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The 13th EMF Forum

Learnings from five years of 5G EMF

Tuesday, 1 October 2024

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#EMFFORUM

Dr Jack Rowley
Senior Director, Research & Sustainability
GSMA

Welcome and introduction

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Evolution of 5G EMF narrative

2019

Mobile phones and health: is 5G being rolled out too fast?

European countries are rolling out 5G mobile communications at breakneck speed as they seek to gain a competitive edge over the US and Asia. But some scientists have raised questions about the effects of 5G mobile phone radiation on public health and are calling for a precautionary approach

2024

THE CONVERSATION

Academic rigour, journalistic flair

5G doesn't affect your health – here are 5 points to put your mind at ease

Published: July 9, 2024 11.57am CEST

Authorities: no health risk expected from 5G

IEEE

ITU

European Commission

BEREC
Body of European Regulators for Electronic Communications

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

Australia
Austria
Belgium
Bermuda
Brunei Darussalam
Canada
China
Costa Rica
Croatia
Czech Republic
Denmark
Estonia
Finland
France
Germany
Hungary
Iceland
India
Ireland
Italy
Japan
Kuwait
Lithuania
Luxembourg
Malaysia
Namibia
Netherlands
New Zealand
Nigeria
North Macedonia
Norway
Poland
Romania
Saudi Arabia
Seychelles
Singapore
Slovenia
South Africa
South Korea
Spain
Sweden
Switzerland
Trinidad and Tobago
Uganda
United Kingdom
United States

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Assessments: RF-EMF levels remain low with 5G

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5G RF-EMF Surveys

Global results demonstrate low 5G levels

5G maximum EMF levels typically less than 1% of international public limit

35 countries, including

- Australia
- Austria
- Belgium
- China
- Colombia
- Croatia
- Denmark
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Japan
- Luxembourg
- Malaysia
- Malta
- Netherlands
- New Zealand
- Nigeria
- Norway
- Poland
- Portugal
- Romania
- Saudi Arabia
- South Korea
- Spain
- Sweden
- Switzerland
- Taiwan
- UK
- USA

Sources

16 Academia surveys

9 Operator surveys

32 Government & regulator surveys

Survey types

Measurements conducted on commercial and trial networks using normal and high data rate traffic

61 surveys

Low-band (<1 GHz)	Mid-band (1-6 GHz)	High-band (>6 GHz)
6	39	11

Indoor small cell	Smart apartment	Rooftop
2	1	2

5G EMF levels across all surveys **0.0000005% to 8.5%** of public limit

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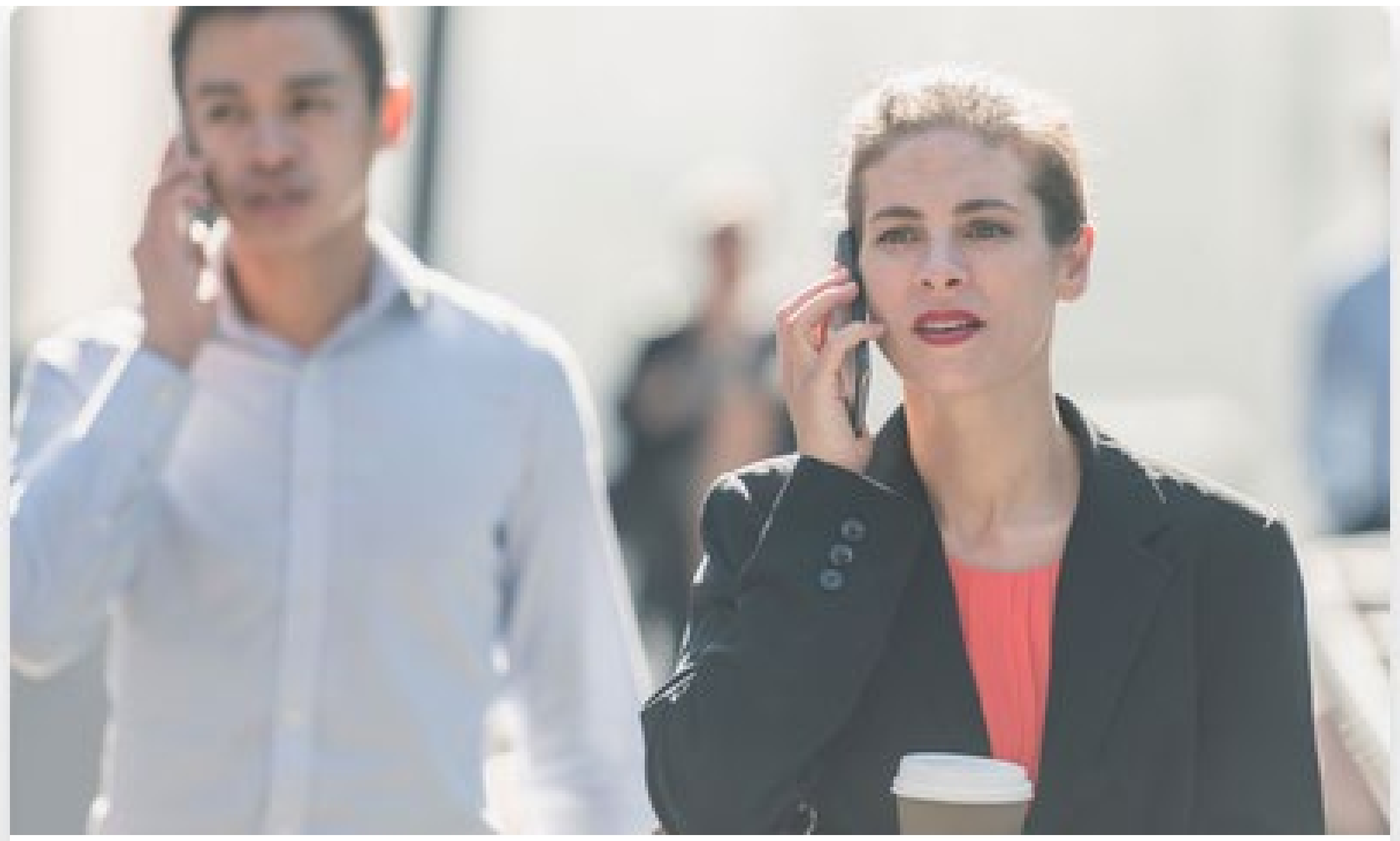
Science: recent studies provide reassurance

Published: 08-03-2024 13:15 | Updated: 08-03-2024 16:35

Mobile phone users who talk for a long time do not have an increased risk of brain tumours



4 Sep 2024

WHO review finds no link between mobile phone use and brain cancer

A World Health Organization commissioned systematic review into the potential health effects from radio wave exposure finds no association between mobile phone use and head cancers.

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Learnings from Five Years of 5G EMF

After five years of rapid rollout of commercial 5G, measurements in 35 countries demonstrate that typical electromagnetic field (EMF) levels across all frequency bands are similar to those of other wireless technologies. Importantly, they remain a small fraction of international limits. By adopting the latest international limits and testing methods countries can ensure protection for all persons from all potential health hazards while at the same time maximising the benefits of 5G connectivity.

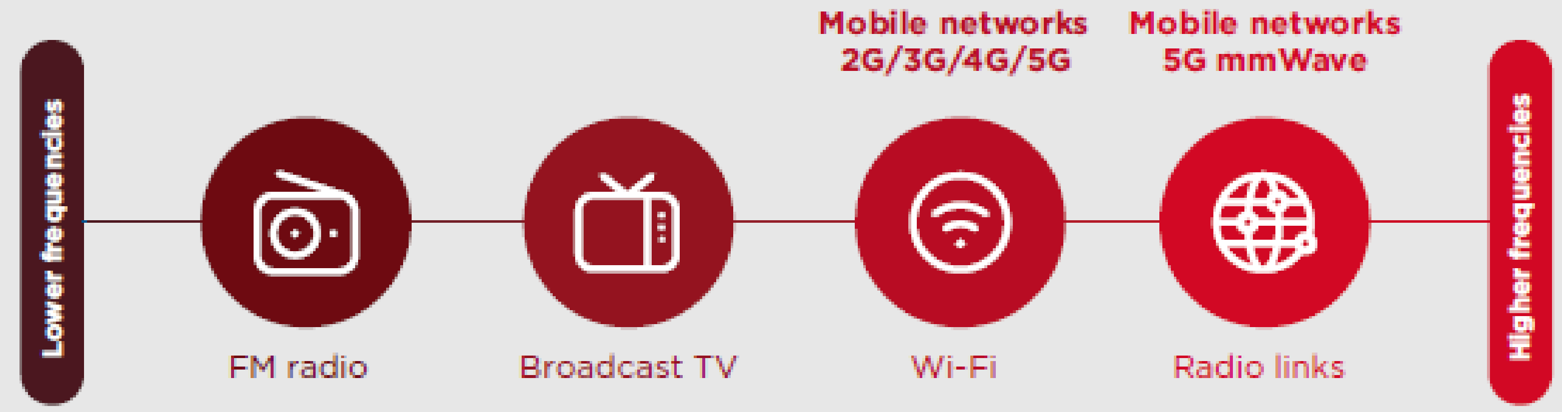
5G rollout

- Rapid user adoption with capabilities still unfolding
- Use of existing and new radio frequency bands
- Forecast to be **56%** of connections by **2030**

5G is designed to support new applications through higher data speeds, faster response times and higher reliability, and a larger number of connected devices, thus expanding the Internet of Things (IoT).

