



Levels of RF-EMF exposure in our everyday environment and review of current epidemiological studies

4th International Conference 3-4 December, 2019, Warsaw



Prof. Dr. Martin Röösli



Content

- Exposure to radiofrequency electromagnetic fields (RF-EMF) in our everyday environment.
 - Microenvironmental surveys
 - Personal measurements
 - RF-EMF dose calculation
- Effects on the brain
- Brain tumours



Two approaches to measure RF-EMF

Personal volunteer measurements



- + all sources including behavior
- data quality, manipulation
- selection bias
- No differentiation between own and other people's mobile phone
- body shielding

Microenvironmental survey



- + data quality, efficient,
- + minimized body shielding
- No individual behavior
- Private place measurements challenging



ELSEVIER

Contents lists available at ScienceDirect

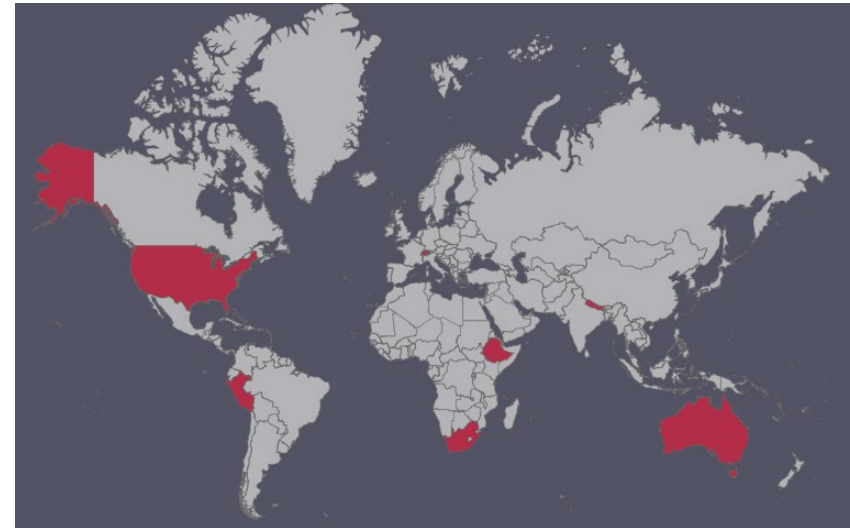
Environment International

journal homepage: www.elsevier.com/locate/envint

Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context

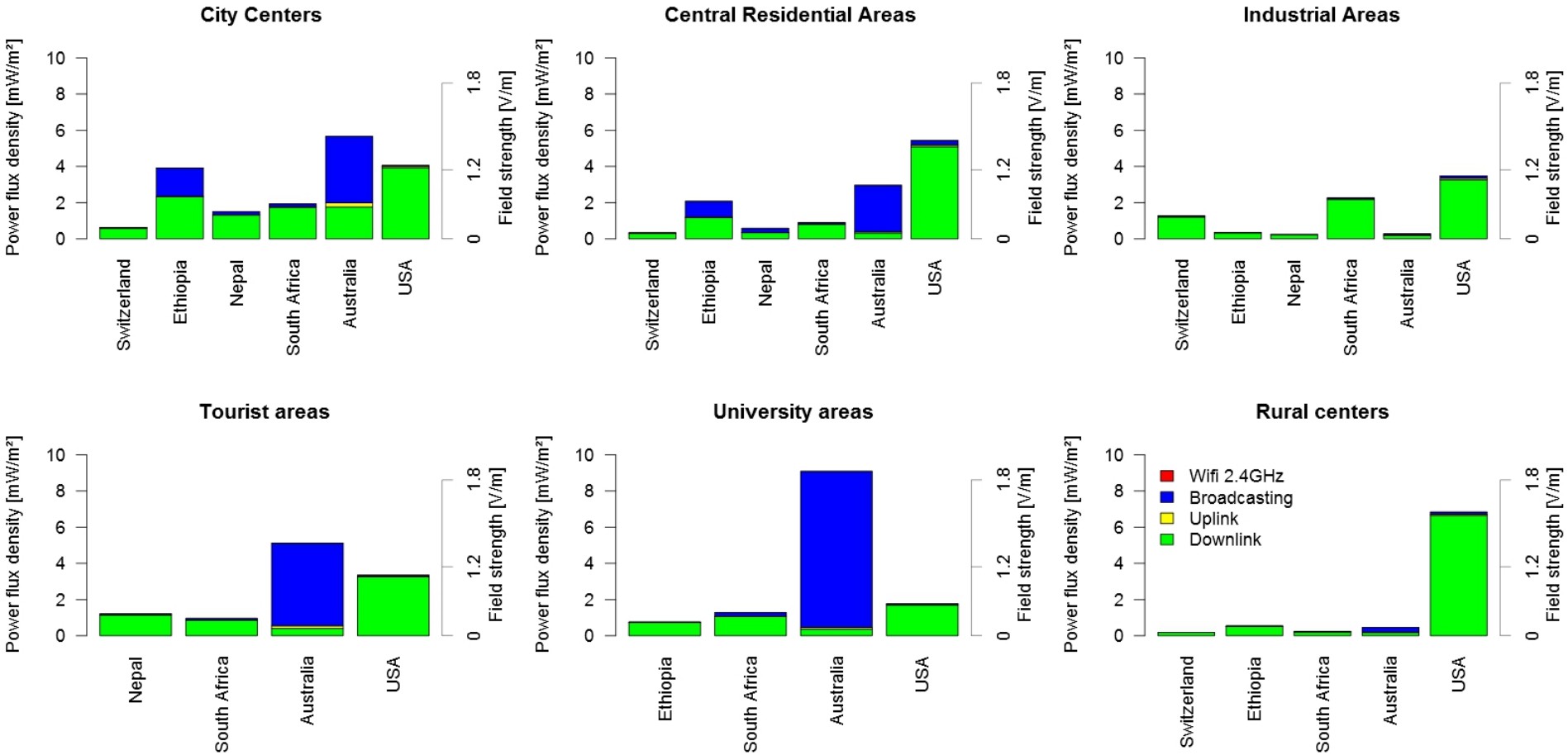


Sanjay Sagar^{a,b,c,d,e}, Seid M. Adem^{a,b}, Benjamin Struchen^{a,b}, Sarah P. Loughran^d,
Michael E. Brunjesⁱ, Lisa Aranguaⁱ, Mohamed Aqiel Dalvie^c, Rodney J. Croft^d, Michael Jerrett^e,
Joel M. Moskowitz^f, Tony Kuo^{g,h}, Martin Röösli^{a,b,*}

