Typical Exposure of Children to EMF

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Short abstract. Typical everyday exposure of children to EMF, determined by survey study with portable exposimeters was used calculate the *in-situ* electric field and SAR values. The average exposure of participants was 0.29 μT for low-frequency magnetic field and 0.09 V/m for GSM base stations, 0.11 V/m for DECT and 0.10 V/m for WiFi; other contribution could be neglected. Calculated values of the *in-situ* electric field and SAR values were below 0.2 % of the basic restrictions.

Keywords: children, numerical dosimetry, exposimeters, EMF

1. Introduction

Extremely low-frequency (ELF) magnetic field, which is classified as possibly carcinogenic for humans by International Agency for Research on Cancer (IARC) since 2002 was followed by radio frequency (RF) electromagnetic fields (EMF) in 2011. As the children start to use various new EMF-emitting technologies earlier in their lives than the current adult population and they are often among the heaviest users with the usage still increasing [1], it is important to investigate the exposure assessment patterns of children due to future epidemiological studies that could address the possible long term health effects.

Different measurement campaigns were used in the last decade to determine typical adult exposure; however limited data are available for the children. In this study, typical individual exposure of the children to ELF and RF EMF was determined by a survey study with portable exposimeters. The results obtained by the exposimeters were later used as input parameters for dosimetric calculations of the children's exposure.

2. Materials and methods

Survey study with portable exposimeters

To obtain everyday typical EMF exposure of the children survey study with personal exposimeters was conducted to determine the whole-day individual exposure of children to ELF and RF EMF. For the study, young volunteers below the age of 17 were publicly invited to participate in the study. No compensation has been given to the participants apart from receiving a personalized report of their individual exposure.

For all 21 volunteers their parents gave permission for their participation in the study. Most of the participants carried both ELF and RF exposimeters (13), while 3 participants carried only the ELF exposimeter, and 5 participants carried only the RF exposimeter. The average carrying time was 69 hours per person per exposimeter.

Enertech Emdex II (*Enertech Consultants, Campbell, USA*) and Antenessa EME SPY 120 (now Satimo EME SPY 121; *Satimo, Villebon-sur-Yvette, France*) exposimeters were used. The first one measures the 3D LF magnetic flux density in the range from 40 to 800 Hz, whereas the second one measures HF electric field strength separately for FM radio (88–108 MHz, TV broadcasting (174–223 MHz; 470–830 MHz), TETRA (380–400 MHz), GSM phones (880–915 MHz) and base stations (925–960 MHz); DCS phones (1710–1785 MHz) and base stations (1805–1880 MHz), UMTS phones (1920–1980 MHz) and base stations (2110–2170 MHz), DECT phones (1880–1900 MHz) and WiFi (2400–2500 MHz). However, the individual exposure to mobile phones was not evaluated in this study.

Since the exposimeters underestimate the exposure due to the effect of the human body, following correction factors were used: for GSM exposure 1.3, for UMTS 1.1 and for WiFi 1.6 [2, 3]. As the correction factor for DECT exposure was not given, we used worst case (1.6) also for DECT.

Dosimetric computations

By the survey study with portable exposimeters we obtained the values of the external electric and magnetic field. Measured results were later used to numerically compute the *in-situ* electric field strengths and SAR values for different exposure scenarios using the SEMCAD X software package (SPEAG, Zurich, Switzerland).

We used 11 y.o. female with a height of 147 cm and weight of 35.5 kg (Billie) model from the Virtual Family set [4]. Basic restrictions from ICNIRP guidelines were used: for ELF exposure ICNIRP guidelines form the 2010 [5] whereas for HF exposure form the 1998 [6].

For 50 Hz (ELF) exposure basic restrictions for internal electric field strength in central nervous system of the head are 20 mV/m and 0.4 V/m for the whole body. Reference levels for 50 Hz are 5 kV/m for electric field strength and 200 μT for magnetic flux density. For RF exposure basic restrictions for the SAR (specific absorption rate) are 0.08 W/kg for the whole body, while the localized 10 g peak limits are 2 W/kg in the head and torso and 4 W/kg in the limbs. Reference levels are frequency dependent and are 28 V/m for FM radio, VHF TV broadcasting and TETRA system, 29.8 V/m for UHF TV broadcasting, 41.8 V/m for GSM base stations, 58.4 V/m for DCS base stations, 59.6 V/m for DECT cordless system and 61 V/m for UMTS base stations and WiFi wireless networks.

3. Results

Survey study with portable exposimeter

The exposure of participants to ELF magnetic fields varied considerably. The results in Table 1 show that the average value of magnetic flux density varied from 0.05 to 1.35 μT with the maximum value for each participant even more widespread: from 0.86 to 139 μT. Moreover 5 out of 16 participants had an average exposure exceeding 0.4 μT and they also had the value of the magnetic flux density higher than 0.4 μT for more than 10 % of the time, with the maximum of 77 % for the same participant that also had the highest average exposure of 1.35 μT.

The average RF exposure was very low and in general at the lower detection range of the exposimeter (0.05 V/m without correction factor). The average electric field strength was slightly above the lower detection range of the exposimeter only for GSM base stations, DECT system and WiFi. Maximum values were above upper detection range of the exposimeter (5 V/m without correction factor) for DECT phones, as this equipment is worn close to the body, and high also for base stations (4.50 V/m) and WiFi (3.95 V/m), but lower for radio (0.68 V/m) and TV broadcasting (below 0.3 V/m).