2009 **4G launch** | 2014 **7%** of connections

2019 5G launch | **2024** 23% of connections



International EMF guidelines

- ICNIRP guidelines updated in 2020 incorporated **20+ years** of more research and feedback from **120 organisations**
- **Protect all persons** against all potential adverse health effects
- Adoption momentum building

2G/3G/4G/5G EMF limits similar for mobile networks and devices

Below 6 GHz

Updates for 6 GHz+

Improved scientific accuracy

Evolution of EMF assessments

- Active antennas use RF-EMF more **efficiently**
- IEC and ITU standards provide **accurate** assessment methods
- Implementation underway **globally**

ICNIRP exposure guidelines → National RF-EMF policy ← IEC/ITU compliance standards

Low EMF levels:

- Data for **>20** years shows that everyday mobile network levels remain low
- Technology evolution has **not significantly** changed levels
- Results from **61** surveys across **35** countries show that 5G levels are similar to other wireless technologies

5G maximum EMF levels typically less than 1% of international public limit

"Provided that the overall exposure remains below international guidelines, no consequences for public health are anticipated."

The World Health Organization[2]

Experts identify no health risks

- *'The ICNIRP 2020 RF EMF guidelines protect against all potential adverse health effects relating to exposure to RF EMF, including from 5G technologies.'* - **ICNIRP**[1]
- ICNIRP conclusions supported by **national experts** from countries around the world
- Over **4,300** studies specific to mobile communications

All data and further analysis found at: www.gsma.com/emf

October 2024

1. https://www.icnirp.org/en/applications/5g/index.html
2. https://www.who.int/news-room/questions-and-answers/item/radiation-5g-mobile-networks-and-health

GSMA infographic

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Prof Maria Feychting
Institute of Environmental Medicine,
Karolinska Institute, Sweden

Progress of the international Cohort Study of Mobile Phone Use and Health (COSMOS) study

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COSMOS – Cohort Study of Mobile Phone Use and Health – an update

Maria Feychting, PhD
Professor of Epidemiology
Head, Unit of Epidemiology, Institute of Environmental Medicine, Karolinska Institutet

Karolinska Institutet

Acknowledgements

Our thanks to:

- COSMOS study participants
- Mobile phone network operators in Denmark, Finland, France, the Netherlands, Sweden and the UK for allowing invitation of their subscribers and/or provision of operator traffic data.

Project Funding:

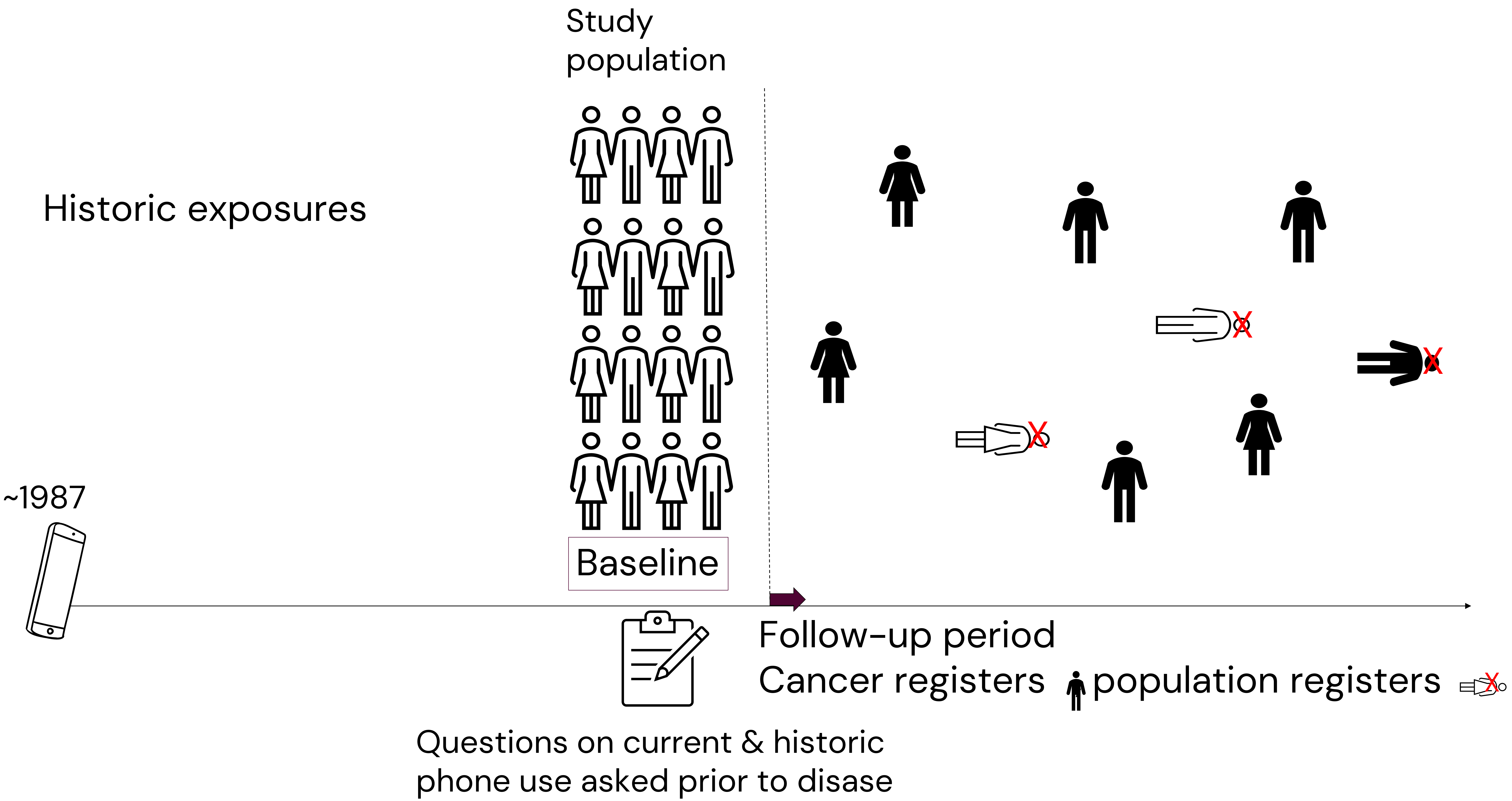
- All funding sources are listed in detail in Feychting et al, Environment Int, 2024
- COSMOS was funded through grant applications to publicly funded research councils or organizations, undergoing the same rigorous and competitive evaluation process as other research grant applications. In some countries, industry complemented the funding either through national research programs led by public authorities without any influence from industry, or by using trusted public authorities as a firewall, with agreements that guaranteed the independence of the researchers.
- It is reasonable that industry contribute to the costs of research into potential health effects of their products, as long as it can be guaranteed that they have no influence on the conduct of the research, and this independence was fully the case in COSMOS.

