VI CONVEGNO NAZIONALE
Il controllo degli agenti fisici

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Esposizione della popolazione ai campi elettromagnetici in Europa

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Outline

1. Limiti di esposizione e normativa Europea e nazionale
2. Monitoraggio ELF in Europa
3. Monitoraggio RF in Europa
4. Conclusioni

1

Limiti di esposizione e relativi internazionali e normativa europea

European Recommendation 1999/519/EC

on the limitation of exposure of the general public to electromagnetic fields 0 Hz to 300 GHz

Basic restrictions for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz)

Frequency range	Magnetic flux density (mT)	Current density (mA/m^2) (rms)	Whole body average SAR (W/kg)	Localised SAR (head and trunk) (W/kg)	Localised SAR (limbs) (W/kg)	Power density, S (W/m^2)
0 Hz	40	—	—	—	—	—
>0-1 Hz	—	8	—	—	—	—
1-4 Hz	—	8/f	—	—	—	—
4-1 000 Hz	—	2	—	—	—	—
1 000 Hz-100 kHz	—	f/500	—	—	—	—
100 kHz-10 MHz	—	f/500	0,08	2	4	—
10 MHz-10 GHz	—	—	0,08	2	4	—
10-300 GHz	—	—	—	—	—	10

European Recommendation 1999/519/EC

on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

Reference levels for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz, unperturbed rms values)

Frequency range	E-field strength (V/m)	H-field strength (A/m)	B-field (μT)	Equivalent plane wave power density S_{eq} (W/m²)
0-1 Hz	—	$3{,}2 \times 10^4$	4×10^4	—
1-8 Hz	10 000	$3{,}2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8-25 Hz	10 000	4 000/f	5 000/f	—
0,025-0,8 kHz	250/f	4/f	5/f	—
0,8-3 kHz	250/f	5	6,25	—
3-150 kHz	87	5	6,25	—
0,15-1 MHz	87	0,73/f	0,92/f	—
1-10 MHz	$87/f^{1/2}$	0,73/f	0,92/f	—
10-400 MHz	28	0,073	0,092	2
400-2 000 MHz	$1{,}375\ f^{1/2}$	$0{,}0037\ f^{1/2}$	$0{,}0046\ f^{1/2}$	f/200
2-300 GHz	61	0,16	0,20	10

Normativa nazionale 0 Hz – 100 kHz

Decreto del Presidente del Consiglio dei Ministri 8 luglio 2003
GU n. 200 del 28-8-2003

Applies to:	Type of Restriction	Quantity	Part of Body	Value	Comment
Public, 50 Hz, power lines only	Exposure limit	E		5 kV m^{-1}	
		B		100 µT	
	Attention value	B		10 µT	24 hours median value. Limit for daily exposure duration >4 hours
	Quality target	B		3 µT	24 hours median value. New power lines and new premises.
Public, all other fields 0-100 kHz					Apply EU Recommendation of 1999

Normativa nazionale 100 kHz – 300 GHz

Decreto del Presidente del Consiglio dei Ministri 8 luglio 2003
GU n. 199 del 28-8-2003

Tabella 1	Intensità di campo elettrico E (V/m)	Intensità di campo Magnetico H (A/m)	Densità di Potenza D (W/m^2)
Limiti di esposizione			
0,1< f ≤ 3 MHz	60	0,2	-
3 < f ≤ 3000 MHz	20	0,05	1
3 < f ≤ 300 GHz	40	0,01	4

Tabella 2	Intensità di campo elettrico E (V/m)	Intensità di campo magnetico H (A/m)	Densità di Potenza D (W/m^2)
Valori di attenzione			
0,1 MHz < f ≤ 300 GHz	6	0,016	0,10 (3 MHz-300 GHz)

Tabella 3	Intensità di campo elettrico E (V/m)	Intensità di campo magnetico H (A/m)	Densità di Potenza D (W/m^2)
Obiettivi di qualità			
0,1 MHz < f ≤ 300 GHz	6	0,016	0,10 (3 MHz-300 GHz)

2

Monitoraggio ELF in Europa

Livelli di esposizione ai campi magnetici ELF in Europa
50 – 10 MHz

- Esposizione media della popolazione fra 0.01 e 0.1 µT
- Esposizione > 0.2 µT per lunghi periodi 0.5% della popolazione
- Esposizione elevata (fino a qualche µT) in appartamenti prossimi a cabine di trasformazione