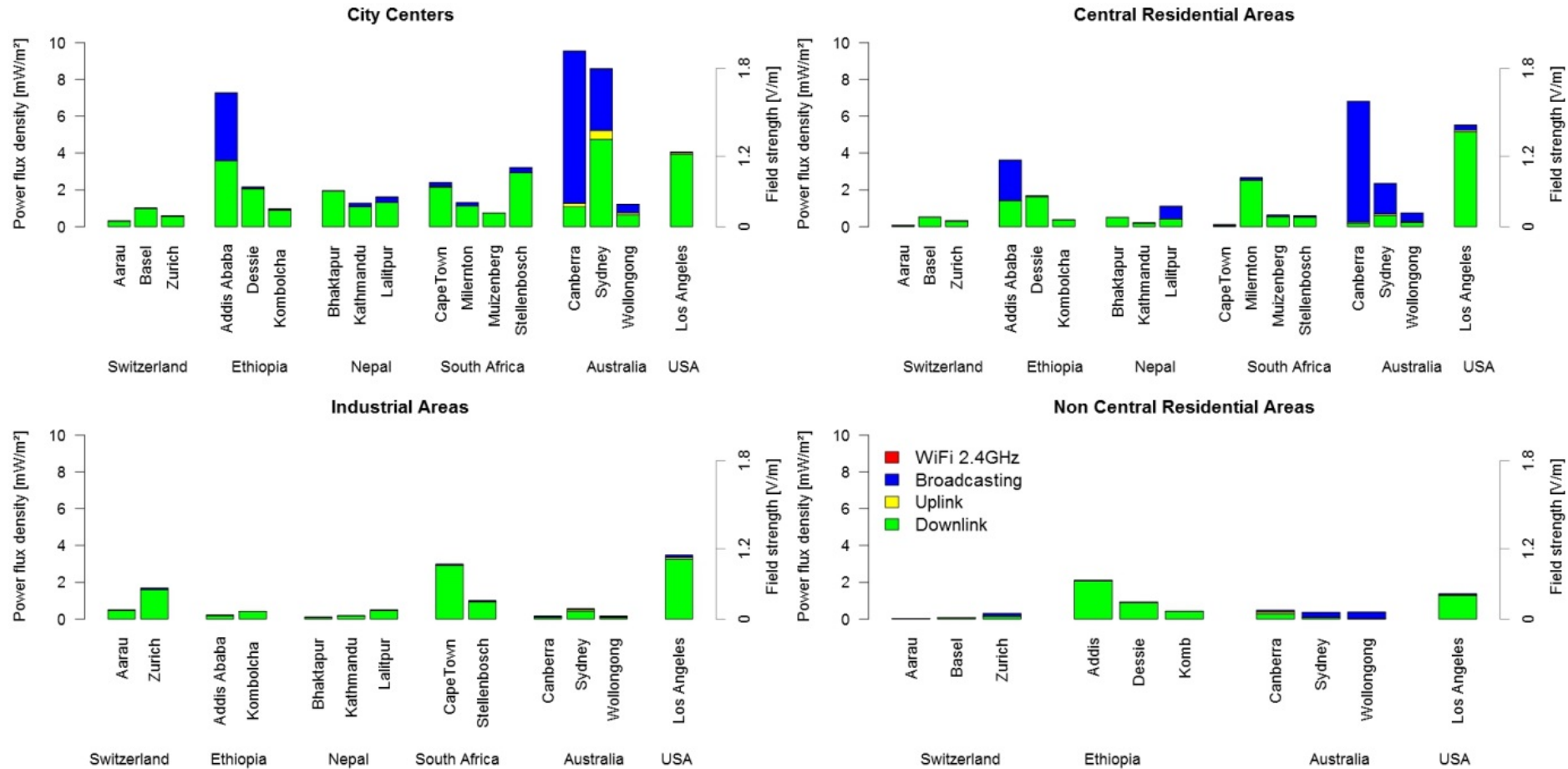


Result: International Comparison

ICNIRP reference levels:
40-60 V/m

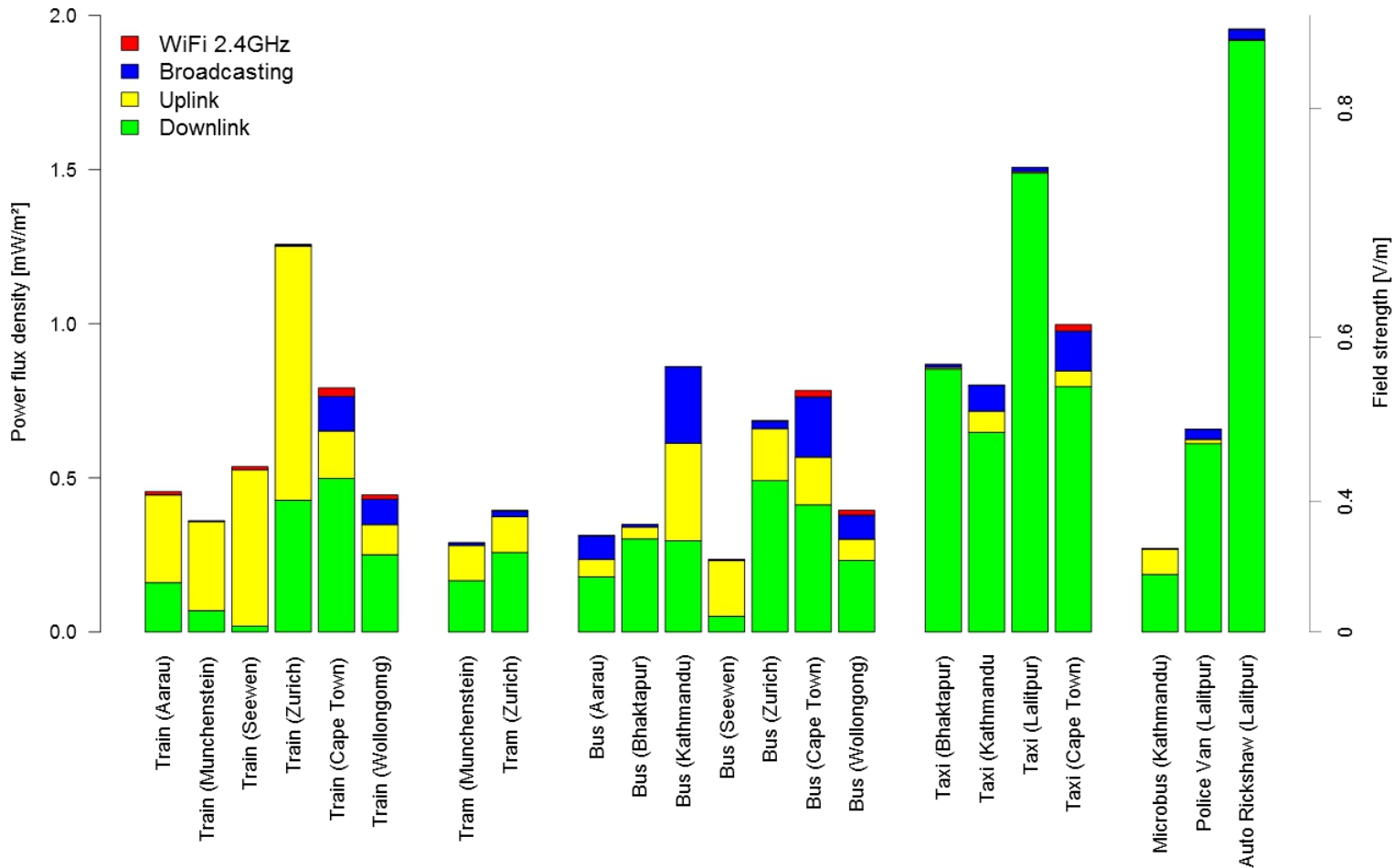


Result: International Comparison



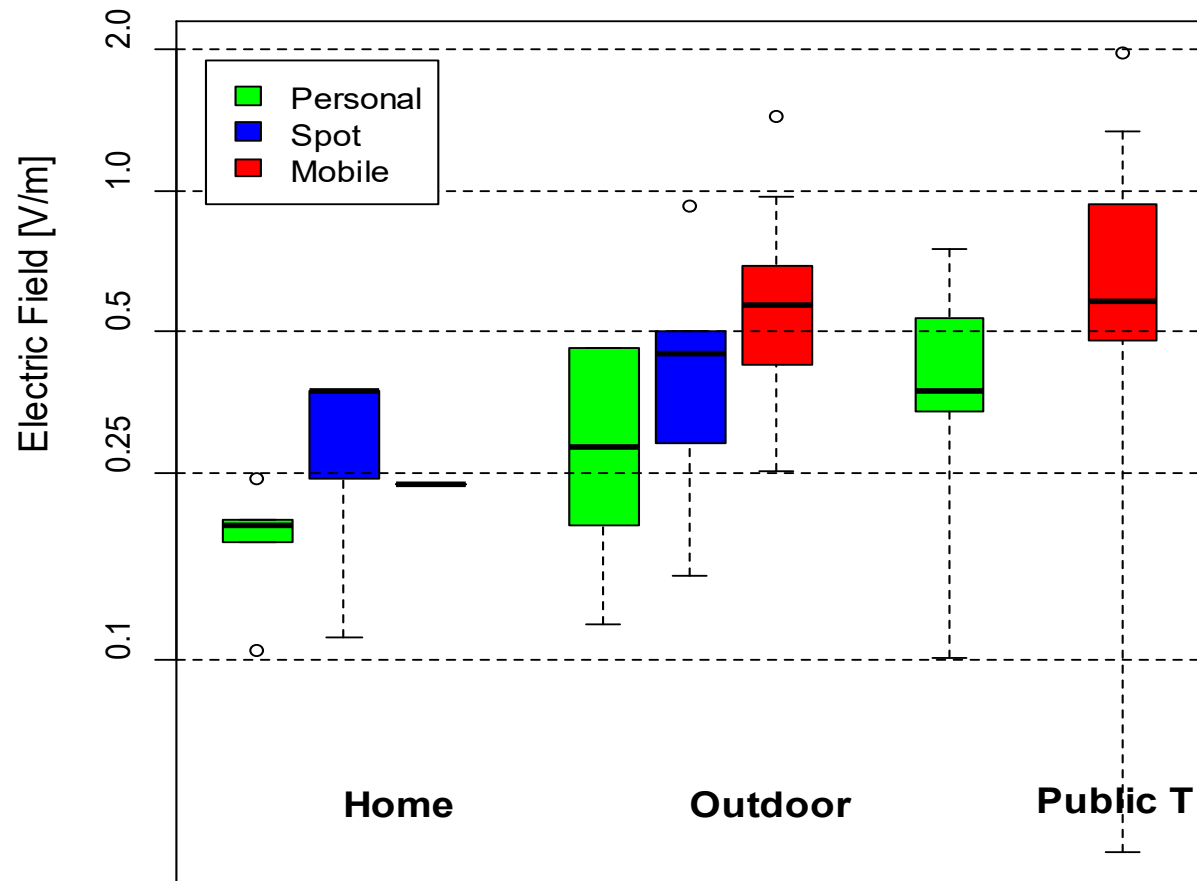
Result: International Comparison

Public Transportation including Taxi and Auto Rickshaw



Sagar et al, Env Int 2018

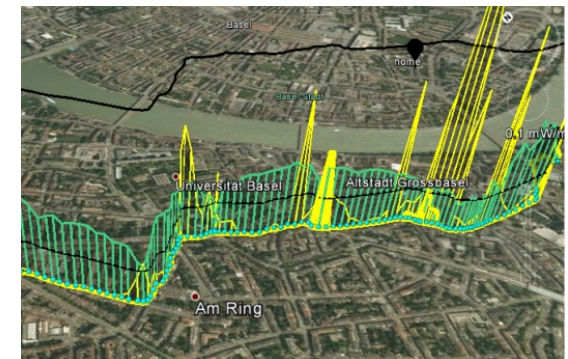
Radiofrequency electromagnetic field exposure in everyday microenvironments in Europe: A systematic literature review



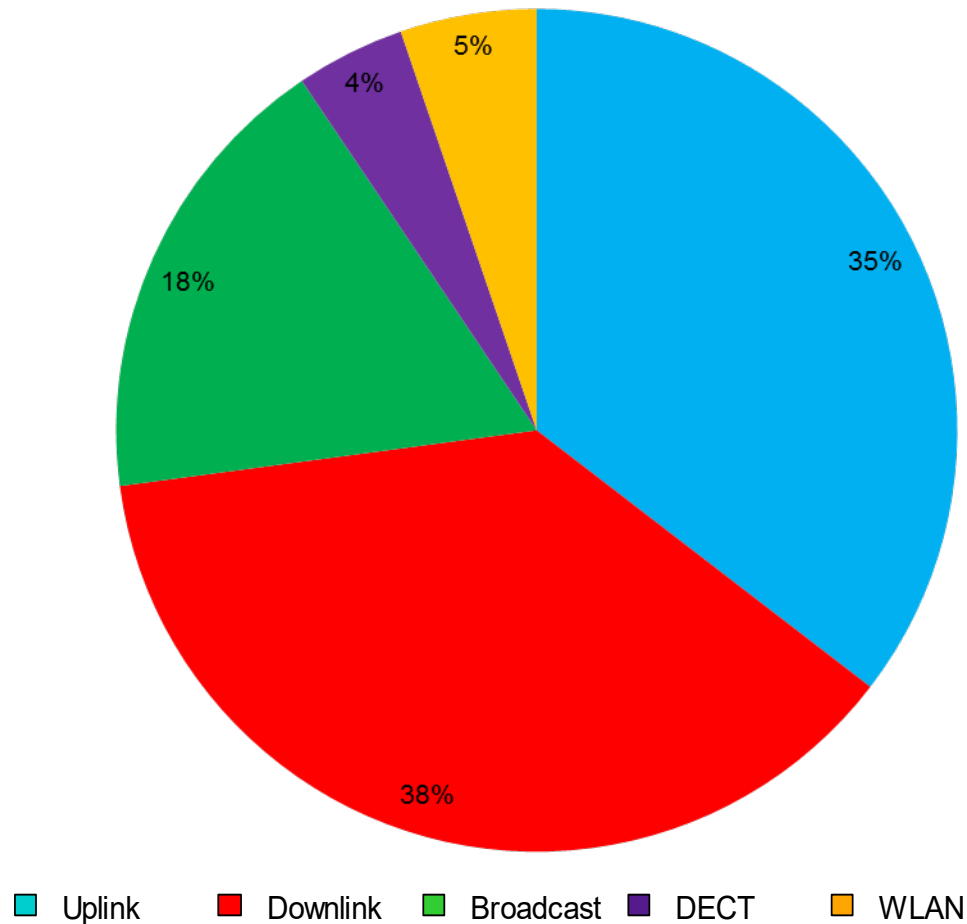
Adapted from Sagar et al, JESEE, 2017

ZüMe: Population based personal radiofrequency electromagnetic field exposure measurements in Zurich

- Random population sample from 12 communities from canton of Zürich (Switzerland) with various degrees of urbanity
- 42 pairs of one parent and adolescent (12-15 years) and 30 young adults (18-30 years)
- Measurements conducted: 21 Feb. – 2 Nov. 2015
- Measurement device ExpoM-RF: 14 frequency bands between 88 MHz – 2690 MHz
- Electronic diary app, GPS recorded by Expom-RF
- Full report (in German): Rösli et al., 2016:
http://www.awel.zh.ch/content/dam/audirektion/awel/luft_asbest_elektrosmog/elektrosmog/dokumente/PersMeas_AWEL_2016.pdf