Background and aim

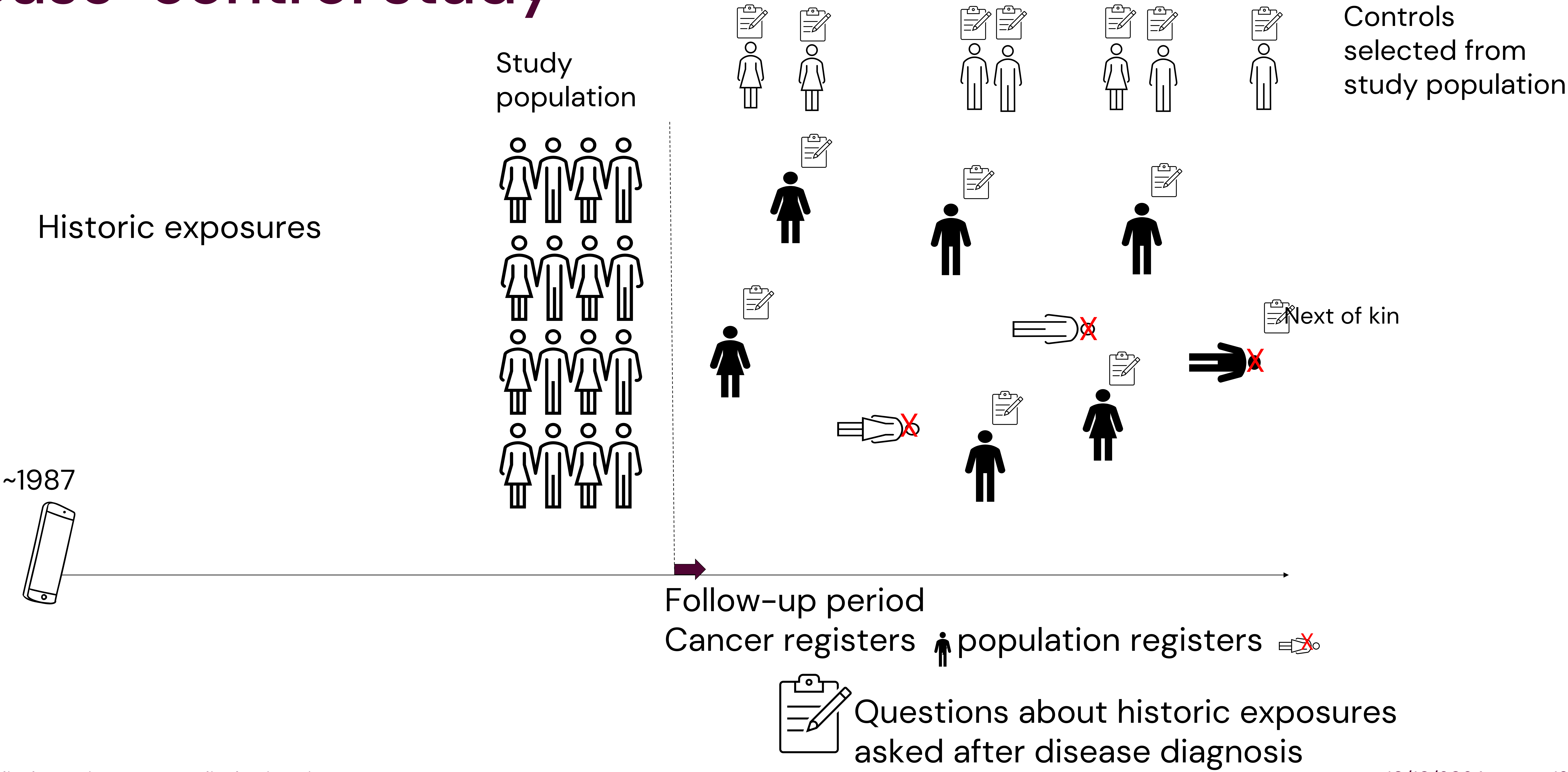
- **Aim: to investigate possible health risks associated with long term use of mobile phones and other wireless technologies**
- Complements previous research, by addressing research gaps highlighted by the WHO regarding long-term mobile phone use and the need for prospective studies
- Major limitations of the case-control studies:
  - → Retrospective collection of exposure information through interviews or questionnaires - differential recall between cases and controls (recall bias)
  - → Selection bias from nonparticipation