Thuróczy G., Ravazzani P., Bakos J., Grellier J., Samaras T., Gajšek P.: Electromagnetic field (EMF) exposure assessment in Europe: Low frequency Fields (50 Hz – 10 MHz), Int. J. Environ. Res. Public Health (under final revision)

Livelli di esposizione ai campi magnetici ELF in Europa
0 – 10 MHz - Sorgenti

Exposure classification	*Description, main sources and relevance for risk assessment*
Intermittent variable partial body exposure	- Highest level of exposure category, including the exposures from household electric devices. The exposure levels are highly variable and partial body or local. The exposure is intermittent and limited in time. The levels of exposure are below the recommended European exposure limits but the local maximum may be close to, and in some cases could be higher that the EU reference levels reaching up to few hundreds of µT54. - Typical sources: household appliances, some transport systems. - This category is considered in the risk assessment studies of general public exposure to ELF that have been performed so far.
Continuous elevated level whole body exposure	- Medium level of exposure category including exposures from built-in transformers, and high voltage power lines within 20-50 m. The exposure levels are variable in time and space. The mean and maximum exposure levels are well below the recommended European exposure limits, reaching up to few µT. - Typical sources: built-in transformers, substations, and high voltage power lines. - This category has importance for risk analysis, when epidemiological studies on childhood leukemia are considered.
Continuous low level background exposure	- Low level of exposure category as the background of todays electromagnetic environment. The exposure is continuous. The mean and maximum exposure levels are many times below the recommended European exposure limits and are in the range of 0.01-0.1 µT. - Typical sources: low-voltage wiring systems, continuously operating household electric devices. - This category has very limited importance for risk analysis.

Livelli di esposizione ai campi magnetici ELF in Europa
0 – 10 MHz - Sorgenti

La classificazione dell'esposizione potrebbe essere utile nei processi di valutazione del rischio, permettendo una migliore stima del possibile impatto sulla salute e della "magnitude of risk"

In termini generali i livelli di campo magnetico alle ELF ai quali la popolazione Europea è esposta sono notevolmente inferiori non solo ai tipici limiti espositivi in Europa per le frequenze in analisi ma anche ai livelli di 0.3-0.4 µT utilizzati per clusterizzare I dati a scopi epidemiologici

Misura dell'esposizione ai campi magnetici a 50 Hz dei bambini in Italia e Svizzera



Liorni I., Parazzini M., Struchen B., Fiocchi S., Röösli M., Ravazzani P.: Children's Personal Exposure Measurements to Extremely Low Frequency Magnetic Fields in Italy Int. J. Environ. Res. Public Health **2016**, 13, 549

Struchen B., Liorni I., Parazzini M., Gängler S., Ravazzani P., Röösli M.: Analysis of personal and bedroom exposure to ELF-MF in Italy and Switzerland, Journal of Exposure Science & Environmental Epidemiology, 1-11, 2015.

Arimmora

FP7-ENV-2011

"Advanced Research on Interaction Mechanism of Electromagnetic Exposure with Organisms for Risk Assessment"

ARIMMORA evaluated the EXPOSURE of children (6-13 years old) to ELF magnetic fields

Partecipants:

- **CNR-IEIIT Milano Italy (WP leader)**
- ITIS, ETHZ, Zurich Switzerland
- UNIBAS, Basel Switzerland
- SPEAG, Zurich Switzerland

➢ **PERSONAL EXPOSURE MEASUREMENTS**

LEVELS AND TEMPORAL PATTERN OF ELF-MF EXPOSURE correlated to the behaviour and movement of children (6-13 years) during their daily-life.

➢ **150 children in 2 different countries** (Italy and Switzerland) with different regulatory limits;

➢ **<u>3 different groups</u>**:

•Children living or attending school **within 200 m of a high voltage power line or within 50 m of an underground cable**;
•Children living **in a building with built-in trasformer station**;
•**Random sample** of a group of children will be used for comparison.

Measurement campaigns in **two different seasons** (Spring/Summer 2012 and Winter 2012/2013) have been performed for each child.