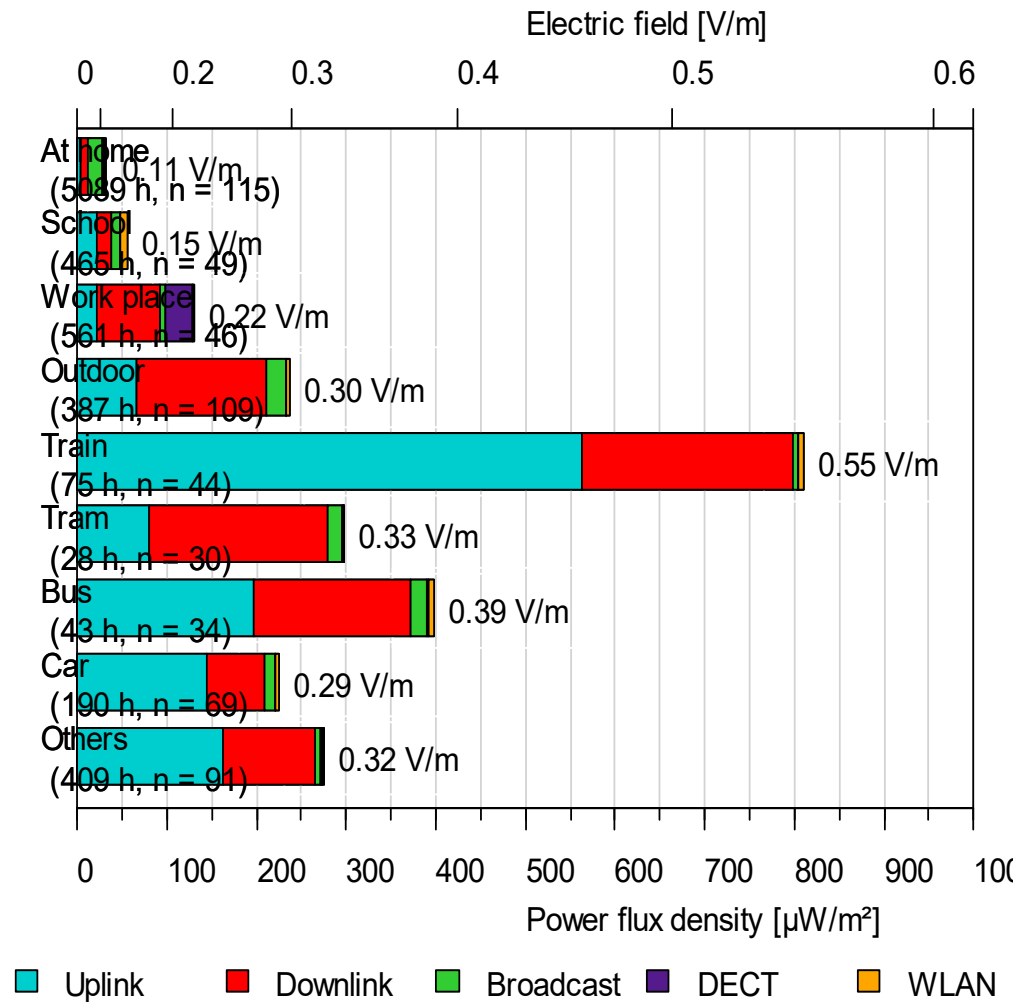


Average source contributions (mean=0.18 V/m)

