Temporal trends of radiofrequency electromagnetic field exposure in everyday environments across European cities

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Images via Nickolay Lamm. Captions by M. Browning Vogel, Ph.D.
Background: Radiofrequency electromagnetic fields

Non-ionising Radiation

Low-frequency EMF

High-frequency EMF

Cell stimulation

Heating

Ionising Radiation

Infrared

Ultraviolet

X-ray and Gamma-ray

Relevant frequency signals: Radio (FM, 88 MHz) to Wireless Local Area Network (W-LAN, up to 2.5 GHz)
Background: Near-field vs. Far-field

Near-field
- Mobile phones
- Cordless phones

Far-field
- Broadcast transmitters
- Mobile phone base stations
- GSM: 2nd generation
- UMTS: 3rd generation

Schüz and Mann, 2010
**Introduction**

- Substantial increase and development of new telecommunication technologies.

![Mobile cellular subscriptions graph](http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx)

- Fundamental change of population-based exposure patterns to radiofrequency electromagnetic fields (RF-EMF).
- Public health concerns about potential adverse health effects.
- WHO Research Agenda 2010 (WHO, 2010)
  - Importance and high relevance of monitoring studies
Objectives

- Monitor RF-EMF exposure in everyday environments.
- Investigation of temporal trends.
- Comparison of exposure levels across environments and between the cities of Basel, Ghent and Brussels.
Methods

Personal exposure measurements during one year between April 2011 and March 2012 in the cities of
Methods: Study instruments

Portable measurement device (exposimeter):
EME Spy 120
Allows to separately measure RF-EMF exposure from 12 frequency bands.
Sensitivity range:
0.05 to 5 V/m
Measurement interval:
4 seconds

GPS device

<table>
<thead>
<tr>
<th>Frequency</th>
<th>-</th>
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</thead>
<tbody>
<tr>
<td>FM</td>
<td>88 MHz</td>
<td>108 MHz</td>
</tr>
<tr>
<td>TV3</td>
<td>174 MHz</td>
<td>223 MHz</td>
</tr>
<tr>
<td>TETRA</td>
<td>380 MHz</td>
<td>400 MHz</td>
</tr>
<tr>
<td>TV4&amp;5</td>
<td>470 MHz</td>
<td>830 MHz</td>
</tr>
<tr>
<td>GSM TX</td>
<td>880 MHz</td>
<td>915 MHz</td>
</tr>
<tr>
<td>GSM RX</td>
<td>925 MHz</td>
<td>960 MHz</td>
</tr>
<tr>
<td>DCS TX</td>
<td>1710 MHz</td>
<td>1785 MHz</td>
</tr>
<tr>
<td>DCS RX</td>
<td>1805 MHz</td>
<td>1880 MHz</td>
</tr>
<tr>
<td>DECT</td>
<td>1880 MHz</td>
<td>1900 MHz</td>
</tr>
<tr>
<td>UMTS TX</td>
<td>1920 MHz</td>
<td>1980 MHz</td>
</tr>
<tr>
<td>UMTS RX</td>
<td>2110 MHz</td>
<td>2170 MHz</td>
</tr>
<tr>
<td>WIFI</td>
<td>2400 MHz</td>
<td>2500 MHz</td>
</tr>
</tbody>
</table>
# Methods: Microenvironments/Data collection

<table>
<thead>
<tr>
<th>Public transports</th>
<th>Indoor settings</th>
<th>Outdoor areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>Airport</td>
<td>Central residential area</td>
</tr>
<tr>
<td>Bus</td>
<td>Train station</td>
<td>Non-central residential area</td>
</tr>
<tr>
<td>Tram</td>
<td>Shopping centers</td>
<td>Downtown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suburban area</td>
</tr>
</tbody>
</table>

- **Standardized measurement protocol**
- **Time recording app on smartphone**
- **Data linkage**
Methods: Statistical analysis

• To take into account that a large proportion of the data was below the detection limit (0.05 V/m), a specific regression algorithm has been applied to calculate daily means (Robust regression on order statistics (ROS)) (Röösli et al., 2008; Helsel, 2005).

Descriptive statistics:

• Exposure levels in everyday environments (outdoor, public transports and indoor)

• Temporal variability

Radiation from all sources = Total RF-EMF exposure (without DECT)
Radiation emitted by mobile phone base stations = Total downlink exposure
Radiation emitted by mobile phones = Total uplink exposure

Temporal trend analysis:

• Mixed linear regression models
Results: Exposure levels in everyday environments

Total RF-EMF exposure

Outdoor
- Influenced by mobile phone base stations

Public transports
- Influenced by mobile phone handsets

Indoor

Electric field strength [V/m]

Locations:
- Basel
- Ghent
- Brussels

Environments:
- Central res.
- Decentral res.
- Downtown
- Suburb
- Train
- Trans/Metro
- Bus
- Airport
- Train station
- Shopping centers
Results: Exposure levels in everyday environments

Mobile phone base station exposure

Electric field strength [V/m]

- Basel
- Ghent
- Brussels

Locations:
- Central res.
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Results: Exposure levels in everyday environments

Mobile phone handset exposure

Electric field strength [V/m]

Basel
Ghent
Brussels

Central res. Decentral res. Downtown Suburb Train Train/Metro Bus Airport Train station Shopping centers
Results: temporal variability

Mobile phone base station exposure across all outdoor areas

Mobile phone handset exposure across all public transports
Results: Yearly percentage change of total RF-EMF exposure in outdoor areas
Results: Yearly percentage change of total RF-EMF exposure in public transports and indoor areas
Conclusions

• Standardized measurements with exposimeters are suitable to monitor RF-EMF exposure in our everyday environment:
  o Large amount of data points
  o Large variety of microenvironments
  o Not time-intensive
• Increasing trend in RF-EMF exposure between April 2011 and March 2012.
• Total RF-EMF exposure was highest in:
  o Downtown areas (0.32 – 0.58 V/m)
  o Trains (0.83 – 1.06 V/m)
• Exposure levels are below regulatory exposure limits implemented in the national laws.
• Outdoor areas: contribution of mobile phone base stations (downlink)
  Public transports: contribution of mobile phone handsets (uplink)
• Similar findings of total RF-EMF exposure as in a European study (Joseph et al., 2010):

<table>
<thead>
<tr>
<th></th>
<th>Joseph et al.*</th>
<th>Urbinello et al.</th>
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</thead>
<tbody>
<tr>
<td><strong>Trains</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>0.59 V/m</td>
<td>0.83-1.06 V/m</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.63 V/m</td>
<td>0.97 V/m</td>
</tr>
<tr>
<td><strong>Outdoor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>0.37 V/m</td>
<td>0.31-0.41 V/m</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.28 V/m</td>
<td>0.26 V/m</td>
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</table>

*including DECT frequency.

• Knowledge of the RF-EMF exposure situation of the population is needed for planning future studies for risk assessment and for anticipating critical areas with respect to regulatory limits.
Thank you!