PERSONAL EXPOSURE MEASUREMENTS

Arimmora

FP7-ENV-2011

SPECIFICATIONS OF THE DEVICES

FEATURE	SPECIFICATION
Meter purpose	Multi-functional Magnetic Field Measurement system
Range	**0,01-300 µT**
Resolution	0,01 µT
Accuracy	± 10%
Frequency	**Broadband: 40- 800 Hz Harmonics: 100-800 Hz**
Measurement Method	True RMS
Frequency of calibration	50 Hz

FEATURE	SPECIFICATION
Meter purpose	Magnetic Field Measurement system for stationary use
Range	**0,01-70 µT**
Resolution	0,01 µT
Accuracy	±15%
Frequency	**Broadband: 10- 1000 Hz**
Measurement Method	True RMS
Frequency of calibration	16 2/3 Hz

VERIFICATION OF THE EXPOSIMETERS (Emdex II and Emdex Lite) before their use in personal measurements (and before the second test season) to check their functioning.

A protocol for the verification has been developed. 10 Emdex II and 2 Emdex Lite devices have been verified by the CNR-IEIIT at the IT'IS Foundation laboratories, Zürich.

PERSONAL MEASUREMENT PROCEDURE

To each child will be given:

Magnetic field meter

GPS logger

- **Time-activity diary** for each personal measurement day;
- **Questionnaire** to check possible exposure relevant factors.

Example of a week-day measurement

Monday	Tuesday	Wednsday	Thursday
Initial visit : **•hand out of time-activity diary and GPS logger** **•start and positioning of EMDEX II device-**			Final visit: •collection of EMDEX II and GPS logger •check and collection of time-activity diary and questionnaire

Spot Measurement in Child's Bedroom — **Personal Measurement** — **Spot Measurement in Child's Bedroom**

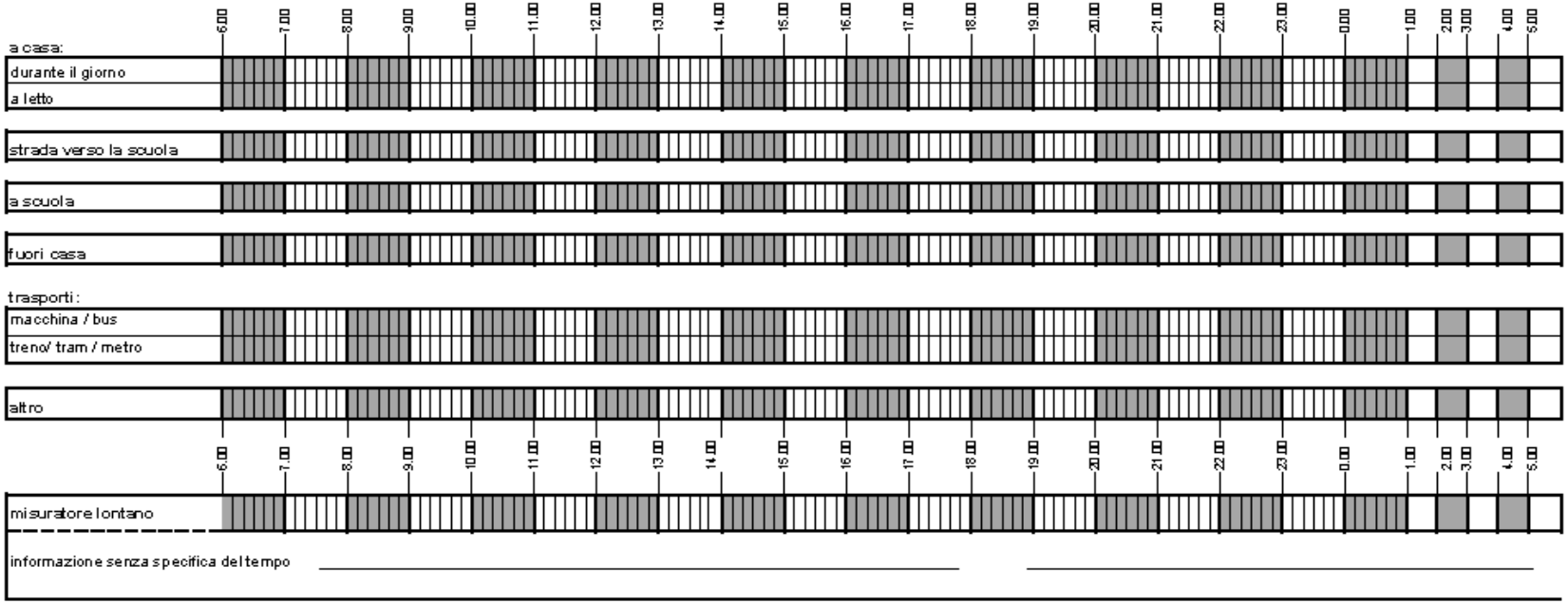
Diario delle attività
Misure di esposizione personale