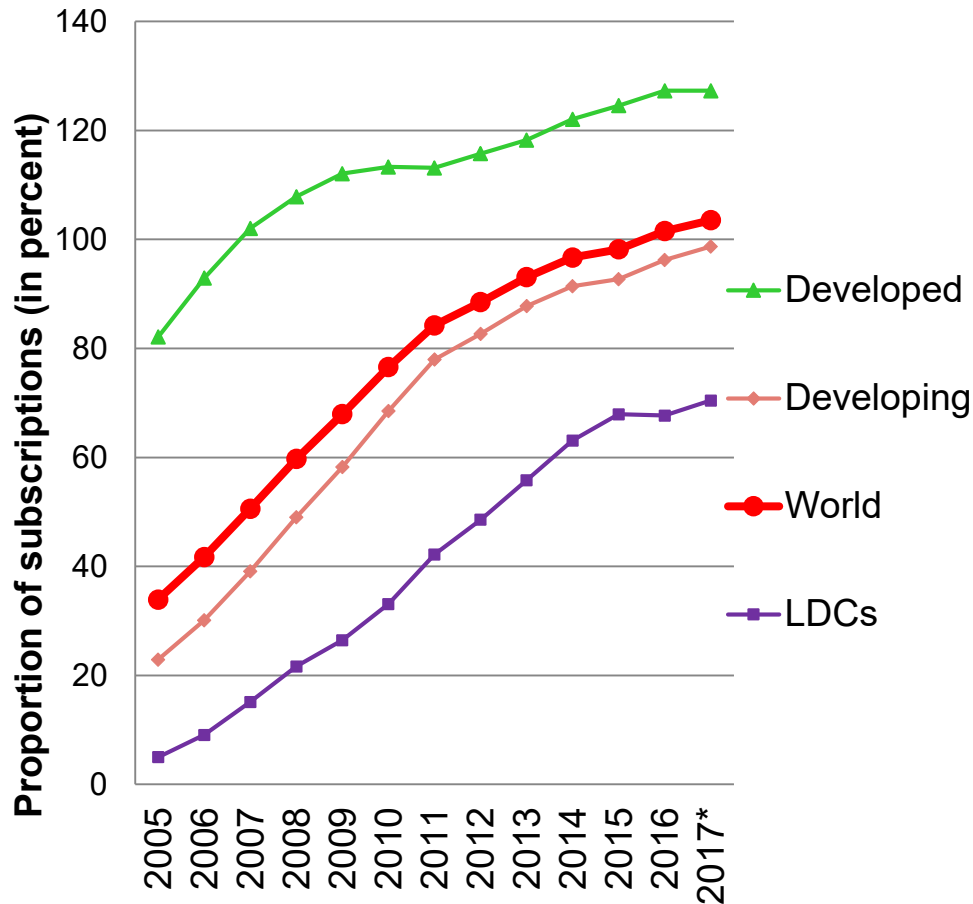


Röösli et al, 2016

RF-EMF per activity

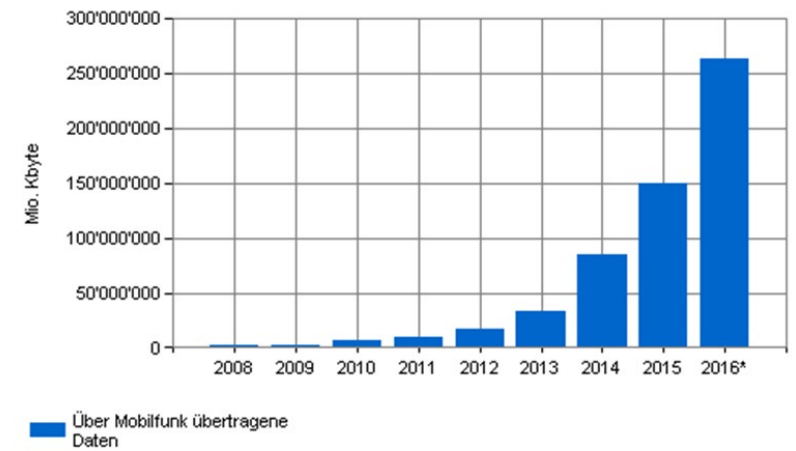


Mobile phone subscriptions and data transmission



ITU, 2017

Data transmission in CH

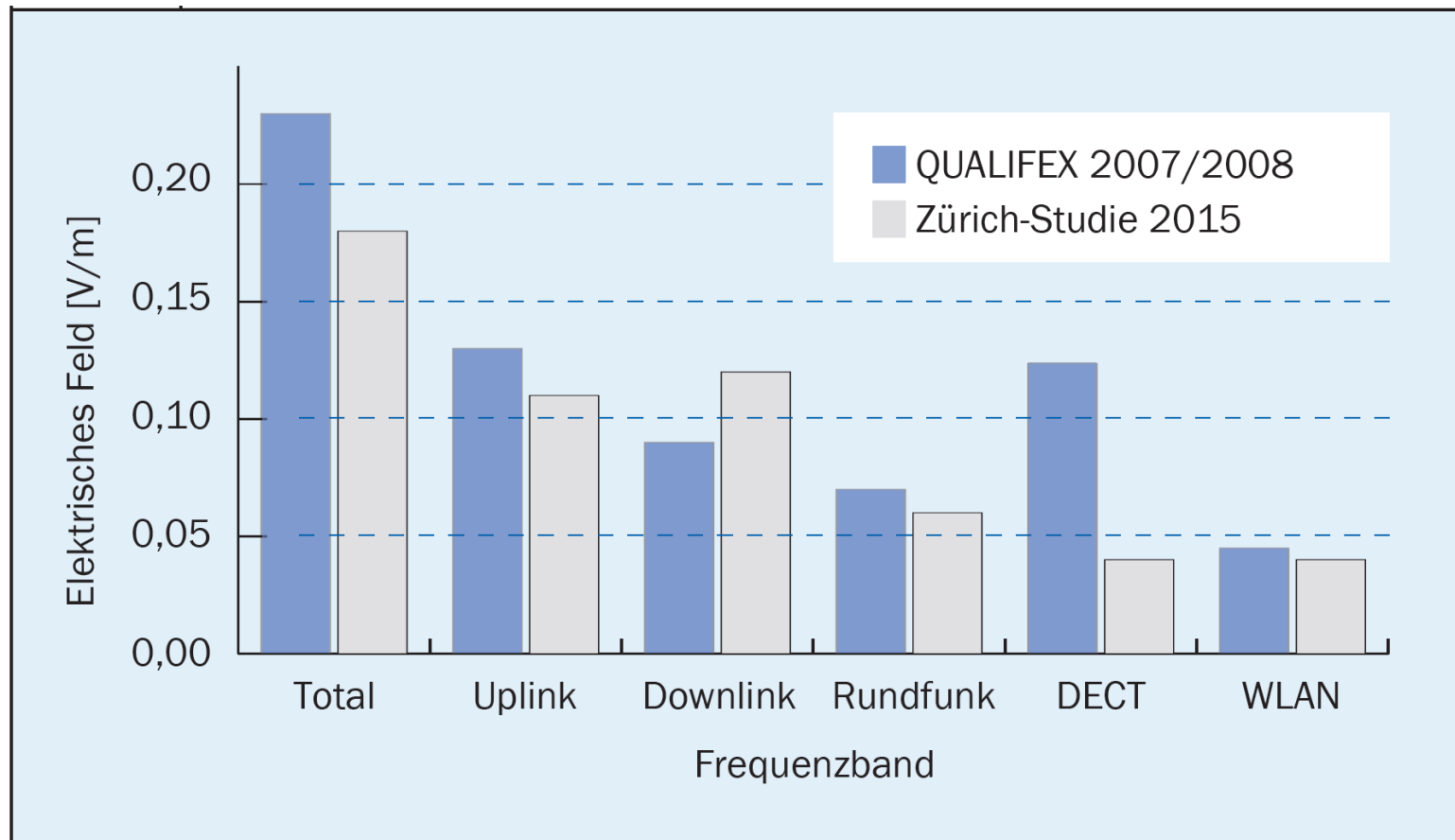


*provisorischer Wert

<https://www.bafu.admin.ch/>



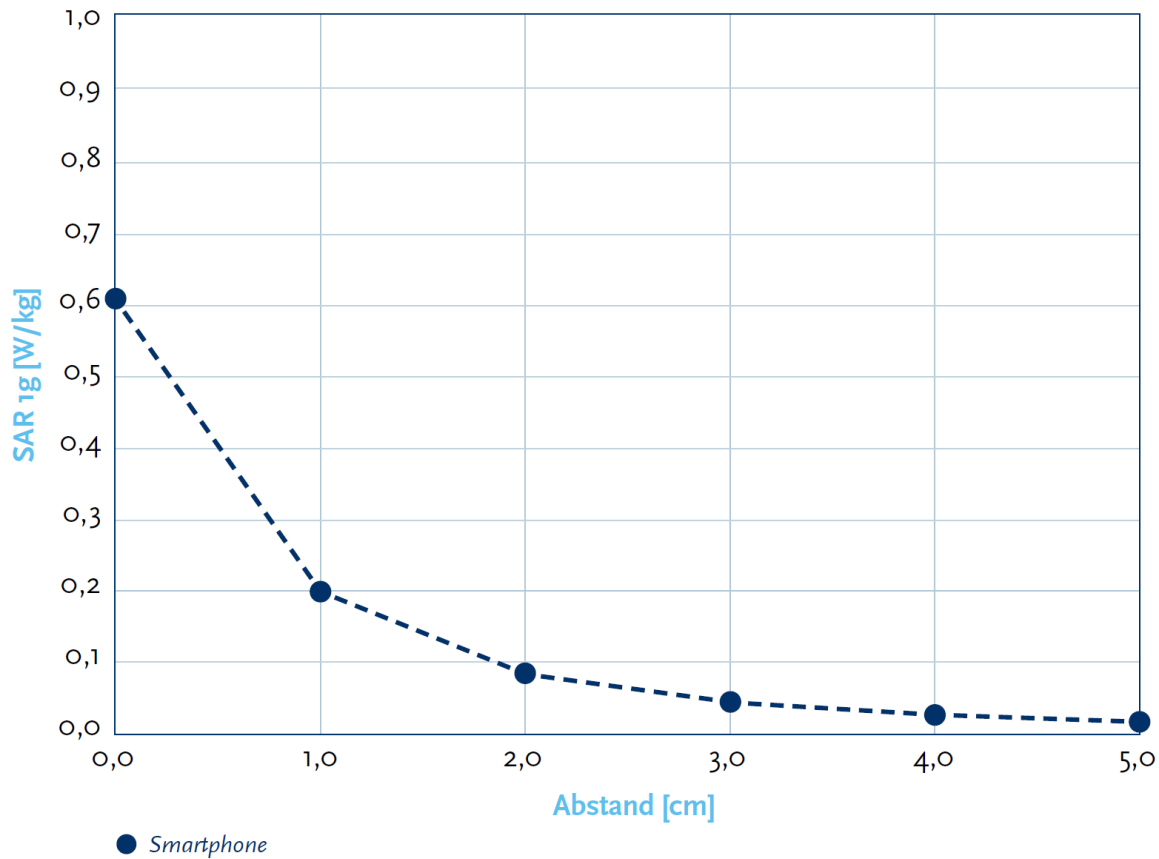
Comparison of personal RF-EMF exposure (2007 vs 2015)



Röösli & Dongus, HP, 2019

Exposure vs. distance to the source

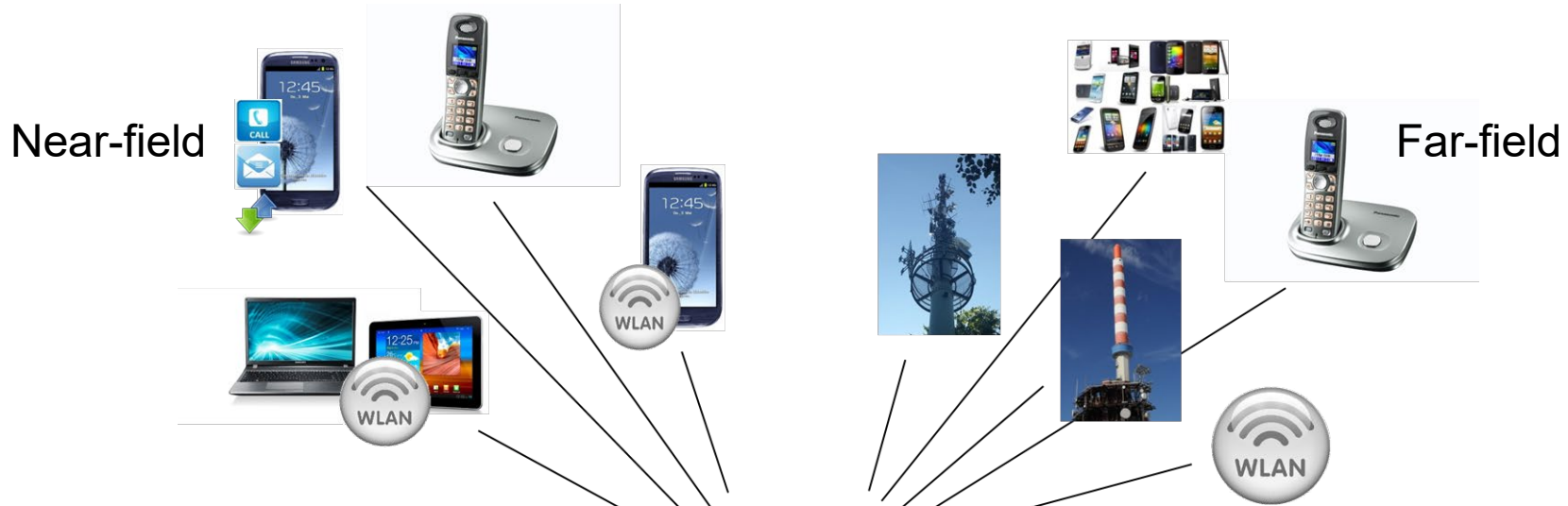
Abbildung 2: SAR-Messungen an einem Smartphone



SAR = Specific Absorption Rate

IZMF, 2015

RF-EMF dose calculation



dose =
*output power * SAR * use duration*

dose =
*incident field * SAR * exposure duration*



brain



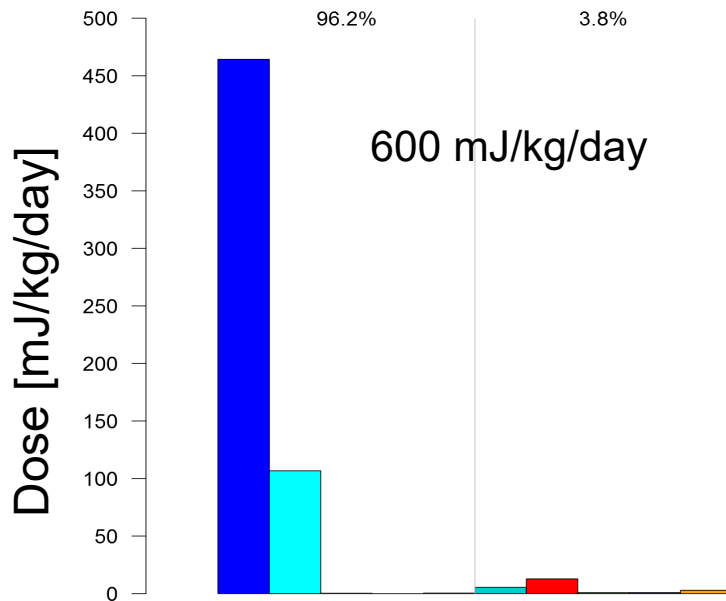
whole body

Roser et al., IJERPH, 2015

SAR = normalized Specific Absorption Rate
RF-EMF = radiofrequency electromagnetic fields

Average cumulative dose

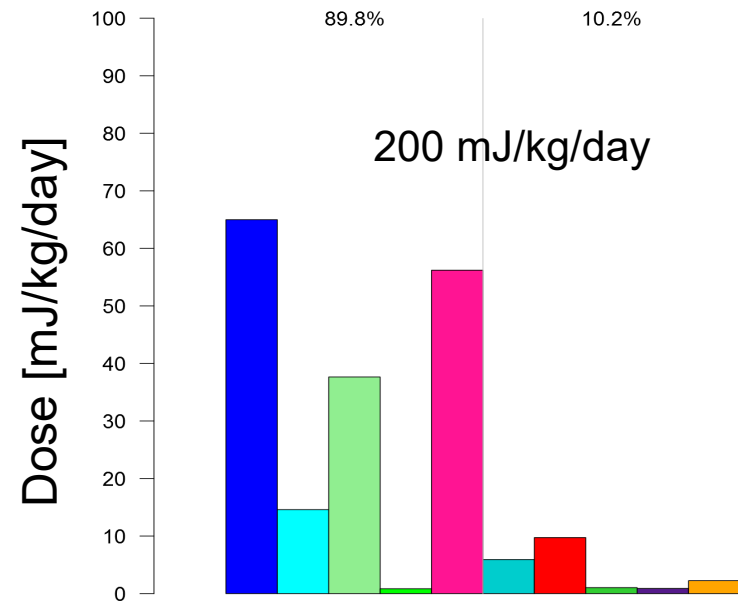
Brain



Close to body

- Mobile phone calls
- Cordless phone calls
- Mobile data traffic
- Mobile phone stand-by data traffic
- WLAN Computer, laptops, tablets

Whole body



Far field

- Broadcasting
- Mobile phone base stations
- WLAN access points
- DECT cordless phone base stations
- Mobile phones

UMTS phones emit 100-500 times less than GSM phones!

GSM:

Adapted from Vreiheid, OEM, 2009

Study centre	900 MHz				1800 MHz			
	No of calls	Output power per call (mW)			No of calls	Output power per call (mW)		
		Mean (SD)	Median	Interoperator range [§]		Mean (SD)	Median	Interoperator range
Sweden	4185	118.2 (95.2)	101.6	67.6–146.5 [†]	2366	52.1 (47.4)	36.2	45.5–68.7
Total	46994	133.3 (91.7)	127.2	67.6–204.0 [‡]	29505	64.2 (45.5)	57.8	44.7–99.0 [‡]

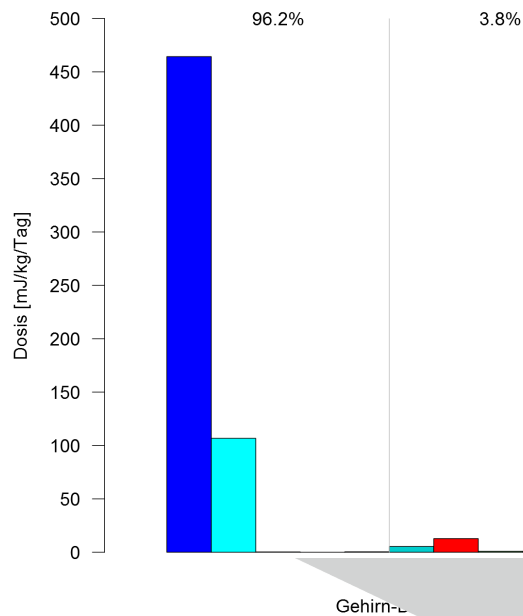
UMTS:

Location	Median	Mean	90th percentile
Rural	0.04	0.5	0.7
Suburban	0.02	0.4	0.4
Urban	0.02	0.4	0.4
Dense urban	0.008	0.3	0.3
Indoor net	<0.008	0.2	0.1

