EUROPEAN **CO**OPERATION IN THE FIELD OF **S**CIENTIFIC AND **T**ECHNICAL RESEARCH
ACTION 281: POTENTIAL HEALTH IMPLICATIONS FROM MOBILE COMMUNICATION SYSTEMS

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Scientific Comment

on

Epidemiologic Studies on the Health Impact of Mobile Communcation Basestations

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Abstract

Epidemiological studies are not capable to prove causal relationships. They can be useful tools in identifying possible health hazards provided sufficient reliability can be achieved in qualitative and quantitative exposure classification. Following an official Swiss request COST Action 281 concludes that from a scientific point of view at present there is insufficient basis for performing epidemiological studies of the health impact of mobile telecommunication basestations. A number of limitations would not allow to resolve small risk factors, should they exist, nor would it be possible to demonstrate the absence of a health risk.
If for political reasons such studies would be considered as a tool in the risk communication process it is the view of COST Action 281 that there is a high probability of such an approach being counterproductive in communicating risk to the public. If there is a health risk from mobile telecommunication systems (MTCS), it should first be seen in epidemiological studies of handset use.
There is, however, a need to develop better tools for exposure metrics and to monitor the MTCS[1] exposure situation in Europe. More work is also required on the study of weak field effects and the development of biology- and health-related assessment methods for the complex exposure situations that are already being encountered today and are expected to become even more common in the future.

1. Preface

One of the aims of COST Action 281 is to contribute to the co-ordination and harmonisation of national research programmes investigating the possible health implications of mobile telecommunication systems. This comment is the response of COST 281 to a joint request by the Swiss Federal Office of Public Health and the Swiss Research Co-operation Sustainable Mobile Communication asking for “an assessment of the chances and risks of epidemiological research on mobile phone basestations and human health and the best practice in this field”.

2. Target identification

An essential precondition for any epidemiological study is to identify the relevant physical factors or environmental agents involved. In the case of basestations associated with mobile communications there exist several different networks for private, public and executive’s use (e.g. DECT, GSM1, GSM2, UMTS, TETRA) with a wide variety of signal types and amplitudes involved, all with different carrier frequencies and characteristics such as sinusoidal signals, sinusoidal-like CDMA signals or pulsed TDMA signals with different repetition frequencies.

Besides these various types of basestation signals there are also many associated handset signals which cumulatively make not insignificant contributions to the general environmental exposure: For example, a fully occupied basestation traffic channel with 10W transmitting power can be associated with 8x2=16W cumulative

[1] *MTCS … **M**obile **T**ele**C**ommunication **S**ystems*

transmitting power of the connected handsets. There are, furthermore, other contributions to environmental radiofrequency exposure besides handsets and basestations. The most powerful are the signals from the numerous radio, television and satellite broadcasting stations using frequency bands across the radiofrequency spectrum. The demand for frequencies has increased so dramatically that the few still available for allocation were sold recently for large amounts.

Essential conditions

Therefore, if an epidemiological study is to be confined to an examination of public exposure to only the basestation downlink signals of one specific frequency band among many, it would need to be supported by one or more of the following conditions:

- The ***signal power is high*** compared to levels associated with known adverse health effects.

  This is not the case with basestation signals. There is ample evidence that public exposure to EMF emitted from basestation antennas are quite low and usually several orders of magnitude below the exposure limits recommended by ICNIRP and the European Commission or set by national authorities to avoid adverse health effects.

- The ***signal power is dominating*** over the other environmental radiofrequency signals.

  This is usually not the case for basestation signals. Available measurements indicate that GSM downlink signals while contributing to overall radiofrequency exposure are not sufficiently dominant to justify ignoring other radiofrequency sources such as broadcasts from radio and television stations. In fact, broadcasting and mobile communication have one essential feature in common: both require a high if not total coverage with radiofrequency signals with amplitudes sufficiently above noise level. They achieve this goal by quite different approaches: on the one hand by a network of weak- power basestations and on the other hand by only few but extremely powerful transmitters.

- The ***signal signature (time course) differs significantly*** from other sources.

