk, HLA-typing, “allergy chip”, cadmium, lead etc in serum).

The results do not give a consistent disease model, which can be applied to all EHS patients. A heterogeneous disorder with different mechanisms has to be considered. Although psychiatric comorbidity could be found in about half of the EHS cases, differences in laboratory data suggest, that the phenomenon can not be described in psychiatric terms alone. For some patients immunological mechanism and environmental factors may play a role.

Discussion

- ♦ Dr. Hillert noted that they had got similar results in their study, but their EHS subjects had been more disturbed by environmental factors like air pollution or noise than in the present study. She also noted that according to the laboratory investigation, the group seemed to be very heterogeneous. In her study three categories of EHS persons could easily be identified: some with minor disturbances, some with strong disturbances, but no laboratory deviations and some persons who, in spite of having a diagnosis of a severe disease, attributed all their problems to EMF. Dr. Dahmen answered, that the first group was not present in their study, because they had selected only cases with severe problems. They also did not look for diagnosis of a disease. Analysis was going on, however, and they planned to look for all possible causes for the deviations found in the laboratory analysis.
- ♦ The question whether there were more cases among the EHS persons with psychiatric problems like schizophrenia or hallucinations was answered in the affirmative.
- ♦ On the question to name some environmental factors, that might play some role in EHS patients, Dr Dahmen noted amalgam, heavy metals and some other chemicals (as had been mentioned by the EHS patients themselves); the only laboratory findings were heavy metals.

General Discussion on Session C

The general discussion was introduced by questions put by the chair Dr. Dehos:

- ♦ Is there a causal relationship between EHS and EMF?
- ♦ Do we need more research on EHS?
- ♦ Can we diagnose EHS?
- ♦ How can we define EHS?

From the discussion the following points can be extracted:

- ♦ *Diagnosis of EHS* was pointed out as an important issue, particularly with respect to a possible therapy. Some simple criteria have to be defined, that can be answered with yes or no like for example to diagnose schizophrenia. The doubt was expressed by some participants whether that was possible, but the psychiatrists among the participants were convinced, that it was.
- ♦ *Heterogeneity*: The only common characteristics of all EHS persons is that they themselves relate their problems to EMF. The spectrum of problems they suffer from is very broad. Whether one can define more homogeneous subgroups, which can be clearly specified is not clear. Characteristics of test groups in the different studies depend on the recruitment strategy and the motivation of EHS persons to participate in the study. Therefore it is also difficult to compare the studies.
- ♦ *Causality*: The participants agreed that, from the existing studies, there was no indication of causality between the phenomena of EHS and EMF. Because of the big amount of uncertainties, it is also not expected to have a better answer in the future.
- ♦ *Need for more research*: The majority of the participants agreed that there was no more profit in further research and Dr. Okubo mentioned that WHO did not put EHS on the new research priority list. Nevertheless there is a need to know more

about the EHS phenomena. On one side because of political reasons and on the other hand we have to continue to think about a hypothesis for possible mechanisms. Finally Dr. Frick mentioned that for schizophrenia there are also no “schizochochen” which would explain the mechanism, but if we would be able to postulate EHS that would be a big step towards a possible therapy.

Final Discussion

Chair: Roger Matthes

Final discussion was introduced by Mr. Matthes with two questions:

- ♦ Do we have to modify our policy in order to protect people? Especially in respect to the public concern and unspecific health effects like sleep disorders, headache etc.?
- ♦ What was achieved by the projects? Will we have results, which appropriately answer public concern?

There was no real discussion related to these questions. Generally expressed opinions and estimations can be summarized as follows:

- ♦ *EHS Studies*: There is no need for more EHS studies. If there are EHS studies, then replication studies should be preferred, because every new study has a different design so that the results are not comparable. It has been shown, that with EHS studies no investigation of causality is possible. The cross-sectional studies conducted presently should give satisfactory answers to most of the public concerns.
- ♦ *Dosimetry*: One of the major problems in research of EMF health effects is the dosimetry and the question of the proper dose quantity for a biological endpoint. It was mentioned that this is still an open issue even in the investigation of causality between ELF-EMF and childhood leukaemia – the field with a number of very good epidemiological studies. In the present studies with the “soft” endpoints the problem is much more severe - what is for example the relevance of a dose assessed by a dosimeter, being worn on the arm, for the investigated biological endpoint?
- ♦ *Implication for limits*: There is no challenge, coming from the results of present studies to change the existing limits. In order to question the limits, the research should concentrate more on the possible mechanisms.

Short Summary and Rapporteur's Comments

A short overview of the studies conducted in the frame of the Research Programme is given in the following table.

Study	Study Type*	Health endpoints	Study population	Exposure / assessment /conditions	Results / Comments
A1	CS	Concern, Self-reported disturbances	51'444 subjects (population-based, age 14-69)	Everyday	Living < 500m to a BS: ~48.7% German average for selfreported disturbances: ~35% in Bavaria
	CS	Sleep, headache, complaint list, quality of life	1390 subjects, regional sub-sample of the main study	Everyday / "Antennessa" personal dosimeter	Will be available in 2007
A2	CS	wellbeing	1500 children (age 8-12), 1500 adolescents (age 13-17)	Everyday / "Maschek" personal dosimeter, worn on arm	Will be available in 2008
B1	LS	Sleep, cognitive functions	30 healthy man (age 18-30)	Mobile phone GSM / UMTS (SAR ~2W/kg),	No effects for visually scored parameters, neither for GSM nor for UMTS
B2	EFS	Sleep, psychological effects	300 volunteers (age > 17) in areas with no BS	Base station / experimental simulation of full capacity transmission	Will be available in 2008
C1	EFS	Sleep	44 volunteers: 17 men, 26 women, 1 girl	Everyday / shielded exposure ("inverse provocation")	No effects
C2	LS	Disposing factors for EHS	89 EHS cases, 107 controls	Transcranial magnetic stimulation (TMS)	Differences between EHS and controls in different parameters
	LS (MRI)	Role of anticipation	15 EHS cases, 15 controls	Only sham exposure	Anticipation plays a role in EHS persons
C3	LS	Clinical information on EHS cases	130 EHS with severe problems (age > 18), 101 controls	everyday	No consistent disease model

* CS: cross-sectional study, EFS: experimental field study; LS: laboratory study

All 7 studies deal with "soft", unspecific health endpoints like sleep disturbances or headache as acute, short-term effects. Big emphasis has been placed on the investigation of the EHS phenomena. Very original and inventive study designs have been chosen. A lot of effort has been put into the appropriate assessment of exposures. In nearly all studies (with the exception of study C2 where TMS and MRI were used) exposures are very low, corresponding to the "normal" everyday exposures. No dose – effect relationship has been investigated explicitly; the focus was more on looking for an effect, if any. The merit of the presented studies to the general and international research of EMF health effects might be in wrapping up the present knowledge on the EHS phenomena – particularly to better answer the public concern. The public concern was anyhow the main motivation for conducting this module of the Programme. Future research should focus more on investigation of causality, in particular possible biological interaction mechanisms.