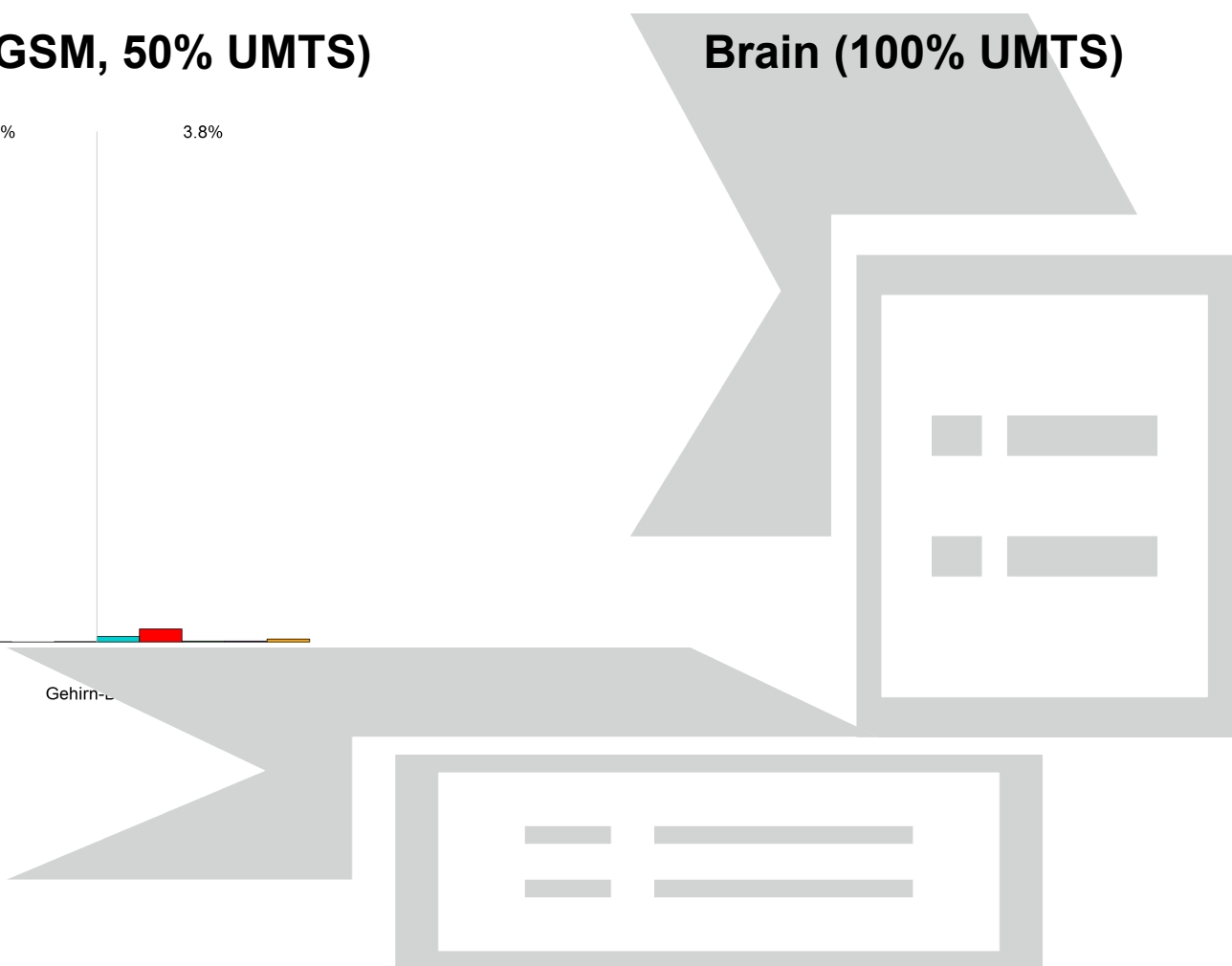
Persson et al., BioEM, 2012

Brain dose Züme: exposure reduction with UMTS call only

Brain (50% GSM, 50% UMTS)



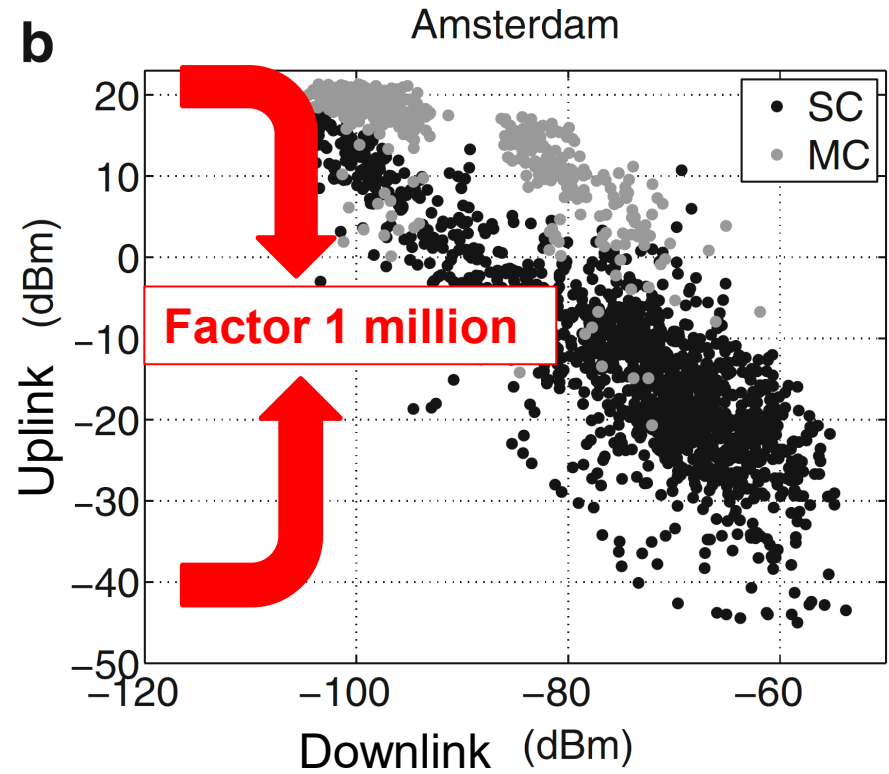
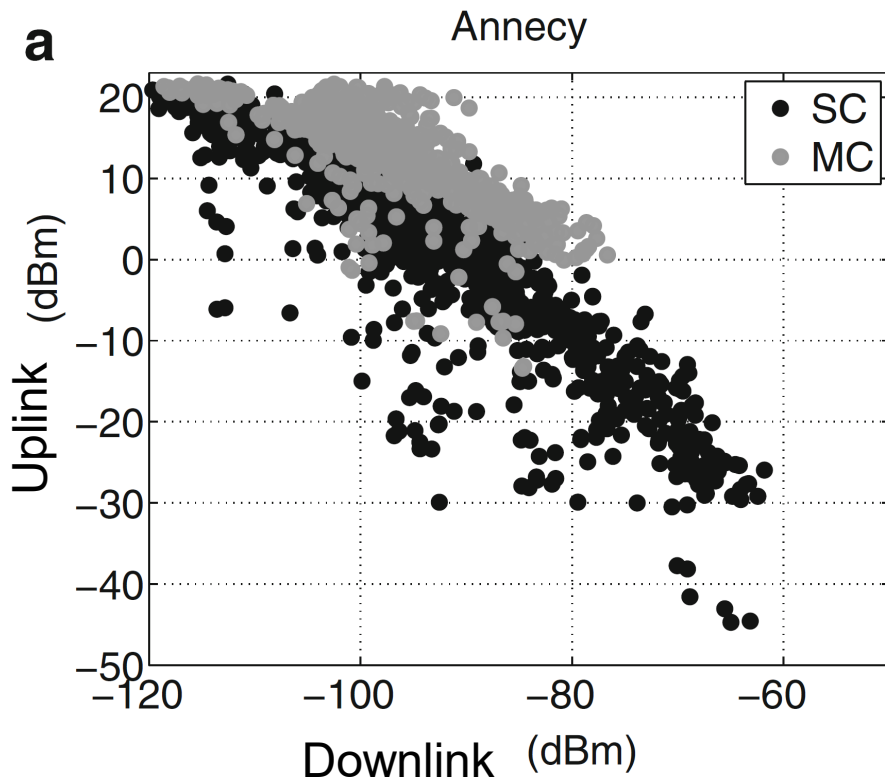
Brain (100% UMTS)



The better the network the less exposure

Example mobile internet in LTE

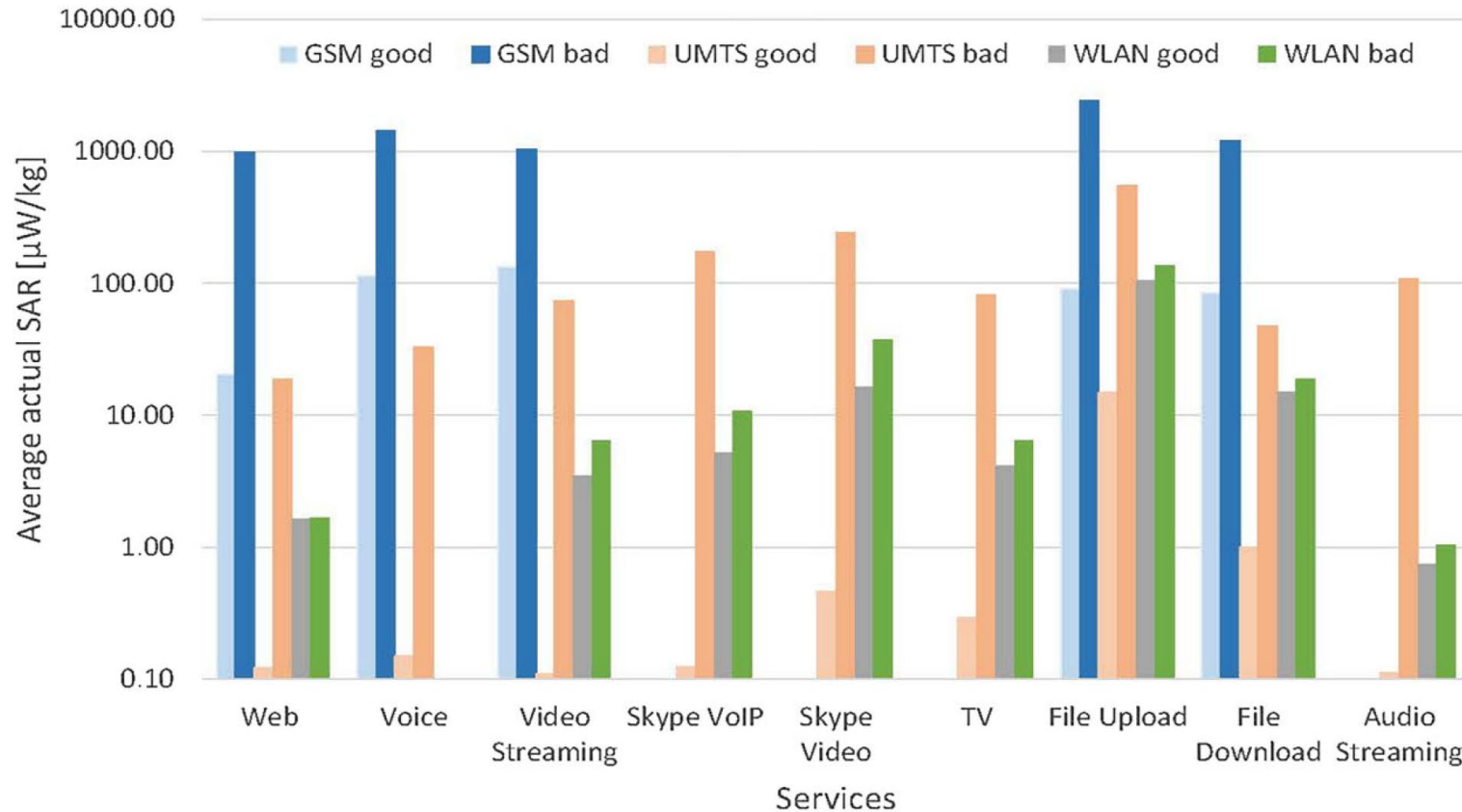
● MC=makro cell ● SC=Small Cells



Mazloun et al., AnnTel, 2019



The better the connection, the less radiation from the devices



Popović, Ann Telecommun, 2019

Brain and electronic media



Content?