1 blocco = 10 minuti

per favore riempite il diario delle attività del vostro bambino
(accuratezza 10 minuti)

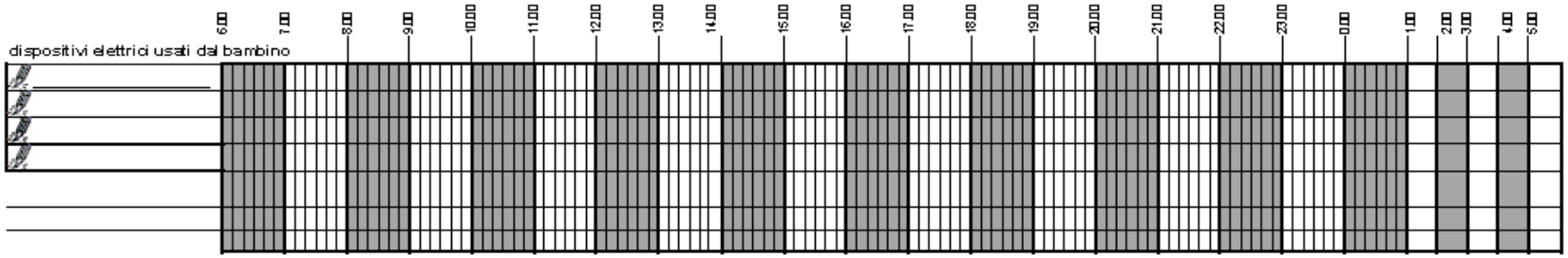
Data: _____

Cognome, nome del bambino: _____



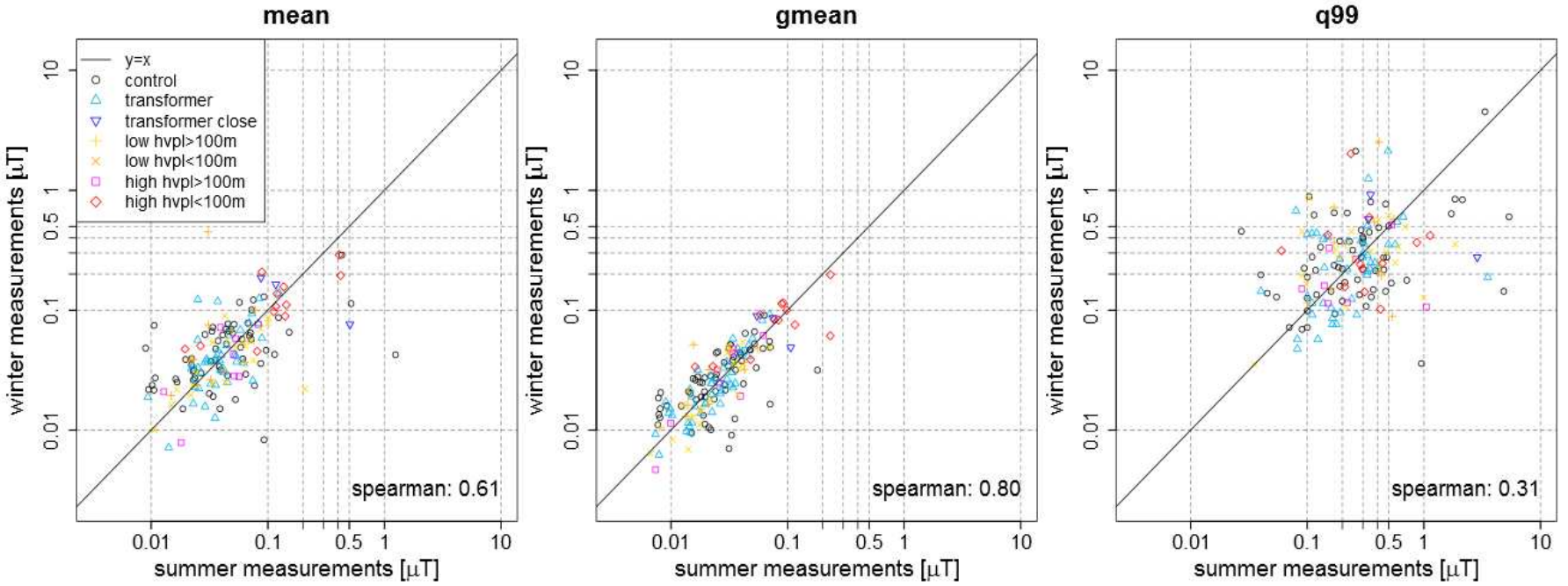
Dispositivi elettrici utilizzati dal vostro bambino