COSMOS

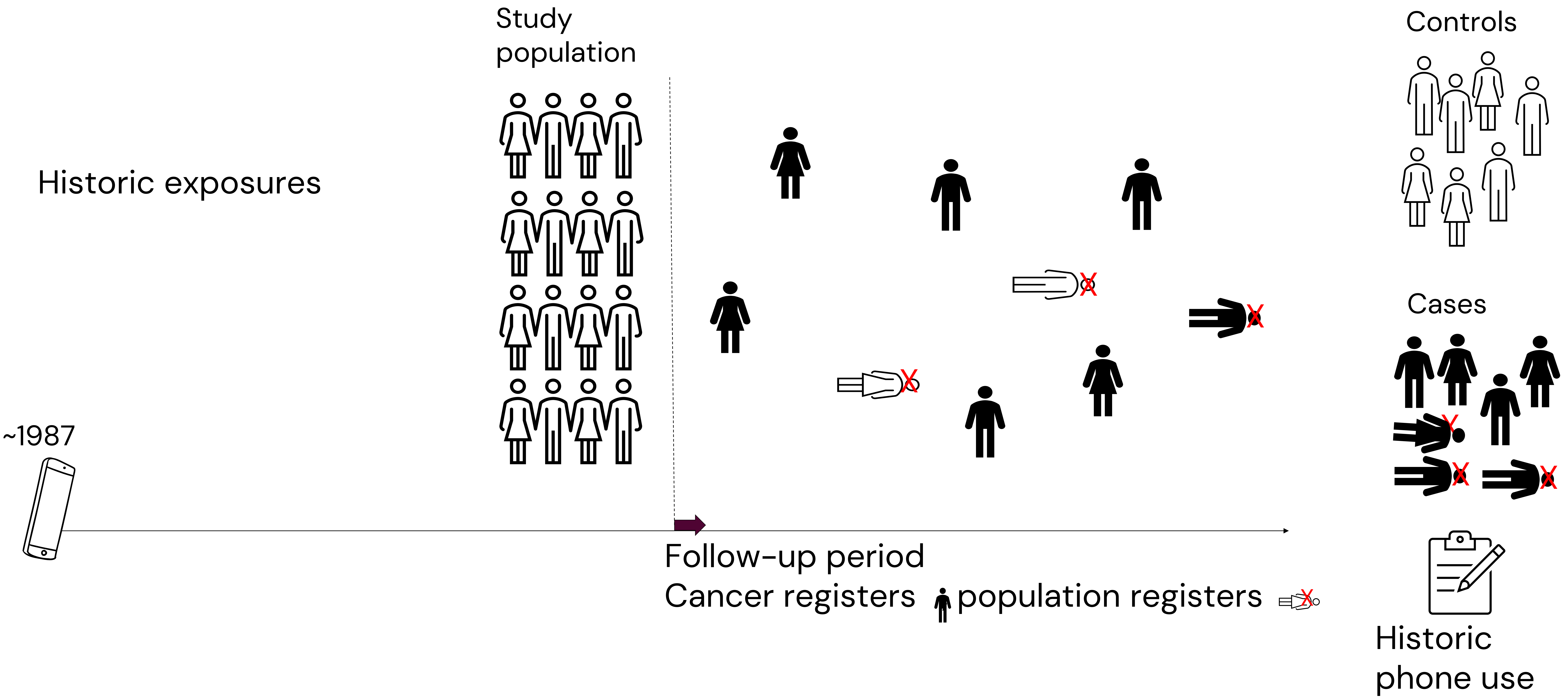
Prospective cohort study

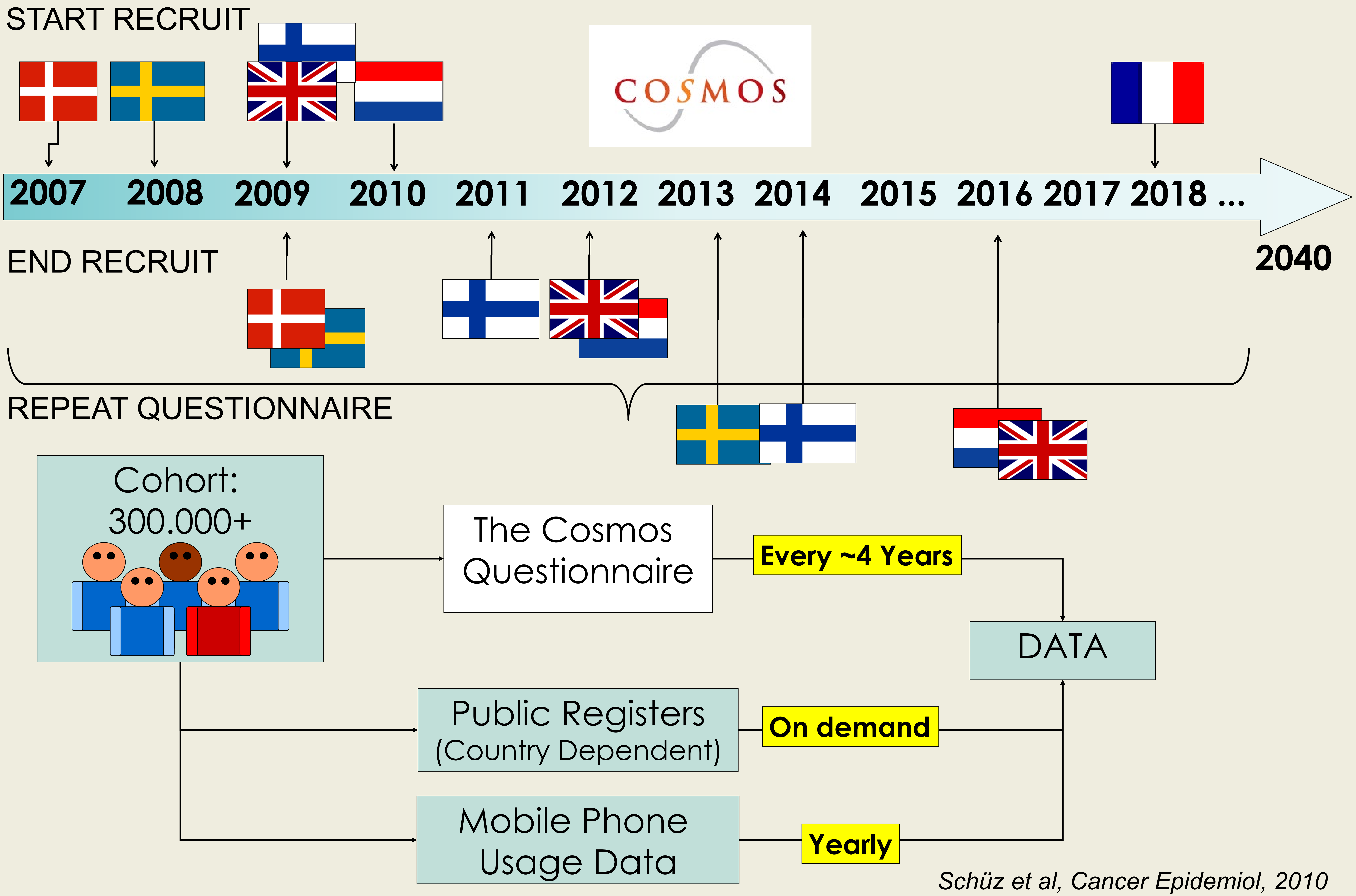


Case-control study



Case–control study



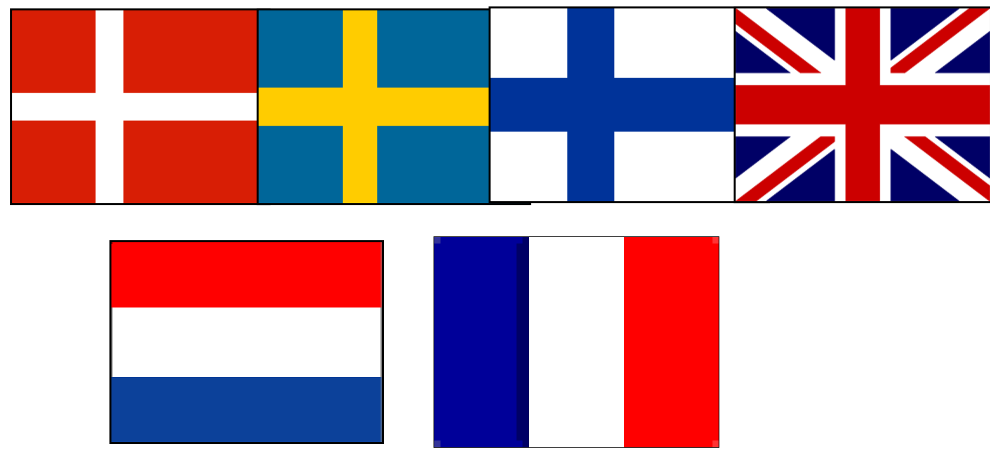


Schüz et al, Cancer Epidemiol, 2010

Design features

- Optimized sampling strategies in cohort recruitment

→ new cohorts: oversampling of low & high users from operator records



→ nested cohorts: sampling within a large-scale population cohorts

- Structured questionnaires not allowing for reporting of implausible values

- Operator records to validate self-reported information for at least subsets of the cohort

- **Questionnaires before the outcomes of interest occur**

Schüz et al, Cancer Epidemiol, 2010

Brain tumor analyses

Country	Participants	Person-years	Glioma cases	Meningioma	Acoustic neuroma
Denmark	25,768	194,193	16	10	2
Finland	11,209	51,189	1	3	2
Sweden	50,163	413,379	36	25	7
Netherlands	87,689	391,652	31	22	6
United Kingdom	94,335	786,066	65	29	12
TOTAL	**269,164**	**1,836,479**	**149**	**89**	**29**

Feychting et al, Environment Int, 2024

COSMOS

Main results

Hazard ratios (HR)[a] and 95% confidence intervals (CI) for the association between cumulative hours of mobile phone call-time and glioma, meningioma, and acoustic neuroma, COSMOS cohort.

	Glioma		Meningioma		Acoustic neuroma	
	No. cases[b]	HR (95 % CI)	No. cases[b]	HR (95 % CI)	No. cases[b]	HR (95 % CI)
Regression calibrated cumulative hours[c]						
<464	66	1 (ref)	48	1 (ref)	12	1 (ref)
464–1061	36	0.99 (0.64–1.52)	13	0.57 (0.27–1.22)	8	0.97 (0.05–17.54)[e]
≥1062	38	0.92 (0.58–1.44)	24	1.08 (0.49–2.35)	8	0.86 (0.29–2.53)
Linear effect per 100 h		*1.00 (0.98–1.02)*		*1.01 (0.96–1.06)*[e]		*1.02 (0.99–1.06)*
Uncalibrated cumulative hours[d]						
<301	72	1 (ref)	51	1 (ref)	12	1 (ref)
301–962	37	0.98 (0.64–1.51)	11	0.51 (0.26–0.99)	8	1.30 (0.27–6.42)
≥963	31	0.77 (0.49–1.22)	23	1.14 (0.47–2.76)	8	1.09 (0.39–3.05)
Linear effect per 100 h		*1.00 (0.98–1.02)*		*1.01 (0.98–1.04)*		*1.02 (0.99–1.05)*

Cutpoints at the median and 75th percentile

Feychting et al, Environment Int, 2024

Additional analyses of glioma

Results when using the 90th percentile as highest exposure cut-point:

- HR=1.07 (95 % CI 0.62–1.86) for ≥1908 regression calibrated cumulative hours (20 cases)
- HR=0.96 (95 % CI 0.54–1.71) for ≥2168 uncalibrated cumulative hours (17 cases)

- No indication of increased risk, but statistically imprecise results

COSMOS Discussion – brain tumor results

- The longest latency possible was ~ 30 years
  - → Almost a third of the COSMOS study population had used a mobile phone 15 years or longer
  - → Results showed no increase in tumor risk associated with time since first use
- Improved exposure assessment compared to previous cohort studies
  - → Detailed prospective information about amount of phone use since start of use, combined with operator data
  - → Handsfree use, incl. changes over time
- Methodologically superior to case-control studies
  - → No differential recall bias – data collected prior to disease occurrence
  - → No selection bias – complete follow-up of all participants

Discussion – cont.

- Longer follow-up is needed to increase precision of risk estimates
  - → Especially for acoustic neuroma (vestibular schwannoma) and meningioma

- Longer follow-up to assess potential effects after even longer latencies
  - → Using updated exposure information from repeat questionnaires and operator data

Conclusions

- COSMOS overcomes several of the limitations of both past cohort and past case-control studies
- Earlier cohort studies show no associations overall – consistent with COSMOS
  - → But these studies are less informative for heavy mobile phone users
- Interphone case-control study found association only among heaviest mobile phone users
  - → Likely a result of differential recall of past mobile phone use between glioma patients and controls (see Vrijheid et al., J Expo Anal Env Epidemiol 2008; Bouaoun et al., Epidemiology 2024)
- Some case-control studies showing positive results are incompatible with the age- and sex-specific time trends of glioma in the same populations and therefore not informative

Future perspective

COSMOS

- Ongoing analyses of CVD, reproductive outcomes
- Further updates in health data registers – longer follow-up
  → E.g. cancer, neurodegenerative diseases, etc
- Additional repeat questionnaires
  → More details on new RF exposure patterns
  → Update of information on soft outcomes (headaches, sleep, etc)

Other efforts

- Continue to follow brain cancer incidence trends in high quality cancer registers
- Monitor RF exposure levels and sources in the population
  → E.g. ongoing EU funded projects
- Not recommended:
  → Further case-control studies

Karolinska
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Prof Theo Samaras
Aristotle University of Thessaloniki, Greece, coordinator of SEAWave, and member of the European Commission Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)

Progress of SEAWave within the CLUE-H research cluster

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Progress of SEAWave within the CLUE-H research cluster

This cluster comprises four projects that have received funding from the European Union's Horizon Europe research and innovation programme: ETAIN (101057216), GOLIAT (101057262) NextGEM (101057527), and SEAWave (101057622).