Blue
light?

EMF?

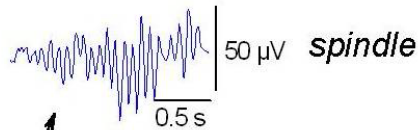


Human experimental trials in the sleep laboratory

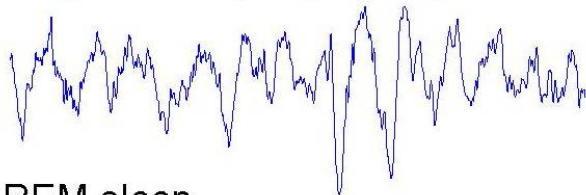
waking



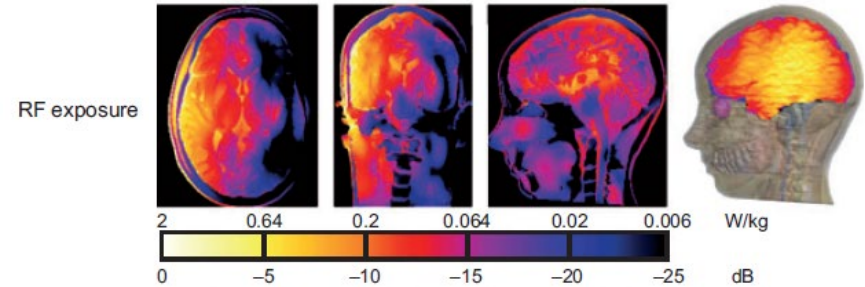
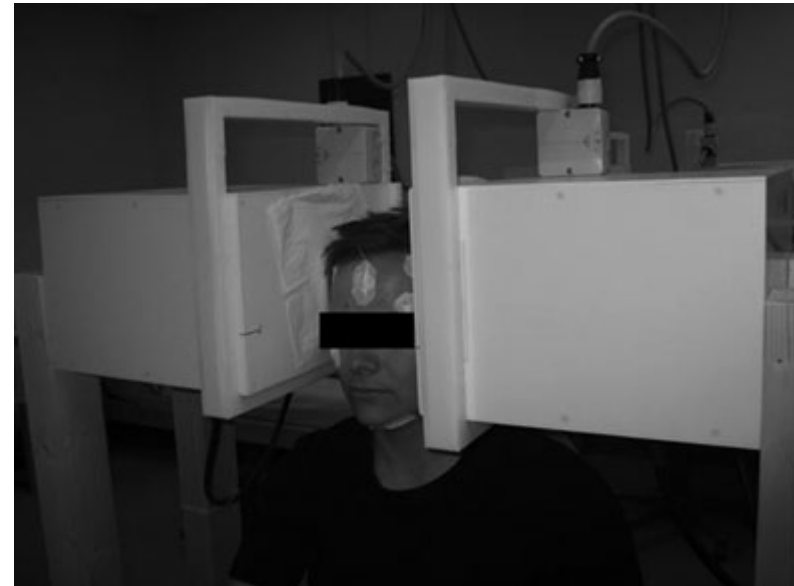
stage 2



stages 3 & 4 (deep sleep)



REM sleep

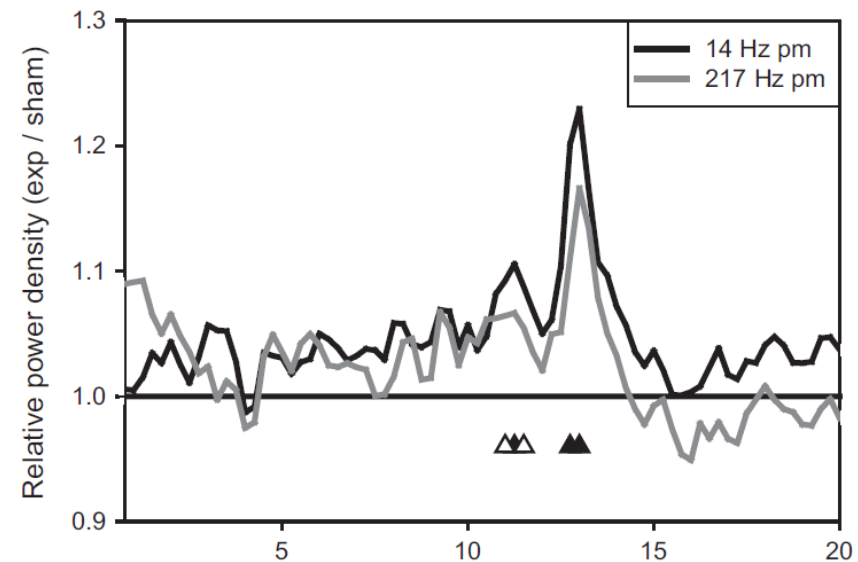


Schmid et al. JSR, 2012



Results

- Amplitude in spindle frequency range increased.
- No effects on sleep phase.
- No effects on subjective sleep quality.



Schmid et al. JSR, 2011

Research

A Section 508–conformant HTML version of this article is available at <https://doi.org/10.1289/EHP2427>.

A Prospective Cohort Study of Adolescents’ Memory Performance and Individual Brain Dose of Microwave Radiation from Wireless Communication

Milena Foerster,^{1,2} Arno Thielens,^{3,4} Wout Joseph,^{4,5} Marloes Eeftens,^{1,2} and Martin Röösli^{1,2}

¹Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

²University of Basel, Basel, Switzerland

³Department of Electrical Engineering and Computer Sciences, Berkeley Wireless Research Center, University of California Berkeley, Berkeley, California, USA

⁴Interuniversity Microelectronics Centre (IMEC), Leuven, Belgium

⁵Department of Information Technology, Waves research group, Ghent University

Environmental Health Perspectives

077007-1

126(7) July 2018

HERMES (HHealth Effects Related to Mobile phonE uSe)



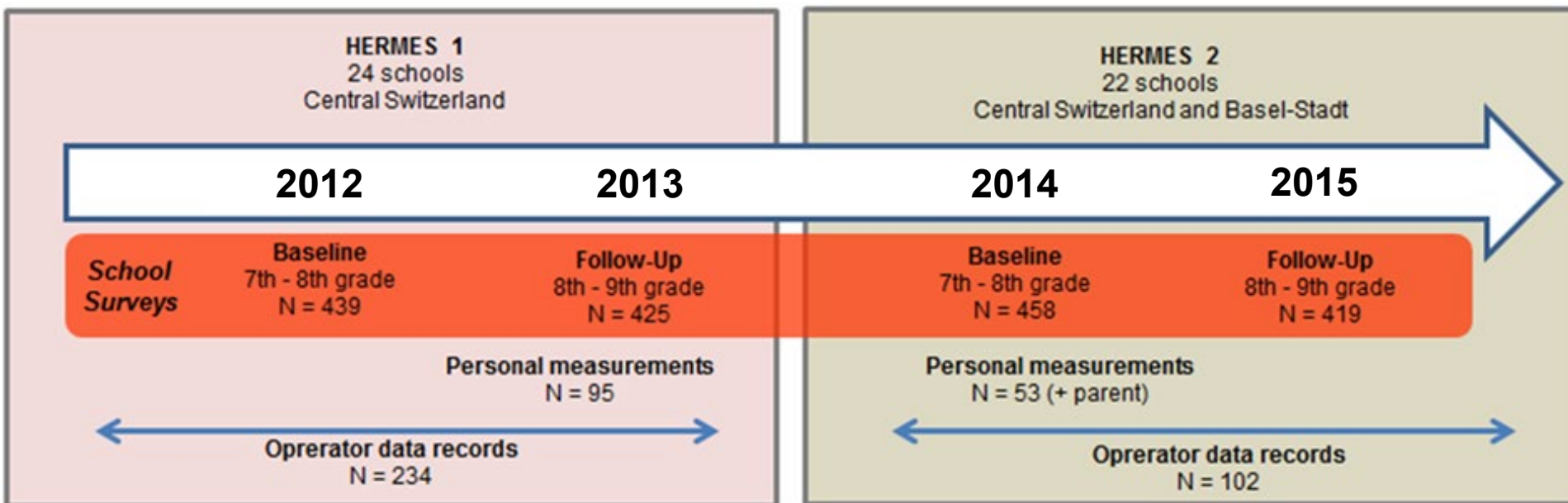
HERMES Kohorte bei Jugendlichen

Survey in Swiss schools

- Mobilfunk und Mediennutzung
- Verhalten, Symptome und kognitive Funktionen
- EMF Expositions- und Dosismodellierung



Parental survey



Summary HERMES

- Symptoms related to night-time use, texting and browsing but not to EMF
- Behaviour: related to self-reported usage but not objective data and no longitudinal association -> recall bias or reverse causality
- Memory: Processes in most exposed brain areas may be affected
- Underlying mechanism for EMF effects not understood
- Strengths:
 - Longitudinal design
 - Objective usage data
 - Dose modelling
- Confirmation in additional research needed.

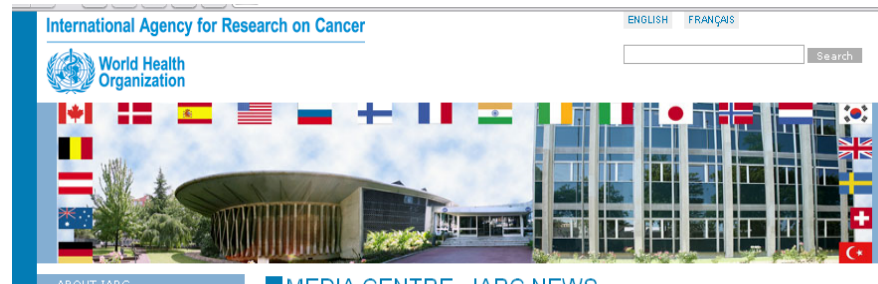
Brain tumour and mobile phone, why?

- No direct DNA damage (non-ionizing radiation)
- Hypothetical biological mechanisms discussed (e.g. free radicals, DNA repair mechanism, oxidative stress) but no mechanism established for radio- and microwave frequency radiation
- Head is most exposed part of the body when using a mobile phone
- In-vivo and in vitro studies mostly negative but some ambiguous/positive findings.





IARC Classification for RF-EMF 2011, 31. May 2011



Possibly Carcinogenic to Humans (Group 2B):
 Limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals

Statistics

GLOBOCAN 2008 is released and is part of the *CANCERmondial* website

FACT SHEETS

-- Select a cancer --

or

-- Select a country or region --

GO

activities. As I travel internationally I ask people what they look to the Agency for and the Monographs are always among the first things mentioned. It is a highly valued and respected program.

