

Health Effects of Mobile Phone Base-stations: Human Studies

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Background

- There is widespread public concern about the potential adverse health effects of mobile phones, and especially their associated base-stations.
- Alongside this there are hundreds of, apparently conflicting, reports in the media about the health effects of mobile phones & base-stations.
- The scientific literature is large and confusing, also apparently showing very inconsistent effects across studies.

How can we bring order to this apparent chaos?

- First, we must identify what aspect of the electromagnetic field is important.
- Are changes in frequency (e.g., from 900 MHz to 2100 MHz) critical?
- What is the presumed bio-physical mechanism that is causing the hypothesized health effects?

Human Studies

- Studies examining the effects of RF-EMFs on human health should report EMF exposure in a clear way.
- In theory, there should be a proposed mechanism predicting what a certain change in frequency (for example) should imply for a particular biological or behavioural function. In practice, there is often no proposed mechanism of action.
- Often it seems that studies are conducted on political grounds, rather than scientific grounds.
- For example, is there something special (in terms of health effects) about the 800 - 2200 MHz range? What about TV and FM radio signals?

How can we investigate the health effects of EMFs?

- Given the variety of questions to be addressed, a convergent approach using multidisciplinary teams with a range of expertise would seem sensible.
- Investigation of the effects of EMFs from the molecular to the systems level is important.

Types of Approach

- **Epidemiological studies**
 - Identifying individual exposure levels is difficult
- **In-vitro studies**
 - Potential to identify mechanisms
- **Animal studies**
 - Dose-response relationships
 - Biological effects
 - Psychomotor functions
 - Cognitive functions
- **Human volunteer studies**
 - long-term effects (e.g., on sleep)
 - Short-term effects

Summary of Research to date

- Many reports and reviews have been published, most concluding that there is little evidence for any adverse health effects that can be attributed to mobile phone base-stations.
- Some examples:

Royal Society of Canada (1999)

“Surveys conducted in proximity to base stations operating in Canada indicate that the public is exposed to extremely low intensity RF fields in the environment”

Stewart Report (2000)

- Independent Expert Group on Mobile Phones in the U.K. (IEGMP, 2000).

“The balance of evidence to date suggests that exposures to RF energy below NRPB and ICNIRP guidelines do not cause adverse health effects to the general population”

*Institute of Electrical & Electronics
Engineers (IEEE, 2001)*

“ ... public exposure to RF fields near wireless base stations is far below recommended safety limits ...
Consequently, wireless base stations are not considered to present a risk to the general population”

*Australian Radiation Protection & Nuclear
Safety Agency (ARPANSA, 2002)*

“ Radiofrequency radiation (RFR) from mobile phone towers makes only a minor contribution to the total environmental RFR that arises primarily from other communication sources Generally less than 3%Further, the exposure levels from all combined radiofrequency sources adjacent to mobile phone towers are below 1% of the maximum allowable public exposure levels.”

U.K. Advisory Group on Non-Ionizing Radiation (2003)

“Exposure levels from living near to mobile phone base-stations are extremely low, and the overall evidence indicates that they are unlikely to pose a risk to health.”

NRPB (2004)

“The widespread development in the use of mobile phones world-wide has not been accompanied by associated, clearly established increases in adverse health effects.”

So, What is the Problem?

- In spite of these reviews, there is still widespread public concern, which if anything has increased.
- Many scientific studies also note that there are insufficient well-controlled studies to draw any firm conclusions.
- Some have argued that laboratory-based studies have used artificial sources of RF energy making it difficult to generalize to the normal working & living environment.

Is pulse-modulated RF energy critical?

- Hyland (2000) argued that amplitude-modulated (AM) and pulse-modulated RF energy might have different effects than continuous-wave (CW, unmodulated) RF energy.
- This could well be important because mobile phones and their base-stations produce a modulated signal, and much of the research has been done with unmodulated RF sources.

Foster & Rapacholi (2004)

- Point out that no clear biological mechanisms have been established to explain how modulation might affect responses.
- “ future research should be directed at confirmation and mechanistic understanding of reported biological effects related to modulation”

What Makes a Good Study?

- In human studies, statistical power is an important issue to consider.
- This can be enhanced by:
 - Testing large numbers of people.
 - Testing people who are particularly sensitive to RF-EMFs.

What is the evidence for enhanced perception of EMFs?

- Leitgeb & Schrottner (2003) tested the perception threshold for 50 Hz electric currents in 708 adults.
- They found large individual differences, with women having lower perception thresholds than men.
- They conclude that some people are more sensitive to EMFs, and that this is a necessary condition for the development of EHS.

However,

- A large literature on implicit perception suggests that responses do occur to stimuli which cannot be detected.
- For example, a wide range of physiological and neural reactions occur to backward masked stimuli.
- Thus, EHS may develop even in the absence of a demonstrated increased perception threshold.

Do people with EHS have a lower threshold for EMFs?

- Muller (2002) tested 49 EHS participants and 14 controls and found no difference between groups in detecting 50 Hz field exposures (100 V/m).
- Lyskov et al (2001) exposed 20 EHS & 20 controls for 10 minutes to a 60 Hz magnetic field & found that neither group responded. However, the EHS group differed in baseline HR and electrodermal activity.
- They concluded that people with EHS may have a physiological predisposition to react to physical & environmental stress.

However,

- As mentioned previously, a lowered threshold to EMFs may *not* be a necessary condition for the development of symptoms.
- What is needed are well-controlled double-blind experiments designed to assess the impact of base-station EMFs on physiological, behavioural, cognitive & neural functions, of both EHS & control participants.