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URBAN HEALTH
Environment
& Health
OCCUPATIONAL
HEALTH &
SAFETY
PUBLIC HEALTH

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CLUE-H Identity

ABOUT WORKING GROUPS NEWS AND EVENTS RESOURCES CONTACT US

Members

The CLUE – H cluster

Uniting four research initiatives in one large cluster will help create synergies and amplify the effort of individual research initiatives.

SEAWave ETAIN NextGEM GOLiAT

LEARN MORE

www.emf-health-cluster.eu

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Working Group 1 (WG1)

Science translation for policy and practice

The working group science translation for policy and practice is responsible for the production of the policy strategy of the cluster and the policy briefs.

The objectives of WG1 include:
– Synthesizing Scientific Knowledge: The translation of science to policy aims at compiling and synthesizing the existing

Working groups:

- WG1: Science translation for policy and practice
- WG2: Data management and exchange
- WG3: Communication and Dissemination
- WG4: Experimental studies
- WG5: Exposure assessment

ETAIN GOLiAT NextGEM SEAWave

5G EXPOSURE, CAUSAL EFFECTS, AND RISK PERCEPTION THROUGH CITIZEN ENGAGEMENT

Scientific-based **E**xposure and risk **A**ssessment of radiofrequency and mm-**Wave** systems from children to elderly (5G and Beyond)

15+2* partners

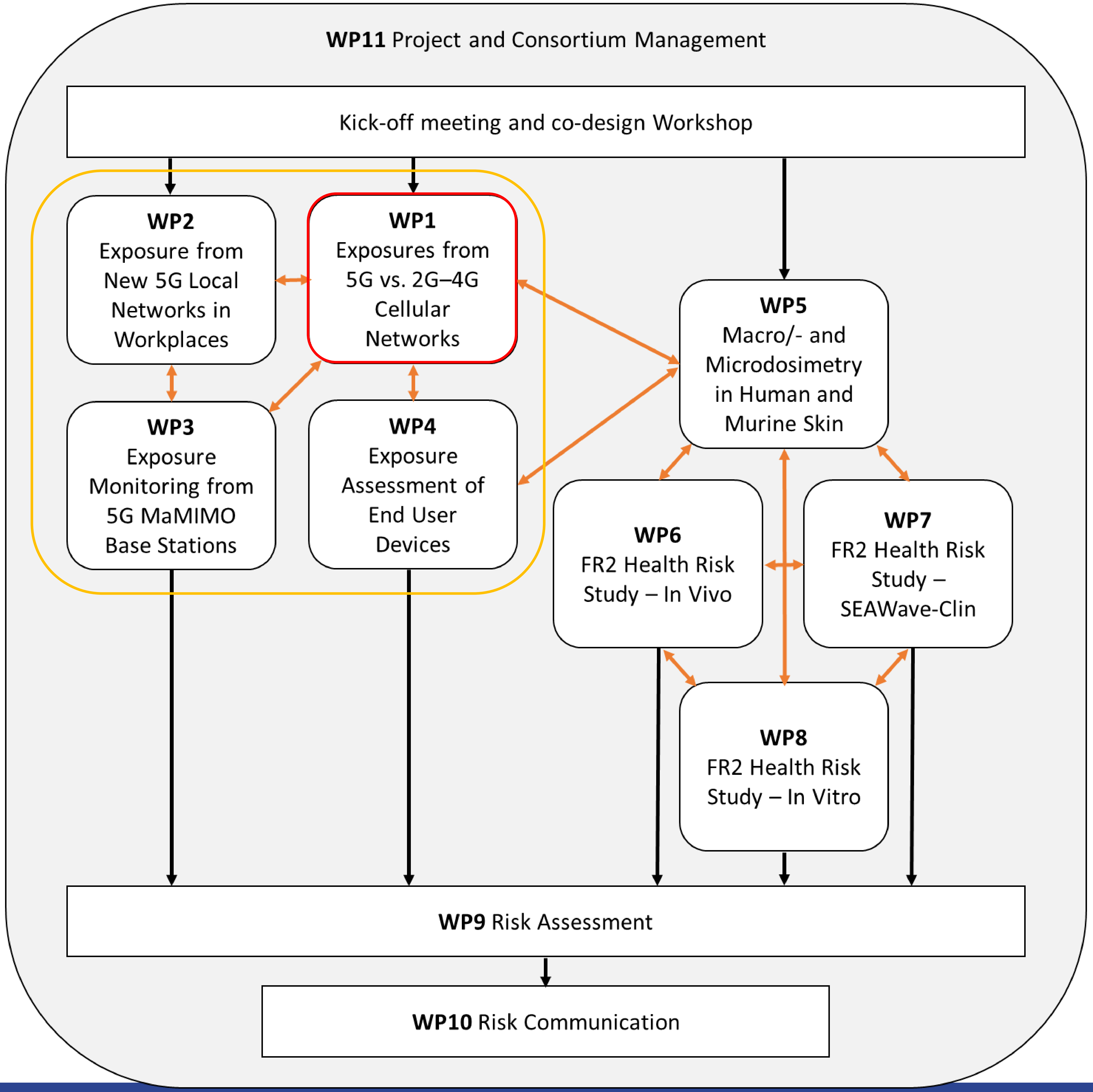
7.3 M€ (EU)

3+? years

*University of Novi Sad

*ETRI (Daejeon)

Scientific-based **E**xposure and risk **A**ssessment of radiofrequency and mm-**Wave** systems from children to elderly (5G and Beyond)



SEAWave

Monitoring of environmental EMF

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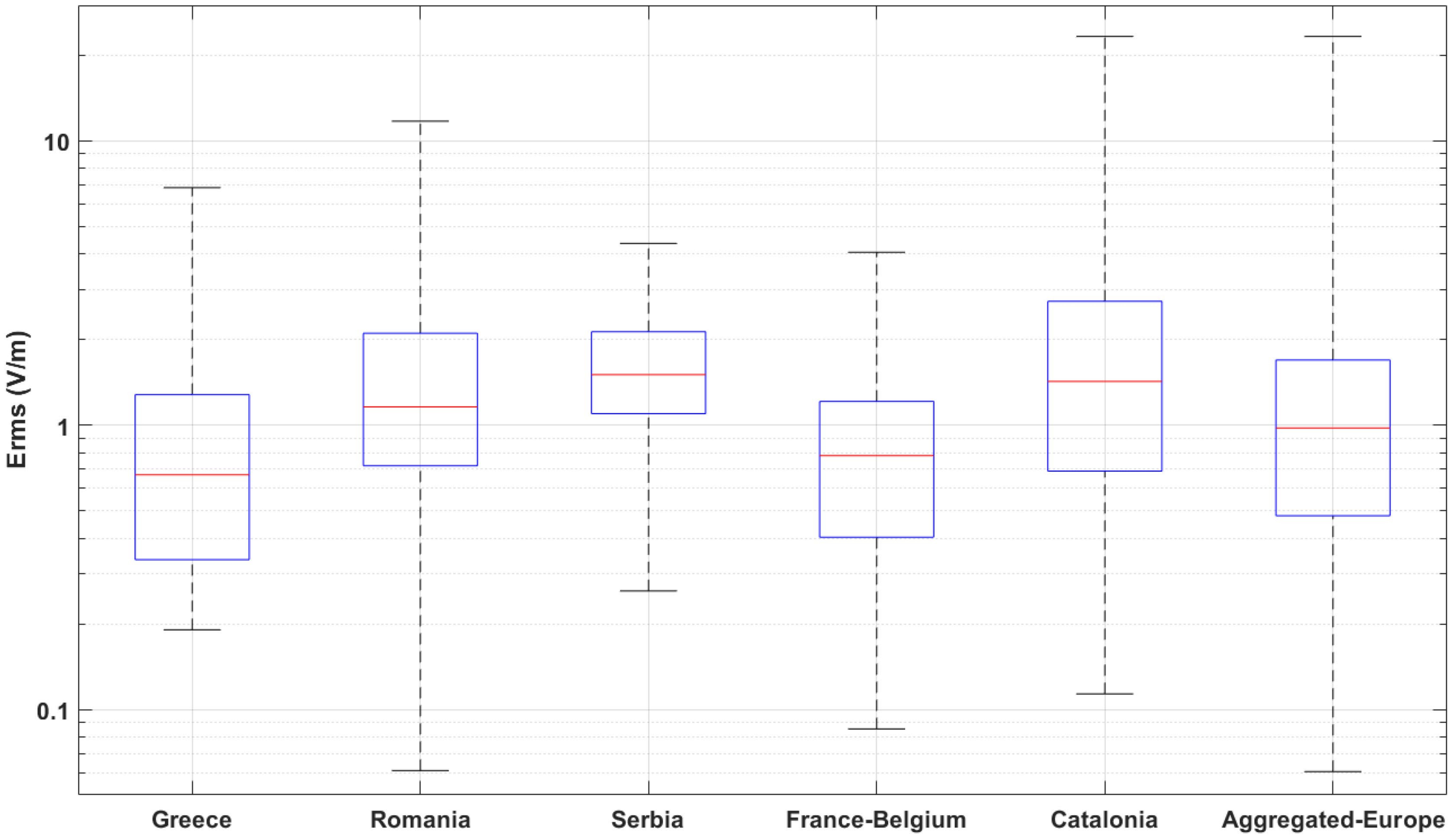