Per esempio dispositivi del tipo: Computer, sistemi stereo, TV, trenini elettrici o macchinine elettriche, giocattoli a pile, smart phone / tablet pc / console portatili, asciugacapelli, termocoperte, spazzolini elettrici, o altri dispositivi. Segnare i dispositivi e il tempo di utilizzo

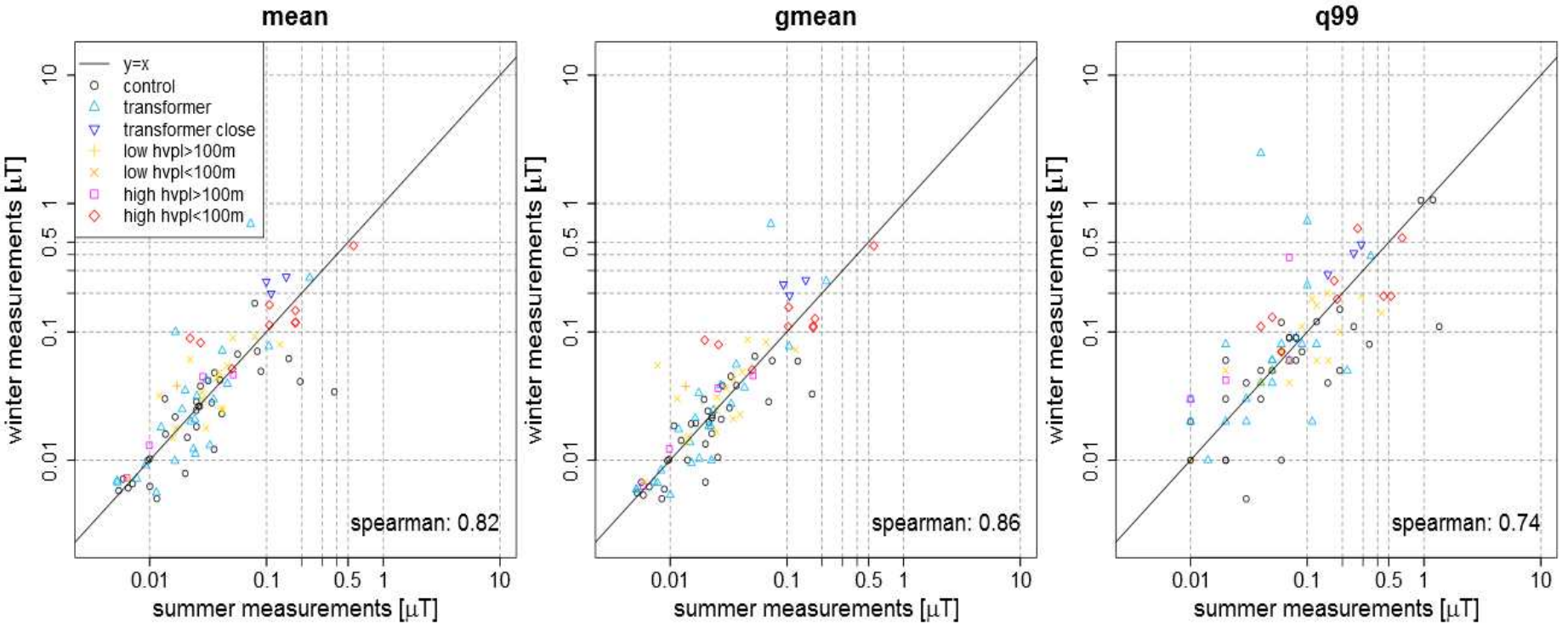


Note: _____

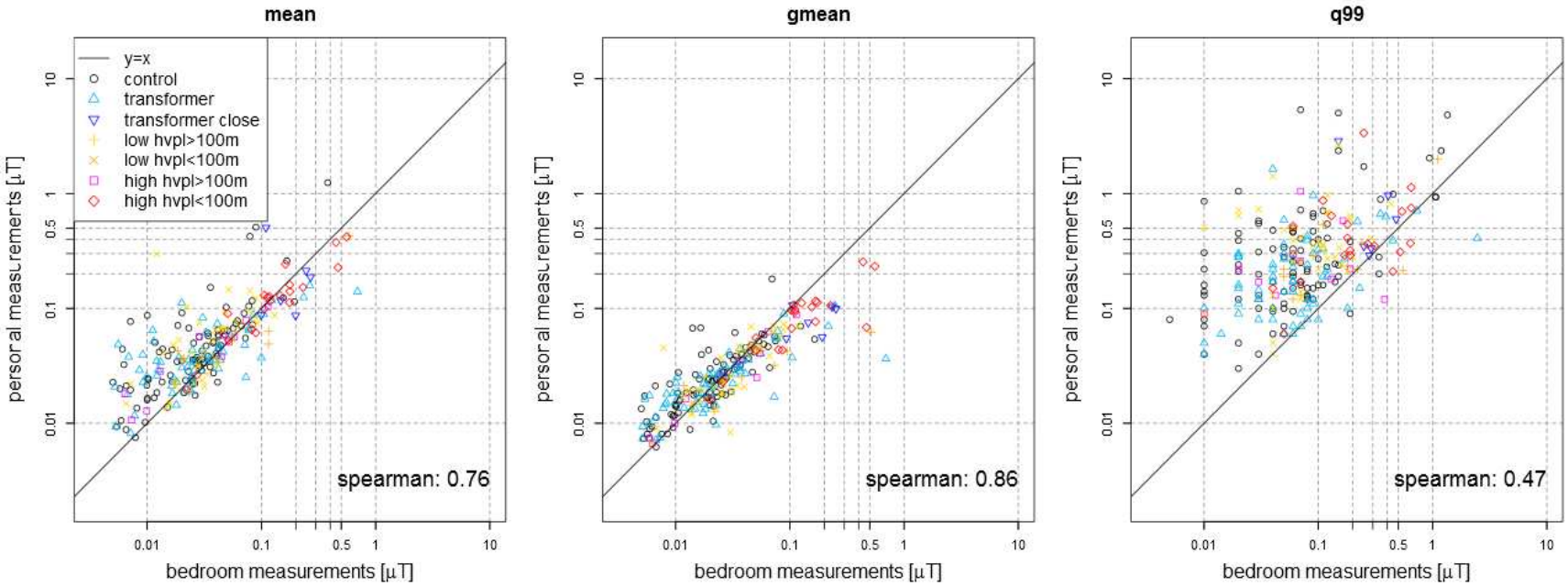