  There is no particular scientific rationale for selecting a particular mobile telecommunications network for investigation. On the one hand, there are only weak indications for believing that signal pulsation might merit special attention, on the other hand, pulsation is a feature also of other applications, such as TV broadcast signals. If the pulsation of GSM signals is to be singled out for special consideration, then it must be recalled that:
  - *the exclusion of other pulsed signals would not be based on a convincing scientific reason but on a political decision;*
  - *GSM basestation downlink signals do not exhibit a high degree of pulsation. In fact, basestations transmit different kinds of signals: Each GSM antenna operates with one channel at a minimum, transmitting with constant power and with signals in all 8 available time slots, either real or dummy, irrespective of the actual number of processed calls. Therefore, this "broadcast channel"*

(BCCH) signal is very similar to a sinusoidal signal. Only if extending the capacity to process calls, when basestations may be equipped with up to three further "traffic" channels (TCH) with 8 time slots each, each of which being used on actual demand and individually slot-specifically power controlled. This results in a random variation of pulsation frequency between 217 and 1.736 Hz and amplitude variations by two orders of magnitudes.

- *If pulsation was the parameter to be considered most relevant in an epidemiological study of the public exposure to radiofrequency signals from whatever source, then handset signals would merit most attention. Handset signals exhibit a greater degree of pulsation (pulse duty cycle) and much more constancy in amplitude and pulse rate than do GSM basestations signals. Moreover, handsets expose users to signals of a very much higher strength.*
- *If pulsation was to be the specific characteristics that distinguishes the radiofrequency exposures of concern from other sources, then Third Generation (3G) mobile telecommunications (UMTS) would not constitute a target of investigation since 3G systems usually employ a CDMA encoding system that does not involve pulsation, but employs sinusoidal signals with dynamic power control.*

- The ***biological interaction is vulnerable to specific signal qualities*** such as frequency or a frequency window, amplitude or an amplitude window, pulsation, or any combination of these.

  For weak signals to generate relevant effects, it is necessary to assume resonance and, therefore, on theoretical grounds, that these signals be highly coherent and regular. However, mobile communications signals from basestations do not meet these criteria. Basestation BCCH signals lack pronounced pulsation and TCH signals lack the necessary coherency and regularity. Neither type of signal fulfils the conditions for producing biological resonance effects.

Since exposures to mobile phone handsets meet several of the listed arguments, epidemiological studies on mobile phone users such as the ongoing international INTERPHONE study are scientifically more justified. Besides their much higher and locally dominating amplitude, handset signals would merit more attention also due to their stronger and more regular pulsation, if pulsation would be a key issue. There is no scientific indication for studies of the passive exposure of populations to a cocktail of environmental basestation downlink and handset uplink signals.

3. Exposure measurement

Exposure measurement requires the solution of a 5-dimensional problem in terms of characterising three dimensional vector fields within a one-dimensional distribution of frequencies which change both randomly and quickly as well as continuously within months and years. This raises a number of problems:

1. Measuring the spatial distribution of the vector field requires the definition of a measurement protocol including measurement procedures and specification of measurement antennas.

At this time, different approaches are under discussion, however, no agreement has yet been reached. It is promising that some helpful tools are already available in the form of personal dosimeters and software programs for outdoor exposure calculation, however more work needs to be done since these tools concentrate on local sources only and do not take account of other RF sources such as broadcasting antennas. Furthermore, software programs have not yet been adapted for estimation of indoor exposure.

2. To determine the contribution of other RF field sources.

   Adequate equipment, such as spectral analysis devices, is available to undertake such measurements. It is evident that the use of spectral analysis in an epidemiological study would significantly increase the volume of work and the cost of such a study. However, there is no rational yet as how to biologically assess the broad range of frequencies with different interaction and absorption characteristics.

3. Characterising the time course or trend of the exposure.

   Based on a single point-in-time measurement characterisation would usually require an extrapolation strategy to estimate both the average (short-term varying) exposure and the exposure changes over the whole study period. No accepted approach yet exists on how to deal with exposure conditions that change with time in respect to signal quality (sinusoidal to pulsed to sinusoidal-like signals) and amplitude in particular where this is accompanied by multiplication of other sources of environmental fields such as increased numbers of broadcast and television channels.

4. Exposure assessment

Epidemiological studies require a clear distinction to be made between the exposed and the unexposed groups of people. At this time, in the context of exposures from telecommunications basestations, it is not possible to make such a clear distinction. There are several reasons for this:

1. The omnipresence of radio and TV signals and the fact that there is now almost 100% coverage provided by mobile telecommunications networks, underlines the virtual impossibility of characterising the public's exposure to radiofrequency EMF into well-defined groups of exposed and unexposed. A more sophisticated approach would be required to differentiate between more or less exposed people. This would need to take account of a number of factors:

   - In epidemiological studies involving extremely low frequency (ELF) magnetic fields, past exposures can be more easily assessed because the signal signature (50Hz/60Hz) remains constant while mobile telecommunication systems have been and still are rapidly changing.