Median values do not vary significantly across Europe

Iakovidis, S.; Apostolidis, C.; Manassas, A.; Samaras, T. Electromagnetic Fields Exposure Assessment in Europe Utilizing Publicly Available Data. Sensors 2022, 22, 8481. https://doi.org/10.3390/s22218481

Monitoring of environmental EMF

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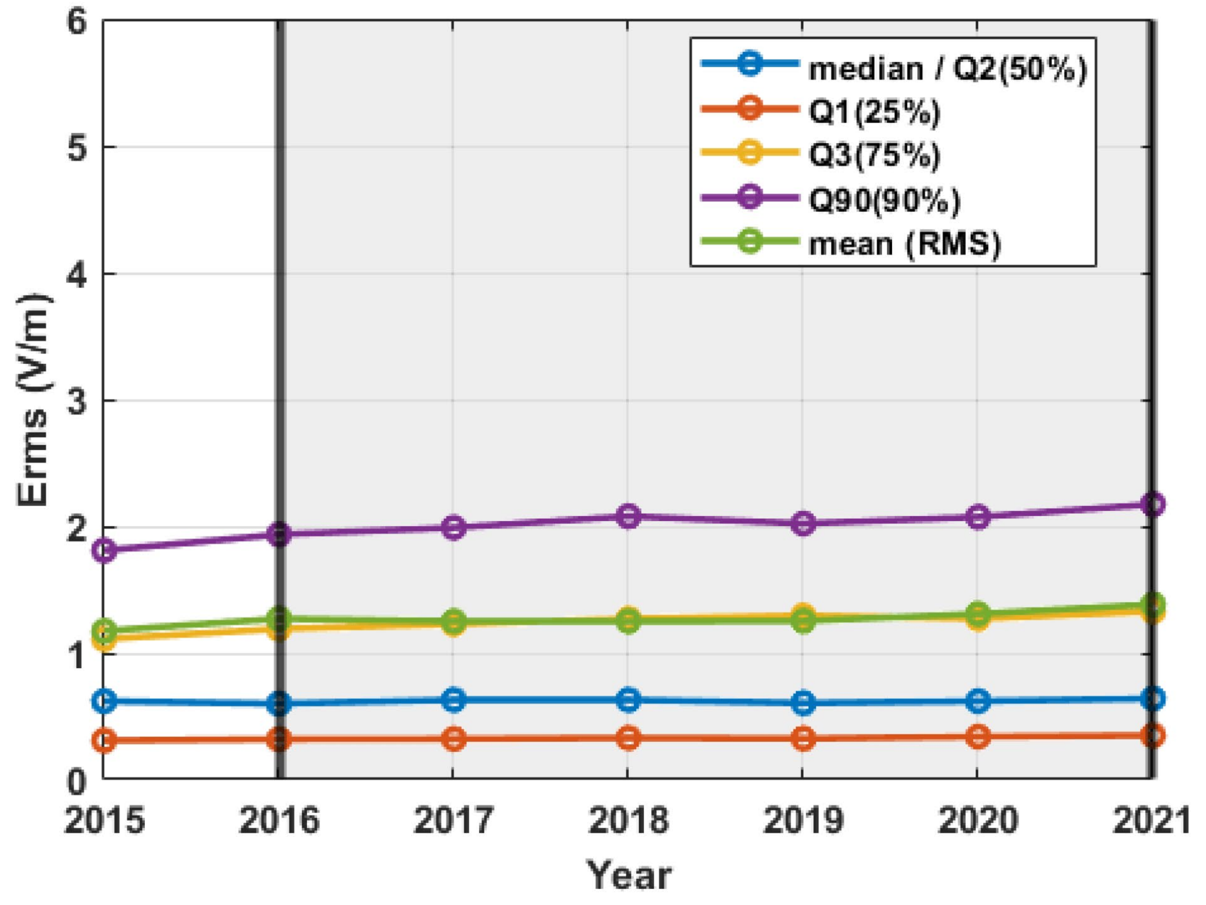
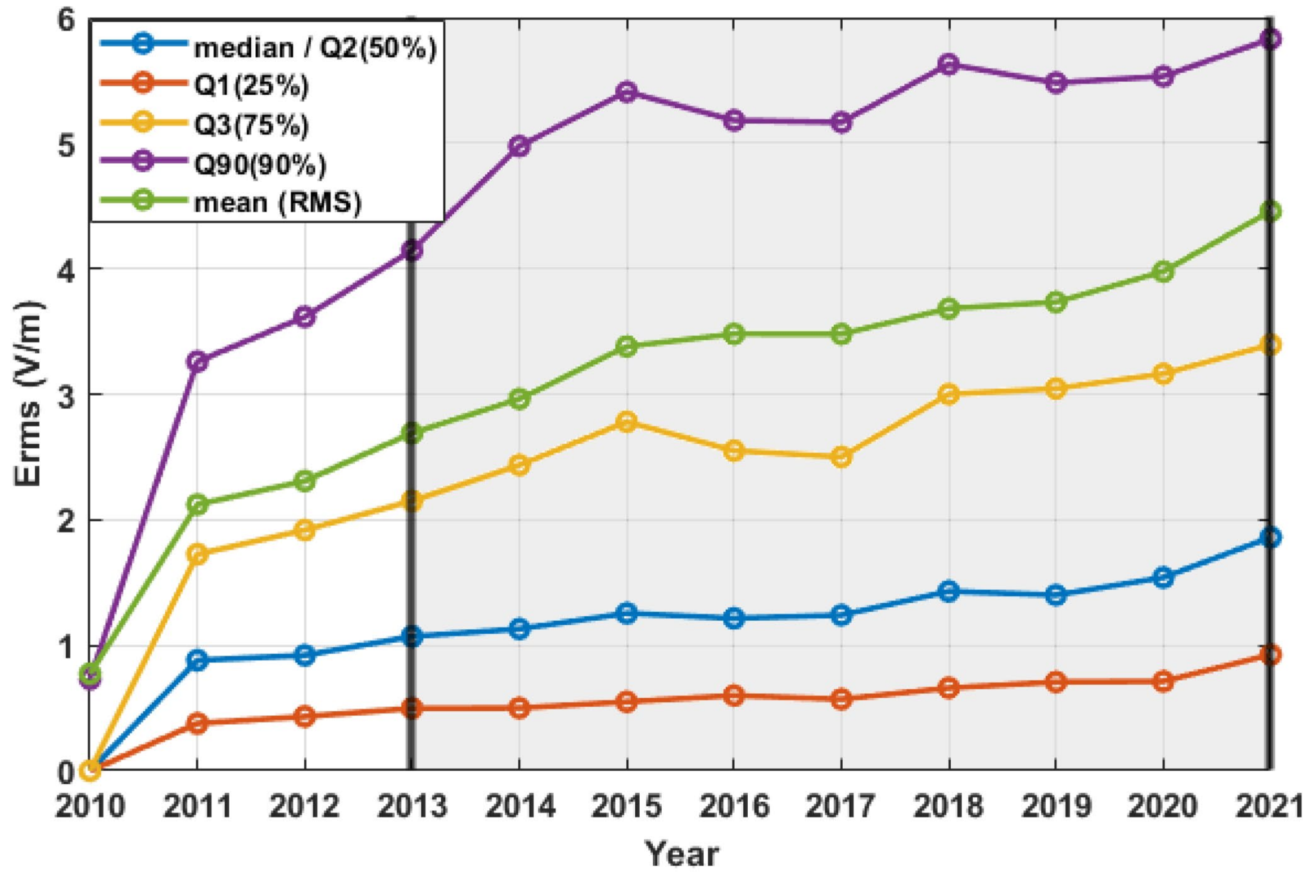
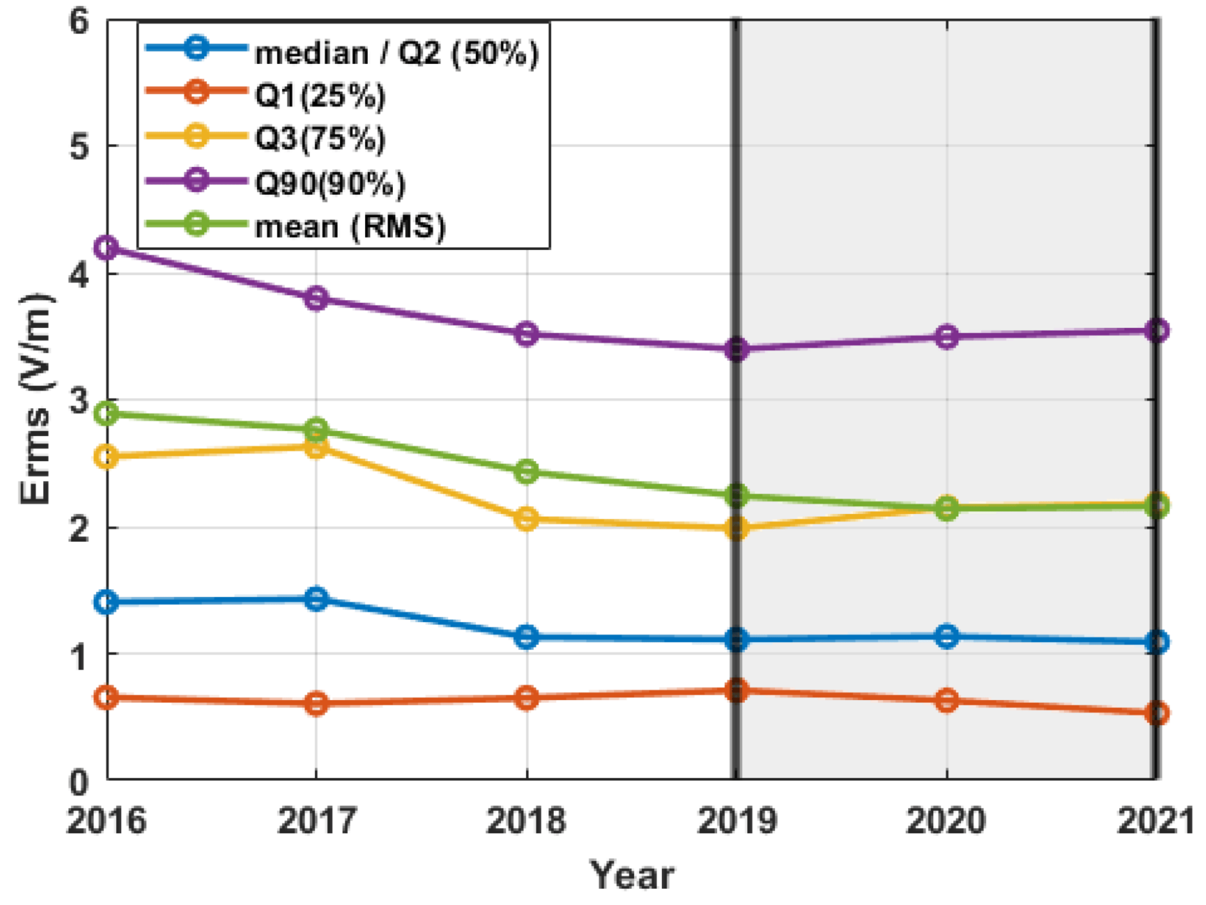