Results for GSM base stations, DECT phones and WiFi for each participant are shown in Table 2. The average values are close to the lower detection range of the exposimeter with some exceptions: participants 5, 7, 10 and 17 for GSMRx, 15, 19 and 20 for DECT and 2 for WiFi. As can be seen from Table 2 the results for the maximum and average exposure are not correlated.

Definition of average and worst-case exposure

Results, obtained by measurements with exposimeters were used to define typical and realistic worst-case children exposure. The mean of all values measured with exposimeters: 0.29 μT for ELF magnetic field, 0.09 V/m for GSM base stations, 0.11 V/m for DECT and 0.10 V/m for WiFi was used for typical exposure, whereas for realistic worst-case exposure the highest average value measured for one participant was used: 1.35 μT for ELF magnetic field, 0.26 V/m for GSM base stations, 0.38 V/m for DECT and 0.13 V/m for WiFi.

Dosimetric calculations

To calculate the *in-situ* electric field strength for ELF exposure the human model was positioned in four different situations: either parallel to the conductors or perpendicular to them, and either lying on the back or on the side. For all calculated situations *in-situ* electric field strength is very low: for the typical exposure the 99th percentile is below 0.03 % of the basic restrictions whereas for the worst-case exposure it is below 0.2 %.

For RF exposure plane-wave excitation for three different directions of the incident field: from the front of the body and from 45 and 90 degrees to the side was used. The calculated SAR values are low: whole-body average SAR values are below 0.001 % of the basic restrictions for typical exposure and below 0.007 % for worst-case exposure, whereas 10 g averaged SAR values are below 0.0005 % of basic restrictions for the typical exposure and below 0.003 % for the worst-case exposure.

4. Discussion and conclusion

The results for ELF exposure show, that the children were exposed to magnetic fields higher than normal as the average value of all ELF measurements was 0.29 μT. However 6 out of 21 participants self reported that they live close to either a transformer substation of high-voltage power line which is rather high compared to normal population. The reason for this was higher interest in participation among those who lived close to known ELF sources. Among those who identified the source of ELF magnetic field close to their homes, most of them were exposed to elevated average levels of magnetic field but some of the participants who did not identify any source of ELF magnetic field in their vicinity were also exposed to elevated average levels of magnetic field. These findings suggest that based only on the data about EMF sources self reported by the participants it is impossible to estimate their exposure to LF magnetic field.

Exposure to RF EMF of the participating children was low as the average values of the exposure were only slightly above the lower detection limit of the exposimeter for GSM base stations, DECT system and WiFi. This indicates that nowadays DECT phones and WiFi routers are present in homes and therefore they should not be overlooked in the analysis of the exposure of children.

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6. References

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Table 1: Results of the survey study for ELF exposure. There is high variability of magnetic flux density among participants: the maximum values were between 0.86 and 139 µT and average values between 0.05 and 1.35 µT. In the last two columns, the percentage of time, when the magnetic flux was higher than 0.4 µT, is shown. The participants, marked with an asterisk (*) self reported that a ELF EMF source was located near their apartment or house (1 case transformer substation, 4 cases high-voltage power line).

participant	B_{max} [µT]	B_{avg} [µT]	% of time B > 0.4 µT
3	1.77	0.05	0
4	139.36	0.12	2
6	36.96	0.53	14
8	53.92	1.07	11
9	1.43	0.06	0
10	15.67	0.07	0
*12	4.09	0.43	27
13	4.09	0.04	2
*14	6.79	0.68	63
*15	15.95	0.14	1
16	3.89	0.10	1
17	1.25	0.08	3
*18	1.63	0.10	0
*19	0.86	0.11	8
20	1.08	0.06	0
*21	4.75	1.35	77

Table 2: Results of the survey study for RF exposure. Most of the average values were equal to the lower detection range of the exposimeter.

	GSM_{Rx}		DECT		WiFi	
participant	E_{max} [V/m]	E_{avg} [V/m]	E_{max} [V/m]	E_{avg} [V/m]	E_{max} [V/m]	E_{avg} [V/m]
1	0.47	0.07	0.22	0.08	0.61	0.08
2	1.55	0.09	2.08	0.10	3.86	0.13
5	0.52	0.13	1.86	0.10	1.50	0.08
7	1.66	0.12	1.22	0.10	0.75	0.08
8	2.04	0.08	1.17	0.10	3.95	0.11
9	0.74	0.08	0.14	0.08	0.21	0.08
10	1.56	0.14	0.21	0.08	1.63	0.08
11	1.98	0.08	0.56	0.08	0.90	0.08
12	1.18	0.08	0.45	0.08	0.18	0.08
13	4.50	0.08	>8.00	0.10	2.51	0.11
14	1.12	0.07	7.90	0.10	1.06	0.08
15	0.73	0.07	2.02	0.14	0.59	0.10
16	1.72	0.08	0.61	0.08	2.05	0.08
17	0.31	0.26	2.62	0.08	0.08	0.08
18	1.34	0.08	0.21	0.08	2.75	0.08
19	0.82	0.08	6.54	0.38	1.87	0.10
20	0.17	0.09	1.23	0.14	0.83	0.10
21	0.75	0.08	1.41	0.08	0.34	0.08