Characteristics of a Good Study

- Well controlled exposure system.
- Electrically screened testing environment.
- Double-blind testing conditions.
- Measure of whether people can detect exposure and sham conditions.
- Test hypersensitive and matched control participants.
- Test a range of age groups.
- Measure a variety of out-come measures (e.g., physiological, behavioural, subjective, cognitive, neural) under exposure & sham conditions.
- Sufficient wash-out period between exposure and sham conditions.
- Adequate follow-up measures.

Laboratory studies to date

- No studies meet all of these criteria, and surprisingly few meet a reasonable proportion of these criteria.
- This may be one reason why there is so much inconsistency in the pattern of results found in lab-based studies.
- A selective overview illustrates this:

Effects of EMFs on Sleep & Brain Function

- No base-station studies could be found.
- Hamblin & Wood (2002) conclude in a review of 14 studies of handsets that:

“in reality no adverse health effect has been found in any published human study on the effects of mobile phones”

Effects of EMFs on Cognitive Functions

- One base-station study; several studies on handsets.
- Some studies have found that EMFs emitted by mobile phones increase reaction time and improve memory, while others show the opposite effect.
- Many effects have failed to replicate, even by the same research team.
- Statistical power has been a large problem in this area.
- We recently conducted a study with 168 volunteers, giving a power of about .80, and found no differences between GSM and sham exposure on a wide range of attention and memory tests (Russo et al, submitted).

What about hypersensitive people?

- Majority of studies randomly selected participants from the general population and therefore these people may have been fairly *insensitive* to RF-EMFs.
- There are people who claim that they experience a range of adverse symptoms & health effects which they attribute clearly to EMFs.
- The traditional terminology has become “Electromagnetic Hypersensitivity Syndrome” (EHS).
- EHS provides an opportunity to assess the health effects of EMFs, since people with EHS generally report that their symptoms emerge within minutes of being exposed to an electromagnetic field.

Rubin, Munshi, & Wessely (2005)

- A systematic review of published provocation studies testing people with EHS.
- 31 double-blind experiments were identified, which tested 725 EHS participants.
- 24 studies found no difference between exposure and sham conditions.
- 7 did find some evidence that EHS participants were affected by exposure. However, for 2 of these the same research groups failed to replicate the results. In 3 more, the results appear to be statistical artifacts, and the remaining 2 found opposing effects (improving and impairing mood, respectively).

Rubin et al (2005) concluded:

“This systematic review could find no robust evidence to support the existence of a biophysical hypersensitivity to EMF.”

However,

- Rubin et al (2005) do point out that low statistical power was a problem in many of the studies they reviewed.
- One of the best controlled studies examined the effects of the EMFs emitted by GSM and UMTS base-stations (Zwamborn et al, 2003, unpublished report).

Design of TNO study

- EHS participants (n = 36), and (fairly) well matched controls (n = 36).
- Double-blind.
- Four sessions of 45 minutes each (not clear what washout period was).
 - Placebo
 - GSM900
 - GSM1800
 - UMTS-like signals.

Summary of TNO report

	EHS			Contro		
	900 Hz	1800 Hz	UMTS	900 Hz	1800 Hz	UMTS
Wellbeing						
Sumscore			P < .05			P < .05
Anxiety			P < .05			
Somatic			p < .05			
Inadequacy			P < .05			P < .05
Cognitive						
RT	P < .05					P < .05
Memory					P < .05	P < .05
Selection			P < .05			P < .05
Dual Task					P < .05	
Filtering	P < .05					

Summary of TNO report

- Zwamborn et al (2003) concluded that “we have found a statistically significant relation between UMTS-like fields with a field strength of 1 V/m and well-being” (p. 61).
- This is an interesting study, although the results are not strong, especially since corrections for multiple-comparisons were not made.
- For the cognitive tasks, more differences were found for the controls.
- In general, no differences were found between EHS and control participants.
- EHS participants were selected for the increased sensitivity to GSM fields & yet no effects were found in this condition.
- Nevertheless, the results imply that a replication is necessary.

What can we conclude ?

- It is very difficult to draw any conclusions on the effects of base-stations on human health.
- There are too few double-blind studies, which test both EHS and control participants.
- Not enough is known about potential biophysical mechanisms (e.g., what is the effect of pulsing on the brain?).
- There are many reports of EMFs affecting neurotransmitter systems, but little evidence in the published literature is generally cited.

Future Research

- A coordinated research strategy, using a multidisciplinary approach would seem to be a practical way forward.
- In particular, more coordination of molecular and other approaches in both animal & human research.

Future Research

- In terms of human studies, the difficulties of research with an EHS population need to be addressed.
 - General mistrust of science
 - Undermining studies on spurious grounds
 - Unwillingness to question belief systems
 - Refusal to participate in scientific studies
- Studies on the impact of EMFs on neural response would be useful.
 - Single cell recording, EEG, MEG, fMRI etc
 - Many technical problems.

Conclusion

- In my view, there is a genuine uncertainty regarding the non-thermal effects of mobile phones & their associated base-stations.
- However, several important studies are running currently and should be completed in 4-5 years.
- We need more well-designed studies to assess biological mechanisms in a more focused way.
- Cognitive & behavioural neuroscientists should work more closely with molecular neuroscientists & physicists, engineers etc in a more co-ordinated way.

Thank You