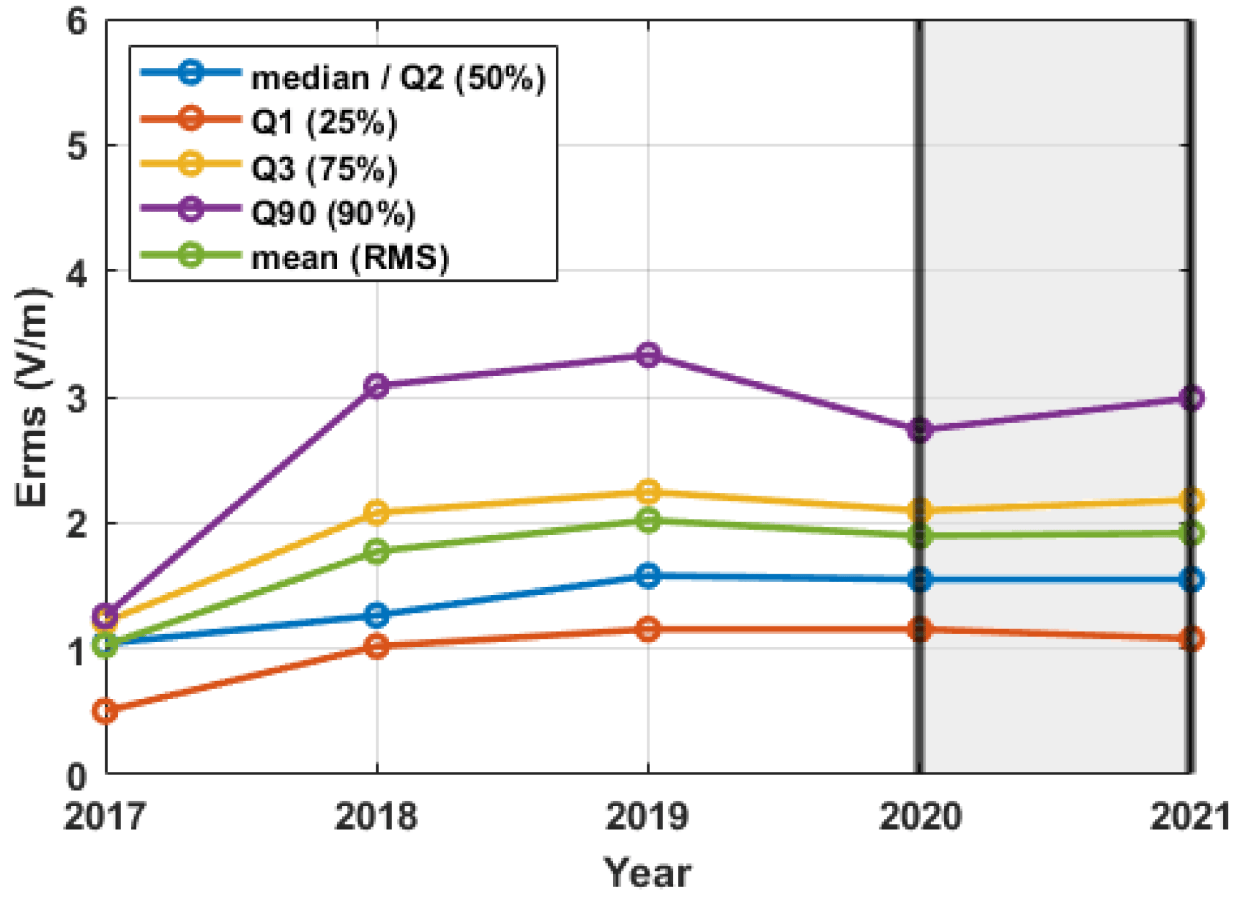
(a)



(b)



(c)



(d)