Per favore controllare di avere riempito correttamente il diario delle attività



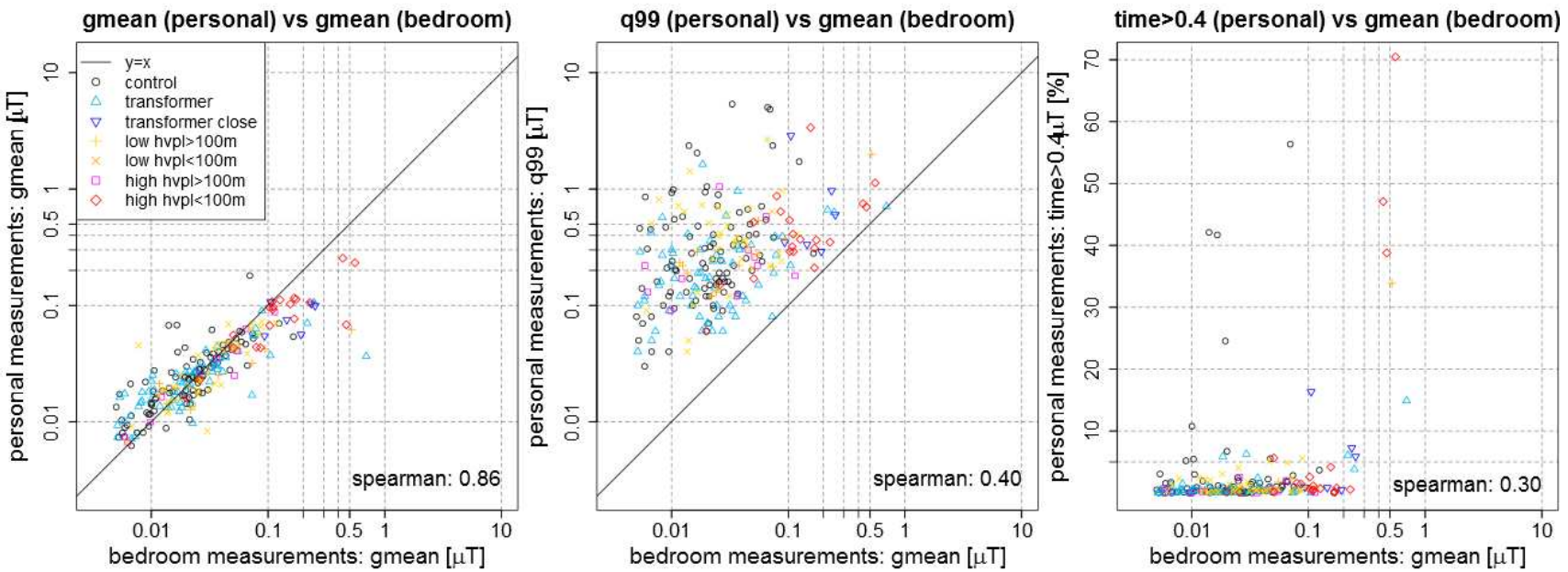
Summer/Winter reproducibility of total personal exposure measurements. The scatterplots show adjusted cold vs warm season measurements for the mean, geometric mean and 99th percentile (n=159). The Spearman's rank correlation coefficient is also given.



