Comparison of child and adult Whole-Body SAR due to downlink sources in 5 Countries from Personal Exposure Measurements

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INTRODUCTION

Personal radio frequency electromagnetic field (RF-EMF) exposure of the general public is often assessed using personal exposure meters (exposimeters). In [1], mean field strength levels obtained from personal RF-EMF measurements in different environments, denoted here as microenvironments, were compared for urban areas in five European countries by applying the same data analysis methods. From a biological perspective absorbed radiation may be more relevant than the electric field occurring at the body surface (incident field).
The objective of this paper is to calculate and compare the whole-body specific absorption rate SAR_{wb} for a child and adult model in five countries (Belgium, Switzerland, Slovenia, Hungary, the Netherlands) for different downlink wireless signals, based on the mean exposure levels measured with personal exposimeters in different microenvironments.

MATERIALS AND METHODS

The considered microenvironments were outdoor–urban, office, train, car/bus, and urban home. In each of the countries, electric field measurements were performed using the selective isotropic personal exposimeter of type DSP90-120-121 EME SPY of SATIMO (Courtaboeuf, France).
The field data from the different countries were converted to SAR_{wb} in three steps. Firstly, exposimeter data were collected from the different national studies. The robust regression on order statistics (ROS) method was used to compute mean exposure levels. Secondly, a human body model was selected and thirdly, SAR_{wb} in the phantom was calculated for the mean power density using the statistical tool of [2] and the method proposed in [3], and is compared for the different countries.
As human models we selected a spheroidal adult man phantom and 1-year-old child phantom (dimensions, see [3] and [4]). In a realistic environment, electromagnetic waves are traveling along multiple paths. It is obvious that the homogeneous exposure of a single plane wave is not representative for the multipath exposure in a realistic environment. Therefore, to assess

the statistics of the absorption correctly and correlate it with the incident field levels, the method of [2] is used. The distribution of whole-body SAR values in a child and an adult human body model is calculated for every measured incident field value at the corresponding communication frequency; 5,000 realistic exposure samples are generated to obtain statistically relevant results. From the SAR_{wb} distribution, the mean SAR_{wb} value is determined. We considered whole-body absorptions from 9 DL sources emitting RF-EMF in the frequency range between 80 MHz and 2.5 GHz (FM, GSM, UMTS, etc.). However, we did not consider uplink exposure from mobile phones because the SAR calculations require far-field conditions [2]. Uplink exposure from the personal mobile phone causes highly localized exposure, which does not fulfil this assumption and necessitates a different calculation procedure.

RESULTS

Figures 1 (a) and (b) summarize the total mean SAR_{wb} values for all the microenvironments and countries for the 1-year-old child and adult man model, respectively. Absorptions were of the same order of magnitude in all countries. Total mean absorptions in the adult phantom (Fig. 1.b) were lower than for the one year-old child (Fig. 1.a) because of the larger dimensions of the adult. The highest total mean SAR_{wb} values (for mean exposure) were obtained in Belgian office and were 3.4 microW/kg for the child and 1.8 microW/kg for the adult man. Other microenvironments with relatively higher whole-body absorptions (> 1 microW/kg) were outdoor-urban (child, and adult in Belgium and the Netherlands) and car/bus in Slovenia and Hungary. Lowest whole-body absorptions occurred in urban homes in all countries.

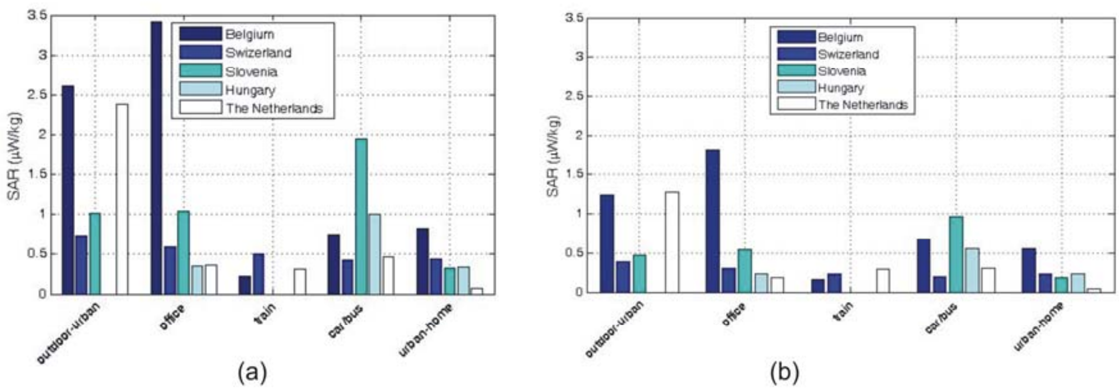

Figure 1: (a) Mean total whole-body absorptions in the 1-year-old child model and (b) adult man model for all considered microenvironments in all countries.

Figure 2 compares the contribution of the different sources to total SAR_{wb} (left part) and incident power density S (right part) in the five microenvironments for all countries for the 1-year-old child and adult man. In all microenvironments, absorption to downlink mobile telecommunication was important. FM radio absorptions were present in all countries (typically 10% or higher for the 1-year-old child) and were important for *adults* in urban-homes, office, car-bus, and trains. For both SAR and incident power density, contributions from mobile telecommunication signals are important in all environments (comparing Fig. 2 left part and right part).

