

## **Radiation Effectiveness of GSM Cellular Phones has Little Effect on Cumulative Exposure**

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**INTRODUCTION:** Cumulative exposure from cellular phones during use on a network is a function of the magnitude and anatomical distribution of SAR (SARdistr), which are determined for the maximum power level (PWCmax), average power control level (PWCavg), which depends on network properties and transmission mode, and the duration of exposure (t). We assume that for a phone always operated at the same position on the head, cumulative exposure represents a dose that can be expressed as

$$\text{Dose} = \text{SARdistr} * \text{PWC}(\text{avg})/\text{PWC}(\text{max}) * t .$$

SAR magnitudes and their distribution in tissue are strongly dependent on the phone design. Radiation effectiveness, a measure of efficiency in converting RF power into useful radiated power, is also greatly affected by phone design. Since power control is a function of the received signal strength at the base station, radiation effectiveness is expected to be a parameter that indirectly determines dose through an effect on PWC(avg).

**OBJECTIVE:** The objective of this study was to evaluate the significance of radiation effectiveness on cumulative exposure from GSM phones.

**METHODS:** Several GSM phones were evaluated with different environments and networks using the SYstem NETwork and HANdset (SYNEHA) Analyzer that can compare the power control of four handsets simultaneously. The phones were mounted on the SAM phantom, and the relative PWC was measured locally with an SAR sensor behind the ear position. The system specifications for SAR measurements were:

- sampling rate: > 3000 samples/s per channel (rise/fall time < 0.3ms)
- dynamic range: > 33dB (> 48dB for whole system with different sensor lengths)
- cross talk attenuation: > 34dB
- linearity: < 0.2dB deviation
- noise: < 1mW/kg
- temperature range: 10 - 40 °C (<< 1dB)
- humidity: 0 - 90%
- relative position accuracy (head/phone/probe): < 1mm
- battery and DC operated

**RESULTS:** During measurements made in urban and remote environments in Zurich and surroundings as well as near San Francisco, we found that radiation effectiveness had little effect on the cumulative dose by GSM phones, since exposure was dominated by handovers (transfers from one base station to another) during which the base station set PWC to PWC(max). Therefore, phone exposure closely reflected SAR at the maximum power level. Consequently, the spatial peak SAR determined during compliance testing is an accurate indicator of relative average exposure by a particular phone compared to other phones.

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