Summer/Winter reproducibility of total bedroom exposure measurements. The scatterplots show cold vs warm season measurements for the mean, geometric mean and 99th percentile (n=88). The Spearman's rank correlation coefficient is also given.



Comparison of total personal and bedroom exposure for the mean, geometric mean and 99th percentile (n=243). The Spearman's rank correlation coefficient is also given.



Comparison of total personal exposure of the geometric 99th percentile and proportion of measurements >0.4 µT with total bedroom geometric mean exposure (n=243). The Spearman's rank correlation coefficient is also given.

3

Monitoraggio RF in Europa

Table 1. RF EMF public exposure assessments in 20 European countries out of 27 member states[a]

Country	*Sport and long-term measurements*	*Characterization of exposure (source, activity)*	*Personal exposimetry*
Austria	✓	✓	✓
Belgium	✓	✓	✓
Bulgaria	✓	—	—
Croatia	✓	—	—
Cyprus	✓	—	—
Denmark	✓	✓	—
France	✓	✓	✓
Germany	✓	✓	✓
Greece	✓	✓	—
Hungary	✓	—	✓
Ireland	✓	—	—
Italy	✓	✓	✓
Malta	—	✓	—
Netherlands	✓	✓	✓
Portugal	✓	—	—
Slovenia	✓	—	✓
Spain	✓	—	—
Sweden	✓	✓	—
Switzerland	✓	—	✓
UK	✓	✓	✓

[a]There are several member states for which we could not identify any measurements.

Table 4. Classification of RF public exposure regarding the possible future risk analysis

Exposure classification	*Description, main sources and relevance of risk evaluation*
Intermittent variable partial body exposure	Highest level of exposure category, including mostly the mobile and wireless handsets (body-close portable devices). The exposure levels are highly variable and local. The exposure is intermittent. The levels of exposure are below the recommended European exposure limit (2 W/kg), but the local maximum may be close to the limit. The most characterstic exposure unit is the SAR (W/kg). Typical sources include: mobile handsets (GSM, 3G), DECT phones, and other wireless handsets. This category is the most important for some risk evaluation studies.
Intermittent variable low-level whole-body exposure	Medium level of exposure category, including mostly the indoor wireless portable and fixed devices. The exposure levels are variable, inhomogeneous whole, and/or partial body. The exposure is intermittent, the mean and maximum exposure levels are well below the recommended European exposure limits. The most characteristic exposure units are the electric and magnetic field strength or under special conditions the SAR. Typical sources include: WiFi, WLAN, DECT base stations, wireless, and Bluetooth USB dongle devices, and other indoor wireless portable and surveillance devices. This category has limited importance for risk analysis, but under some conditions (i.e., children exposure from WiFi and baby surveillance systems) may be relevant for investigations.
Continuous low-level whole-body exposure	Low level of exposure category, including mostly the fixed outdoor sources of TV and radio broadcasts, and wireless telecommunication systems (mobile base stations and body far-fixed sources). The exposure levels are variable in space and time. The exposure is continuous, whole body and the mean and maximum exposure levels are many times below the recommended European exposure limits (typically <1 V/m). The most characteristic exposure units are the electric and magnetic field strength. Typical sources: TV and radio broadcasts antennas, mobile telephone base stations (GSM, 3G, LTE), WiMAX base stations. This category has been studied previously for risk analysis; therefore, it has limited importance for risk analysis except the investigations of long-term changes of exposure to RF of general population.