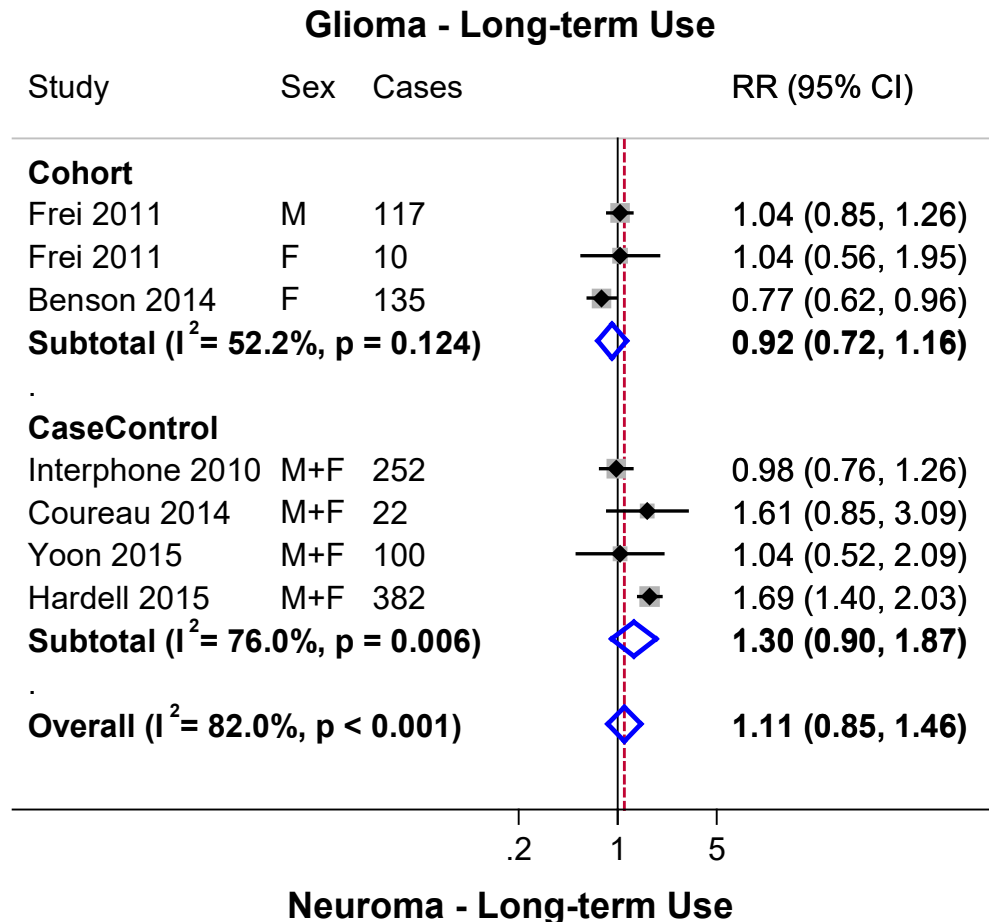
The program was initiated by the late Dr Lorenzo Tomatis and volume 1 appeared in 1972. The program still sits well with the core mission of the Agency, namely that of cancer prevention. Cancer prevention is thankfully increasingly being highlighted. Later this year the United Nations General Assembly will hold a high-level meeting on non-communicable diseases - only the second one ever on a health topic, the first being on HIV/AIDS. Prevention through avoidance of risk factors will be a major focus of the world leaders at that meeting. But of course one cannot prevent unless one first identifies causes and the Monographs are an important part of that process.

Inside the cover of the Monographs you will see stated that the Monograph is the "views and expert opinion of an IARC Working Group". You are a part of the Working Group because you are an acknowledged expert, as testified through your scientific publication record. Your interpretations of the research findings in the field will differ, and indeed we seek a balance of views when establishing the Working Group, but you are chosen on the basis of your expertise. You have much evidence to assess across a range of disciplines and I am pleased that among the manuscripts to be considered are a number of recent ones from the IARC-led Interphone study.

If you are here it is not only also because of your complementary expertise and perspective, it is because none of the information you have provided on your Declaration of Interest form has led us to reconsider your participation.

[Listen to this episode \[mp3 9.5 Mb\]](#)
[Download transcript \(PDF\)](#)
[Read introduction to Vol. 102](#)

Glioma risk for long term mobile phone users (>10 years)

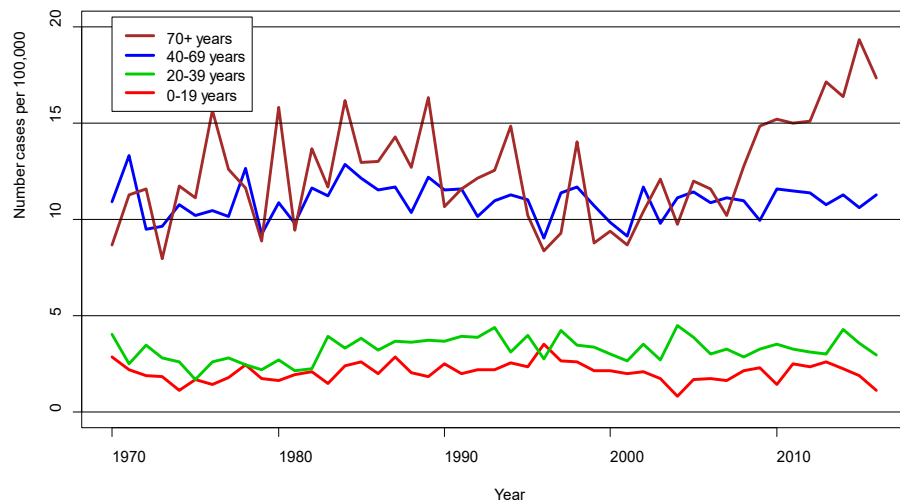


Röösli, Ann Review PH, 2019

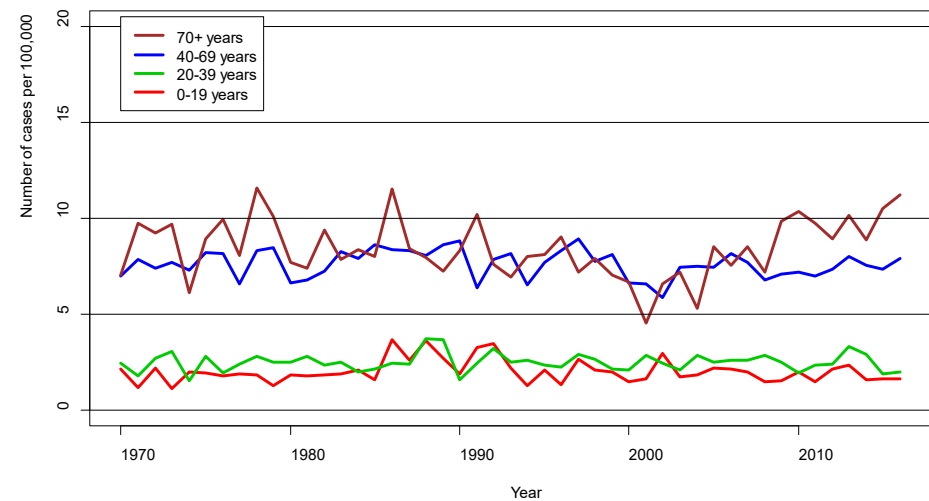
No increase in brain tumours in Sweden at age <70y*

Incidence of brain tumours in Sweden:

A) Glioma, Male



B) Glioma, Female



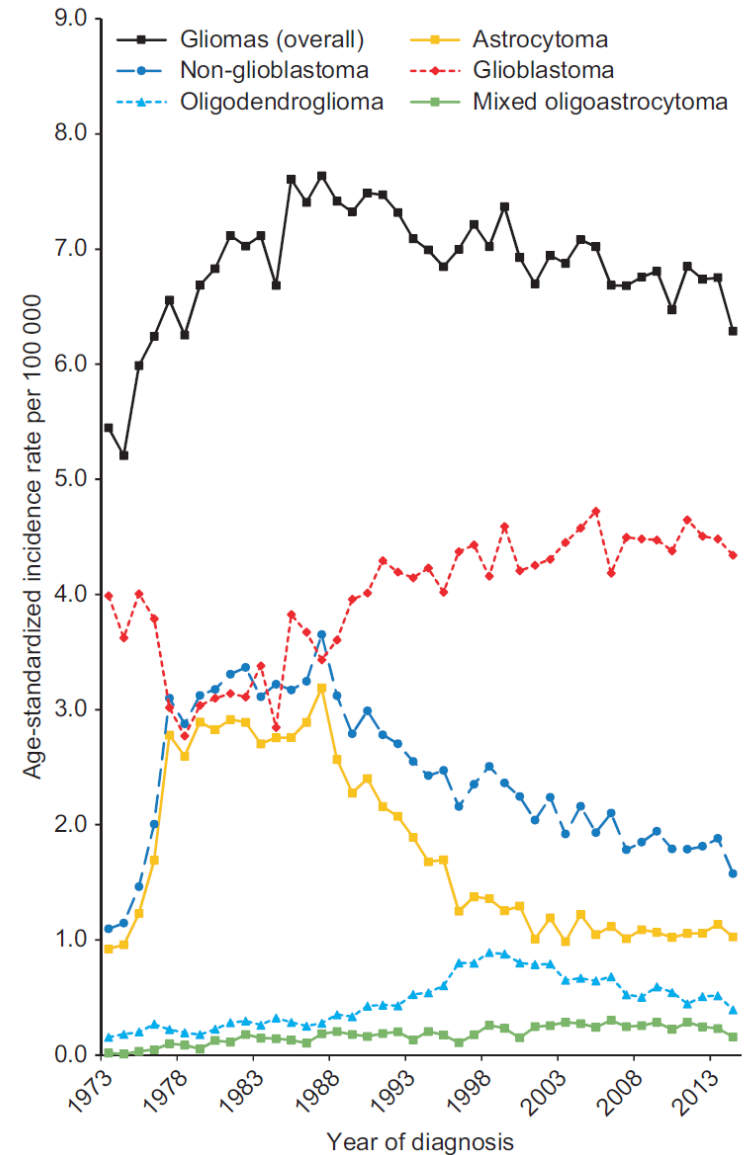
*Why increase at age 70y?

1. Longer life expectancy
2. More diagnostic testing

Röösli, Ann Review PH, 2019

Observed trends in brain tumours

United States

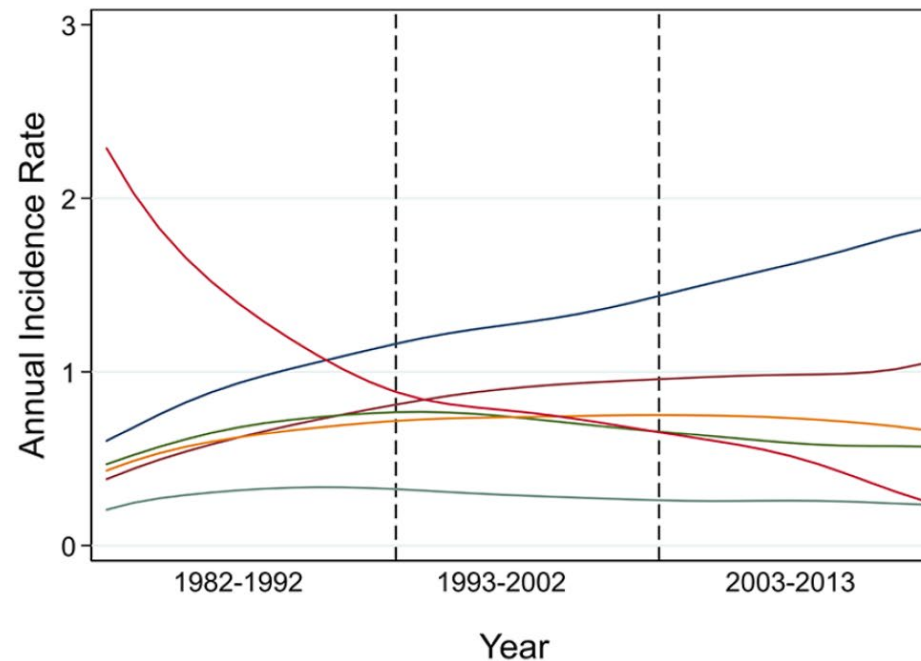


Li, 2018

Increase of temporal tumours?