     Exposures to power frequency can roughly be derived from surrogates such as power consumption and power line load data. In contrast, the exposures associated with mobile telecommunication systems (MTCS) continue to change as they are affected by extent of coverage, number of providers,

amplitude (strength) of signal, frequencies employed, and signal time course. Initially MTCS exposures were characterised by the displacement of analogue systems by TDMA – coded GSM systems. At the present time the number of GSM basestations continues to increase while the roll-out of the next generation UMTS network is well underway.
The density of MTCS antennas is expected to continue to increase into the foreseeable future. Therefore the average distance between basestation antennas and the population at large will continue to decrease. The advent of Fourth Generation (4G) mobile communications will even involve body-worn antennas. These developments will require a rationale to assess past exposures and a means to extrapolate to predict future exposures, especially from spot measurements. Unfortunately there is no strategy yet available to account for this problem.

- The exceptional success of mobile telecommunications has led to a wide acceptance of the use of handsets exposing individual users to signals that are significantly higher than those they experience from basestations.

  These handset- exposures are dominating over the passive exposures experienced by non-users to basestations and the handset signals of others. In some countries the fact that the number of handsets in use already exceeds the number of inhabitants adds a further difficulty in the selection of exposed and unexposed populations.

2. The exposure assessment of RF-EMF differs considerably from ELF magnetic field exposure. While ELF magnetic fields remain unaffected by the presence of buildings, RF-EMF-exposure assessment is much more complicated due to shielding, scattering, diffraction and interference. As a consequence:
   - Outdoor measurements are poorly correlated with indoor exposure. This may cause severe misclassification of weakly exposed as highly exposed.
   - Using surrogates to characterise exposure, in particular distance from the nearest basestation, is not an approach that can be employed in the MTCS frequency range. This is for the following reasons:
     - shielding, reflection and diffraction of RF waves by buildings produces a complex exposure pattern with weakly exposed regions close to basestations;
     - the selective antenna transmission characteristics cause quite different exposures at comparable distances depending on the position relative to the main lobe;
     - since the transmitted power of a basestation depends on cell size (macro, micro, or pico), quite different exposures can be found at the same distances from different basestations.
     - a higher basestation density with smaller distances between antennas does not necessarily produce higher public exposure.

Therefore, using "distance from basestation" as a surrogate may lead to significant misclassification of unexposed individuals as exposed and vice versa. Therefore, this parameter is misleading and clearly not indicated for basestation epidemiological studies.

At the present time there is no acceptable approach available that would permit retrospective estimates of indoor exposures. For prospective studies a combination between calculation, verification by point measurements and personal dosimetry could be useful. However, for the reasons given, there remains still a high risk of inadequate categorisation into exposed and unexposed persons. This would compromise the statistical power and the reliability of results of epidemiological studies. This has already happened with some inadequate studies in this field[2] whose results are open to a variety of contradictory conclusions. Therefore, such studies would not contribute to the health risk assessment of basestations but simply increase public uncertainty and concern.

5. Biological endpoints

Existing exposure limits are set at levels which include a reduction factor and are well below those levels where adverse health effects are found. Therefore, selection of endpoints for epidemiological studies of MTCS signal levels that are several orders of magnitude below these limits cannot be based on established experimental or theoretical data but would be the result of speculations.

From a scientific point of view biological endpoints for an epidemiological study should meet at minimum the following conditions:

- in the absence of firm evidence, there should at least be some scientific indication that an adverse health effect might exist;

- suspected adverse health effects should be possible at the low levels of basestation EMF encountered indoors;

- such health effects should be selectively linked with MTCS signals and not with exposures from other RF sources, otherwise the results would be masked.

In any case diseases with long latency periods, which include most kinds of cancer are contraindicated because:

- Mobile telecommunication signals (MTCS) have existed for only a comparatively short period of time. The first analogue systems were followed by a period when analogue and digital pulsed systems developed in parallel. The present dominance of the digital GSM systems in Europe is a fairly recent phenomenon. This changing pattern of exposure makes it very difficult to associate diseases with long latency periods to a specific technology or to derive risk factors.

- The anticipated future development of MTCS would make it equally difficult to draw conclusions on the long-term health risks of the new systems that are expected to be introduced.