We observed quite consistently in all countries that the highest whole-body absorption contributions were from downlink telecommunications (DL), FM, TV/DAB, and DECT and mainly for outdoor-urban and office environments (also car/bus in Slovenia). A similar pattern was observed for the power density from [1] (Fig. 2, right part). This demonstrates that the choice of the exposure surrogate in epidemiology might not be very crucial, if the ranking of exposure is of major intrest. Nevertheless, the relative importance of the TV/DAB contribution is considerably increased in the child phantom compared to the power density and for adult SAR the relative importance of FM is increased. The reason for the high values of SAR_{wb} for TV/DAB in the child phantom at 200 MHz (or lower frequencies as FM) are the dimensions of the 1-year-old child (length of 0.74 m and width of 0.16 m in [4]): 200 MHz is about the resonance frequency of the 1-year-old child model for a vertically polarized plane wave arriving at a zero elevation angle [4] and half the wavelength at 200 MHz is 0.75 m, while the length of the 1-year-old child is 0.74 m. The contribution of FM at 100 MHz is clearly higher in the adult than for the 1-year-old child, because FM is closer to the resonance frequency of the adult man (73 MHz for the adult according to [4]) than the frequencies of the other signals and sources.

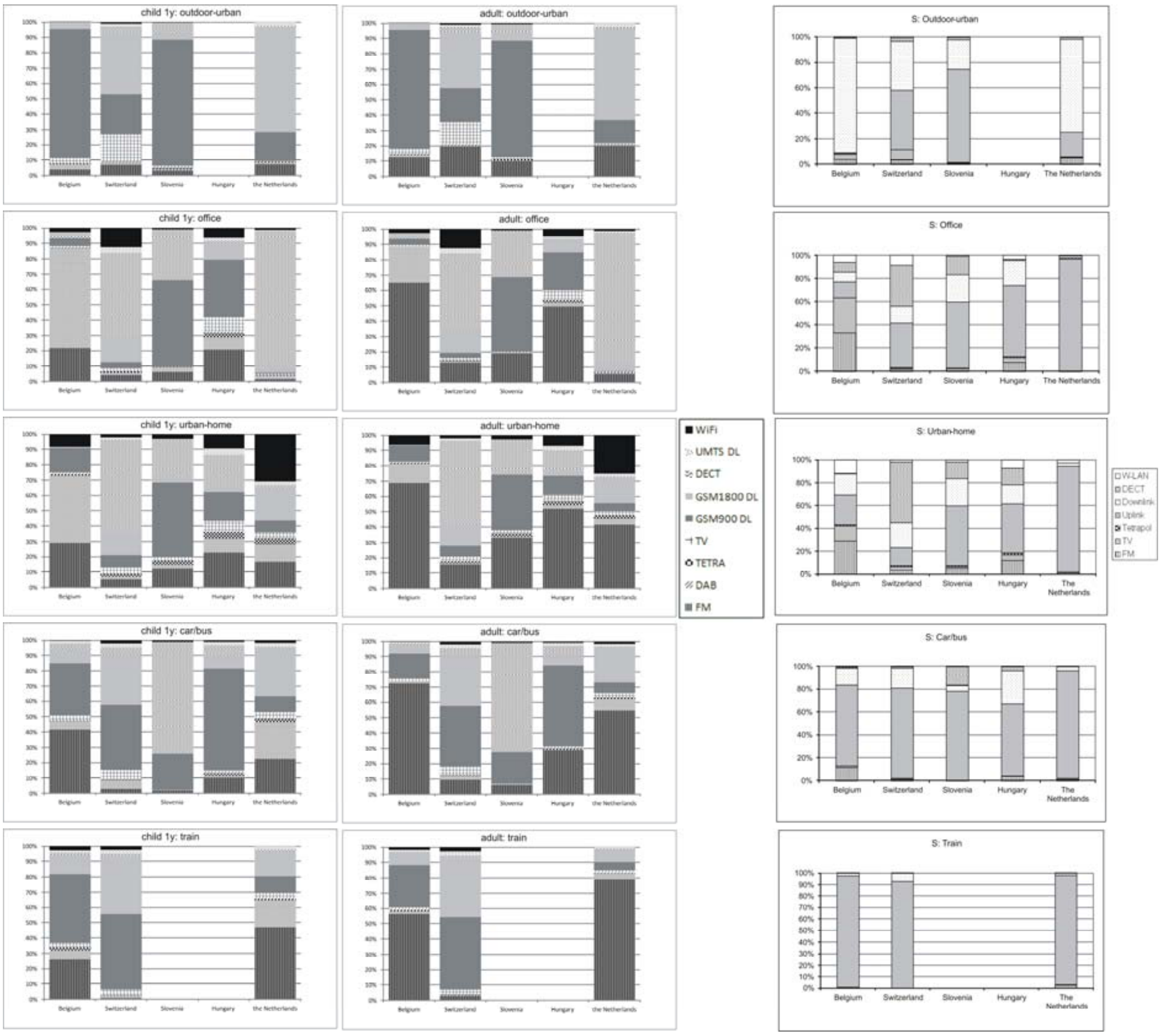

Figure 2: Comparison of the contribution of the different sources of exposure to SAR_{wb} and incident power density S in child and adult for all countries.

CONCLUSIONS

In this paper, a comparison of whole-body absorption for child and adult models based upon personal exposure measured in 5 countries is made. This enables to distinguish between the field exposure situation and the actual absorption in real circumstances.

An important conclusion is that higher power densities mostly correspond to higher whole-body absorptions. Exposure to the TV/DAB band causes relatively higher whole-body absorption values for the 1-year-old child (FM for the adult) than signals at higher frequencies due to the body-size dependent absorption rates.

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