Smoothed time trends of glioma in 20-59 year adults from Australia:

Topography



Karipidis, 2018

Predictions for brain tumours for the US

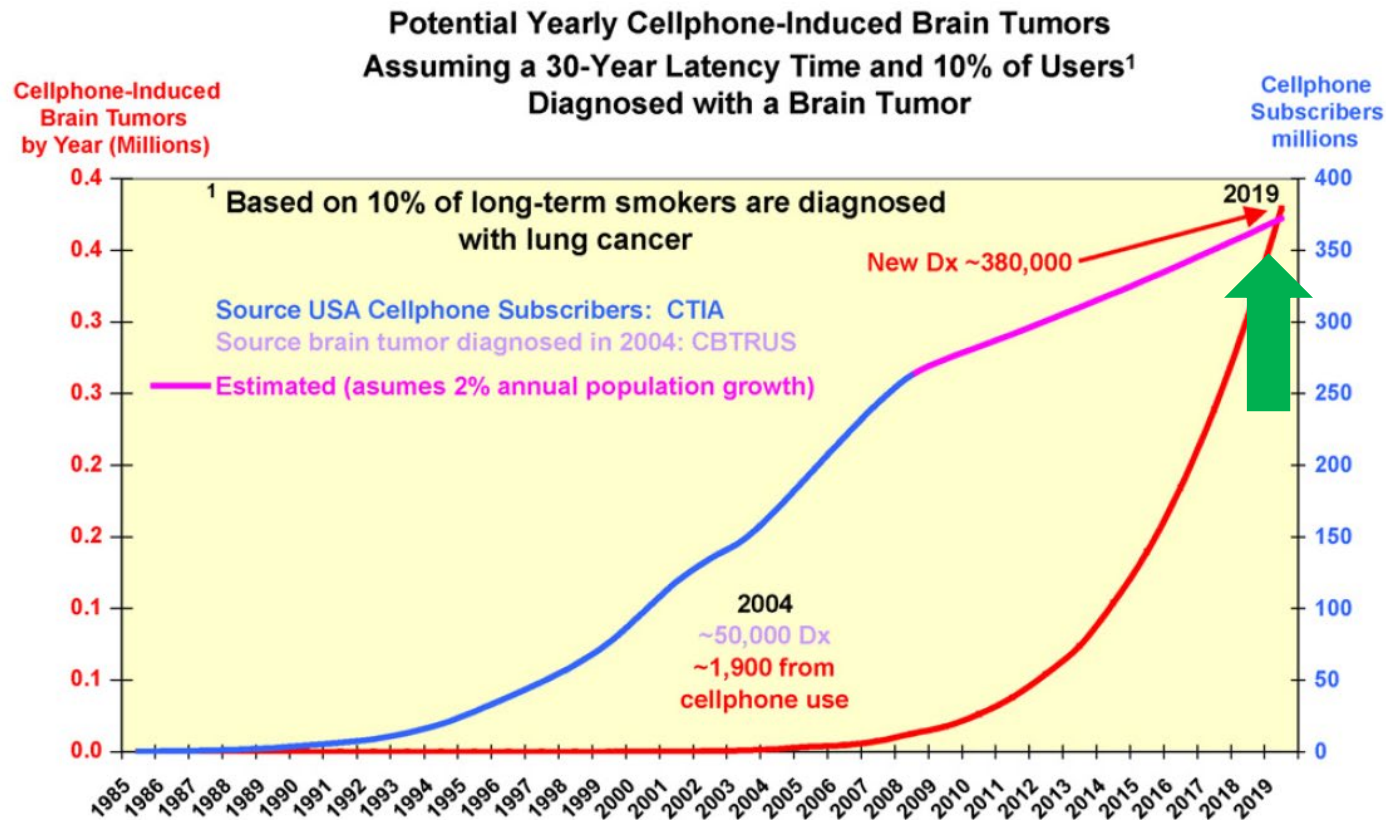


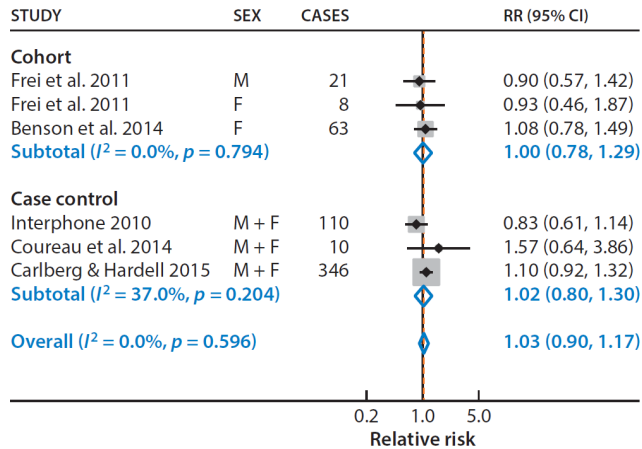
Fig. 1. Long-delay followed by sudden onset of brain tumor epidemic.

Morgan, Pathophys, 2009

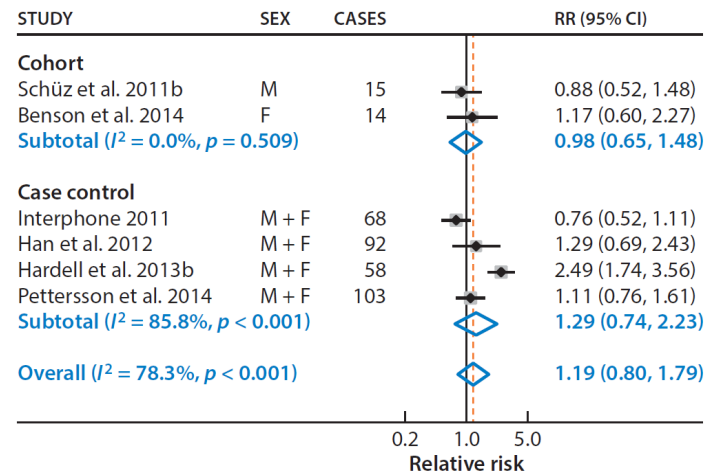


Other tumours of the head

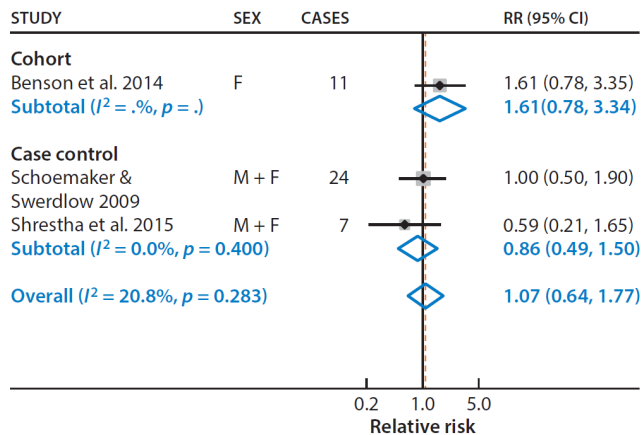
Meningioma (long-term use)



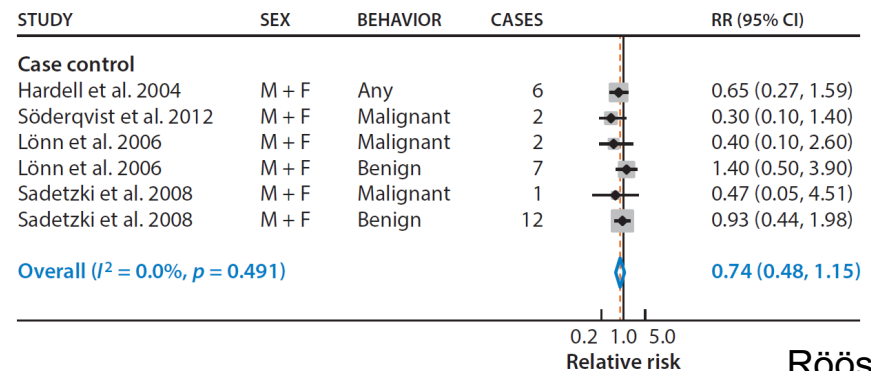
Neuroma (long-term use)



Pituitary tumors (long-term use)



Salivary tumors (long-term use)



Röösli, 2019



Transmitters and childhood leukemia: ecologic studies

Studie	Exposition	Intensität [V/m]	Studientyp	Anz. Fälle	Lymphome und Leukämien	alle Leukämien	akute myeloische Leukämie	akute lymphatische Leukämie	chron. lymphatische Leukämien	chron. myeloische Leukämie	Hodgkin-Lymphom	Non-Hodgkin-Lymphom
Sevin et al. 1992	TV-/Radiosender	< 3,5 km	Cluster	98	0,89 (n.s.) ^{a)}	0,73 (n.s.) ^{a)}					1,23 (n.s.) ^{a)}	1,03 (n.s.) ^{a)}
Maskarinec et al. 1994 ¹⁾	Radiosender (23,4 kHz)	< 4,2 km	Cluster	12			2,09 ^{a),5)}					
Hocking et al. 1996 ²⁾	3 TV-/Radiosender (63–533 MHz)	0,9–5,5 V/m < 4 km	Cluster	1 206 134 ^{a)}		1,24 (1,09–1,40)		1,32 ⁶⁾ (1,09–1,59)		1,00 (0,91–1,32)		
Dolk et al. 1997b	TV-/Radiosender	< 5 V/m < 10 km	Cluster	935	1,04 (0,98–1,11)	1,01 (0,90–1,13)	0,85 (0,68)	1,02 (0,67–1,56)	1,32 (1,08–1,62)	1,05 (0,78–1,42)		1,23 (1,11–1,36)
Dolk et al. 1997a	TV-/Radiosender	< 5 V/m < 10 km	Cluster	3 205		1,03 (1,07)	1,00	1,00 (0,88–1,15)	1,02 (0,95–1,09)	1,00 (0,91–1,10)		
Cooper et al. 2001 ³⁾	TV-/Radiosender	< 5 V/m < 10 km	Cluster		1,08					1,28 (0,95–1,62)		1,06 (0,95–1,17)
Michelozzi et al. 2002 ⁴⁾	TV-/Radiosender	< 95 V/m < 10 km	Cluster									

OR=1.55
(1.00-2.41)

OR=2.09
(1.08-3.65)

OR=1.23
(1.11-1.36)

OR=1.58
(1.07-2.33)

OR=1.32
(1.08-1.62)

- Real risk increase?
- Publication bias?
- Surveillance bias?
- Texas sharpshooter fallacy?

Röösli et al, 2003

All but one risk estimates >1!



Conclusions: transmitters and childhood leukaemia

- 2003: (Small) ecological studies on childhood leukaemia
 - most ecologic studies found increased risk
(eg. Dolk et al., 1997, Hocking et al., 1996, Michelozzi et al., 2002)
- 2016: Four (large) case-control studies:
 - no association between RF-EMF exposure and leukaemias other childhood tumours (Merzenich et al., 2008, Ha et al., 2007, Elliott et al, 2010, Hauri et al, 2014)



Summary

- Public exposure levels substantially below regulatory limits
- Despite increasing wireless communication use, no indication for increase in exposure
- Mobile phone is relevant RF-EMF exposure source
- Subtle effects on the brain may occur at very high exposure levels
- No indication for an increase in tumours of the head.
- No association between exposure from transmitters and childhood leukaemia
- No indication for a risk for other diseases.