[2] Several attempts with inconclusive results have already been made in this field: Santini et. al. (2002) related answers in 530 questionnaires to distance to basestations, Navarro et. al. (2002) studied 97 questionnaires in relation to measured outdoor electric fields and Hutter et. al. (2002) correlated interviewer- collected health complaints of 336 people with their concerns and broadband and narrowband indoor measurements.

Evaluations of the scientific literature by many reputable committees, both national and international, do not support the assumption of a causal link between MTCS basestation exposure and adverse health effects. Anecdotal reports of the onset of sometimes even severe non-specific (neurasthenic) health effects coinciding with the activation of basestations are countered by other anecdotal reports of similar kinds of effect coinciding with the erection of basestations that remained inactive.

In the absence of a sound scientific rationale, epidemiological endpoints would need to be based on convictions and the reports of people suffering from health problems. The decision then, on which biological end points to choose, would become more political than scientific. If concerns of people were the basis, it should be considered, that they are not restricted to MTCS basestations but are also associated to radio and television broadcasting antennas.

If a selection of biological endpoints (with necessarily short latency such as non-specific acute health symptoms) is based on pragmatic or political considerations to respond to the concern by the public or the media, it should be clear that at this time:

- Our lack of basic knowledge does not allow us to design an epidemiological study which is powerful enough to resolve a small risk, even if such a risk exists.

- The statistical power of such an epidemiological study is expected to be severely compromised. This would result in statistically insignificant results and leave room for any interpretation. It would not contribute to reduction of public concern.

For these reasons, at least for the time being, epidemiological studies on mobile telecommunication basestations are not considered to be an adequate means of responding to public concern and cannot, under present circumstances, substitute for good risk communication. There is no sound scientific reason to assume that RF exposures so many orders of magnitude below the existing exposure limits and guidelines could cause adverse health effects and so justify such a study.

6. Conclusion

Epidemiological studies are useful tools in identifying possible health hazards provided sufficient reliability can be achieved in differentiating between exposed and non-exposed subjects. However, the resolution of risk factors decreases with increasing uncertainties. By their nature such studies are not capable to prove causal relationships. At present there is insufficient basis for performing scientifically sound epidemiological studies of the health impact of mobile telecommunication basestations. Among the reasons are the still unsolved quantitative and qualitative exposure assessment which is complicated by the presence of other RF exposure, the ongoing rapid technological changes and lack of scientific indication for biological study endpoints.

The rationale and justification for concentrating solely on one specific radiofrequency signal, such as GSM basestation downlink signals, in the presence of other RF

sources, including mobile telecommunication handsets and broadcast antennas, which also contribute to overall environmental exposure, remains political rather than scientific.

If such a political decision were to be taken it would be necessary to perform a feasibility study prior to the envisaged epidemiological study to address the following issues:

- Devising a protocol for assessing indoor exposures, possibly combining calculation methods and point measurements and/or personal dosimeters. It should be noted that distance from source is not an adequate approach for estimating exposures from basestations; it is by no means state of the art in this field.
- Accounting for other radiofrequency sources contributing to exposure.
- Developing a dose metric for reliable classification of people into exposed and non-exposed groups.
- Monitoring exposure changes during the latency period of the chosen biological endpoint.

Another weak point remains the selection of the specific biological endpoint of the study. In the absence of a sound scientific rationale, endpoints would of necessity need to be based on the convictions and anecdotal reports of individuals who may or may not be actually suffering from health problems. The decision then, on which biological endpoint to choose, would be more political than scientific. It would move the study into the area of risk communication and away from one of scientific rigour.

However, if considered simply as a tool in the risk communication process, it is the view of COST Action 281 that there is a high probability of such an epidemiological study being counterproductive. Because of its inherent deficiencies it could be expected to raise rather than lower existing concerns. It must be considered that for the given reasons epidemiological basestation studies are not an adequate tool to demonstrate the presence or absence of a health risk and cannot substitute adequate risk communication to the public.

From a scientific point of view COST Action 281 cannot therefore recommend that epidemiological studies of mobile telecommunication basestation exposures are carried out at this time. If there is a health risk from mobile telecommunication systems it should first be seen in epidemiological studies of handset use. There is, however, a need to develop better tools for exposure metrics and for monitoring the MTCS exposure situation in Europe. More work is also required on the study of weak field effects and the development of biologically related assessment methods for the complex exposure situations that are already being encountered today and are expected to become even more common in the future.