Abbreviations: RF, radiofrequency; WiMAX, worldwide interoperability for microwave access; WLAN, wireless local area network.

Table 3. Summary of the measurement data on the RF EMF exposure of individuals using PEM in Europe in mean total electric field strength in V/m or average exposure in % of the ICNIRP level

Country	*Mean total electric field strenght (V/m)*	*Authors*
Belgium	0.12	Joseph *et al.*[21]
Switzerland	0.24	Frey *et al.*[22,23]
Slovenia	0.27	Trček *et al.*[24]
Hungary	0.10	Thuróczy *et al.*[26]
Netherlands	0.15	Bolte *et al.*[27]
France	0.21	Viel *et al.*[31]
UK	0.11	Mann[33]
Germany[a]	0.09	Breckenkamp *et al.*[34]
Netherlands	0.26	Bolte and Eikelboom[32]

Abbreviations: EMF, electromagnetic field; PEM, personal exposimeters; RF, radiofrequency

[a]Additional German studies on the average exposure in % of ICNIRP reference level: 0.92 (Heinrich *et al*)[35] and 1.00 (Thomas *et al*)[36] in percent of ICNIRP reference level, respectively.

Table 2. Summary of the measurement data on the RF EMF exposure using on-site (spot or long term) campaigns in Europe in mean total electric field strength in V/m or average exposure in % of the ICNIRP level

Country	*Mean total electric field strength (V/m)*	*Description*	*Reference*
Austria	0.39	Spot measurements in 226 households	Tomitsch *et al.*[4]
Austria	0.13 (rural) 0.08 (urban)	Sport measurements of 10 randomly selected base stations	Hutter *et al.*[38]
Switzerland	0.56	AM radio transmitter	Altpeter *et al.*[13]
Greece	1.64	46 monitoring stations, 4 million measurements	Gotsis *et al.*[10]
UK	0.1–1.8	20 randomly selected GSM microcell, and picocell	Cooper *et al.*[11]
Spain	0.6	18 outdoor locations	Rufo *et al.*[7]
Belgium, Netherlands, Sweden	0.74 (urban) 0.46 (suburban) 0.40 (residential) 0.09 (rural)	311 locations, 68 indoor and 243 outdoor, in three European countries	Joseph *et al.*[8]
20 countries	0.52 global average	173,000 measurement surveys of mobile phone base stations in more than 20 countries	Rowley and Joyner[16]
Italy	68.8% below 1 22.6% from 1 to 3 6.3% from 3 to 6 2.2% from 6 to 20 0.1% >20	Nationwide EMF long-term monitoring network	Troisi *et al.*[6]

Abbreviations: EMF, electromagnetic field; RF, radiofrequency.

Gajšek P., Ravazzani P., Wiart J., Grellier J., Samaras T. and Thuróczy G.: Electromagnetic field (EMF) exposure assessment in Europe. Radio Frequency Fields (10 MHz - 6 GHz), *Journal of Exposure Science and Environmental Epidemiology*, 25, pp. 37–44, 2015

1. The general RF exposure level of the population from the fixed RF sources including LF/MF broadcast, VHF broadcast, UHF TV and telecommunications is very low**. The range is between 0,01-1 V/m in Europe** that is many times below the exposure limits of EU recommendations.

2. The results of exposure measurements show that **more than 60% of recorded total EMF exposures were below 1 V/m**, less than 1% above 6 V/m and only less than 0,1 % were above 20 V/m field strength. The relevant European recommended exposure limit for the public is **in the range of 28 V/m to 87 V/m**.

3. The contribution of the RF exposure from wireless communication technology is continuously increasing and now **is above 60 % of the total exposure.**

Science consists in grouping facts so that general laws or conclusions may be drawn from them

Charles Darwin