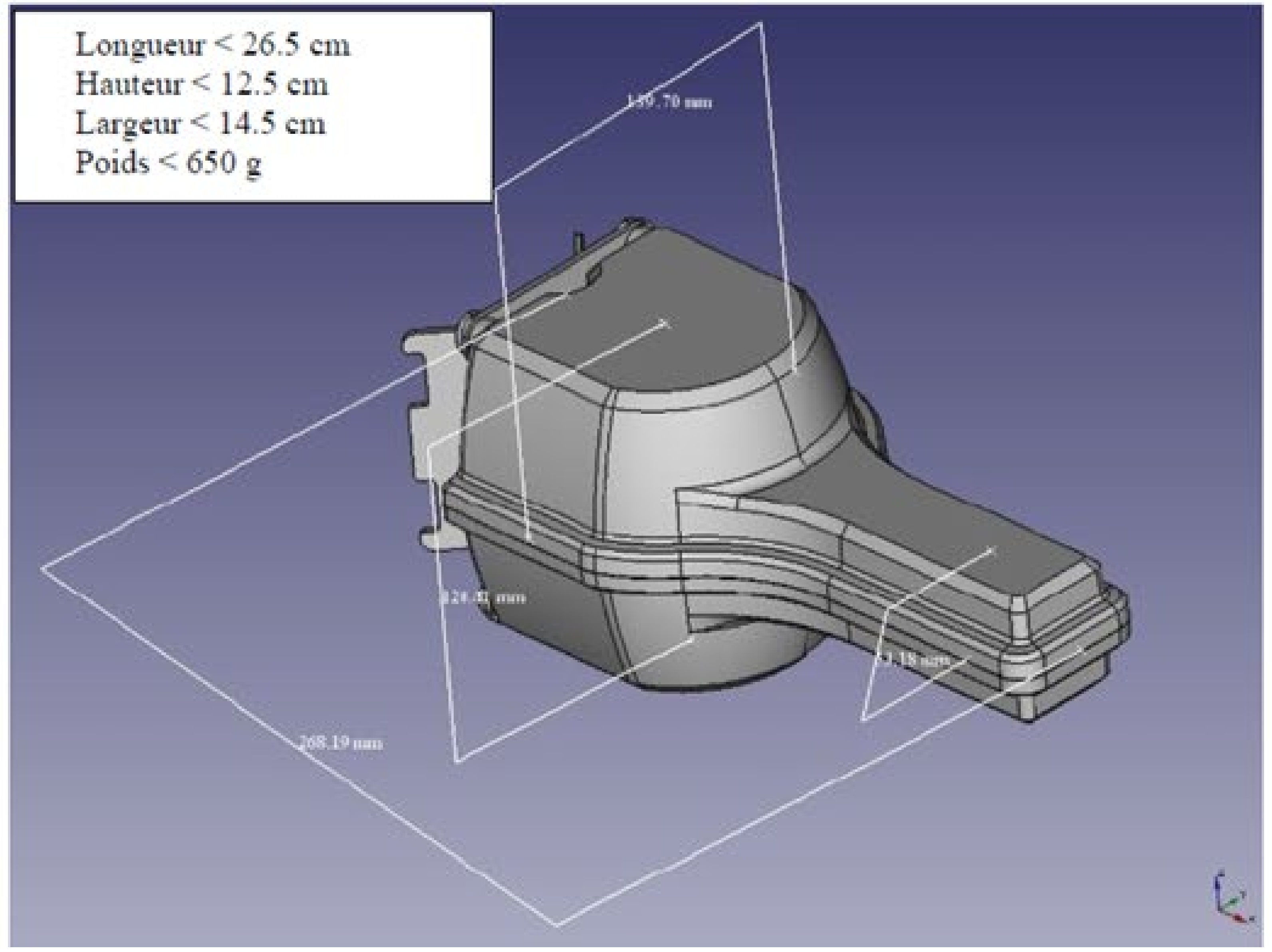
Temporal evolution of E-field levels for four monitoring networks:
(a) Greece,
(b) Catalonia in Spain,
(c) Romania, and
(d) Serbia.

Median, mean (rms), and several percentiles' values for the yearly E_{rms} distribution of each network are shown.

The time period where at least 75% of monitoring sensors are active is indicated between black vertical lines in grey-shaded background, for each network.

Iakovidis, S.; Apostolidis, C.; Manassas, A.; Samaras, T. Electromagnetic Fields Exposure Assessment in Europe Utilizing Publicly Available Data. Sensors 2022, 22, 8481. https://doi.org/10.3390/s22218481

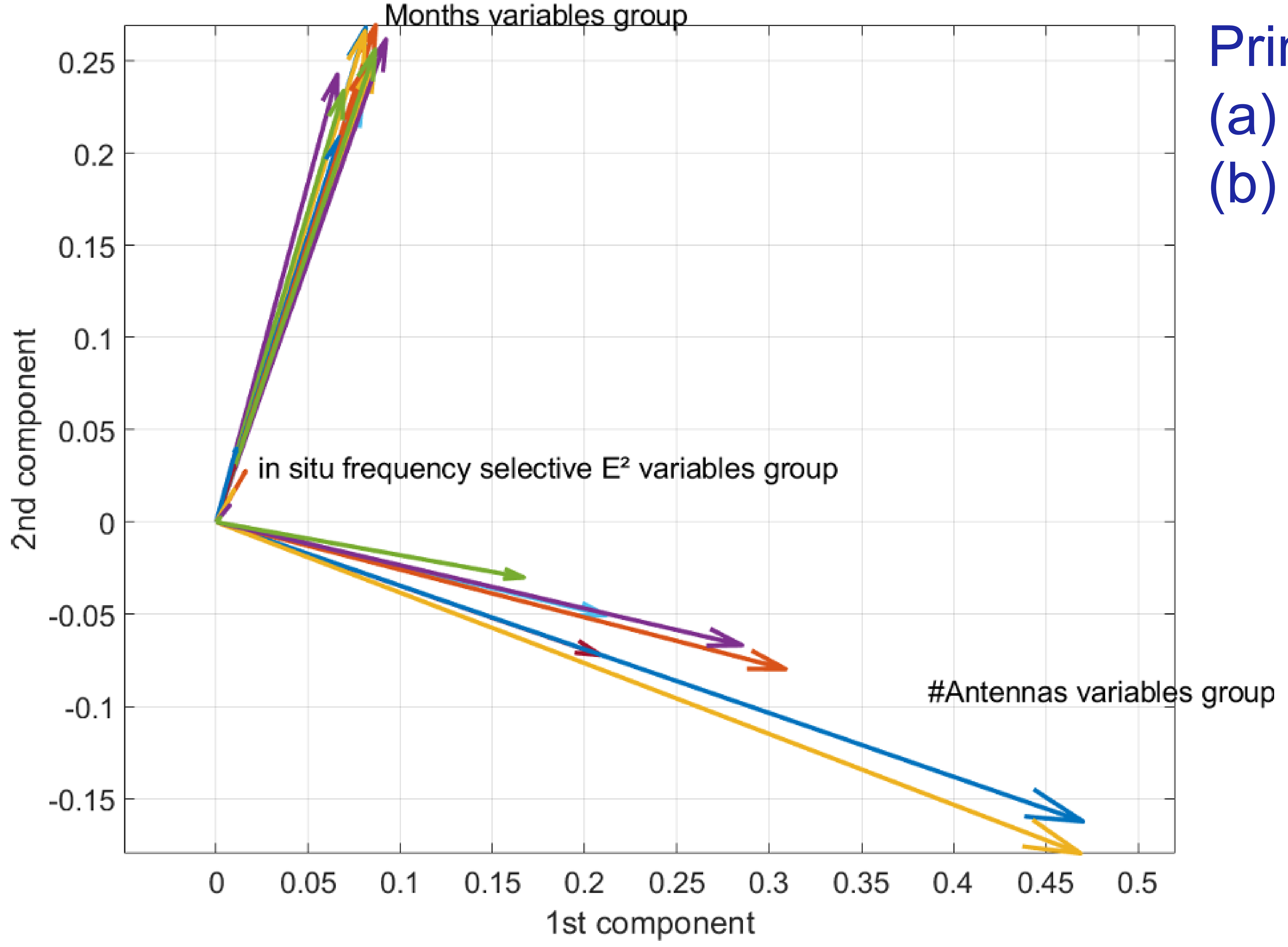
Monitoring of environmental EMF



Number of probes	Name of city or conurbation authority
5	Lille Métropole
9	Paris
19	Massy
4	Grand Paris Sud
7	Orléans Métropole
8	Eurométropole de Strasbourg
3	Mulhouse
10	Rennes
50	Nantes Métropole
33	Bordeaux Métropole
3	Marseille

Ourouk Jawad; Emmanuelle Conil; Jean-Benoît Agnani; Shanshan Wang; Joe Wiart. Monitoring of the exposure to electromagnetic fields with autonomous probes installed outdoors in France. Reports. Physics, Online first (2024), pp. 1-21. doi:10.5802/crphys.182

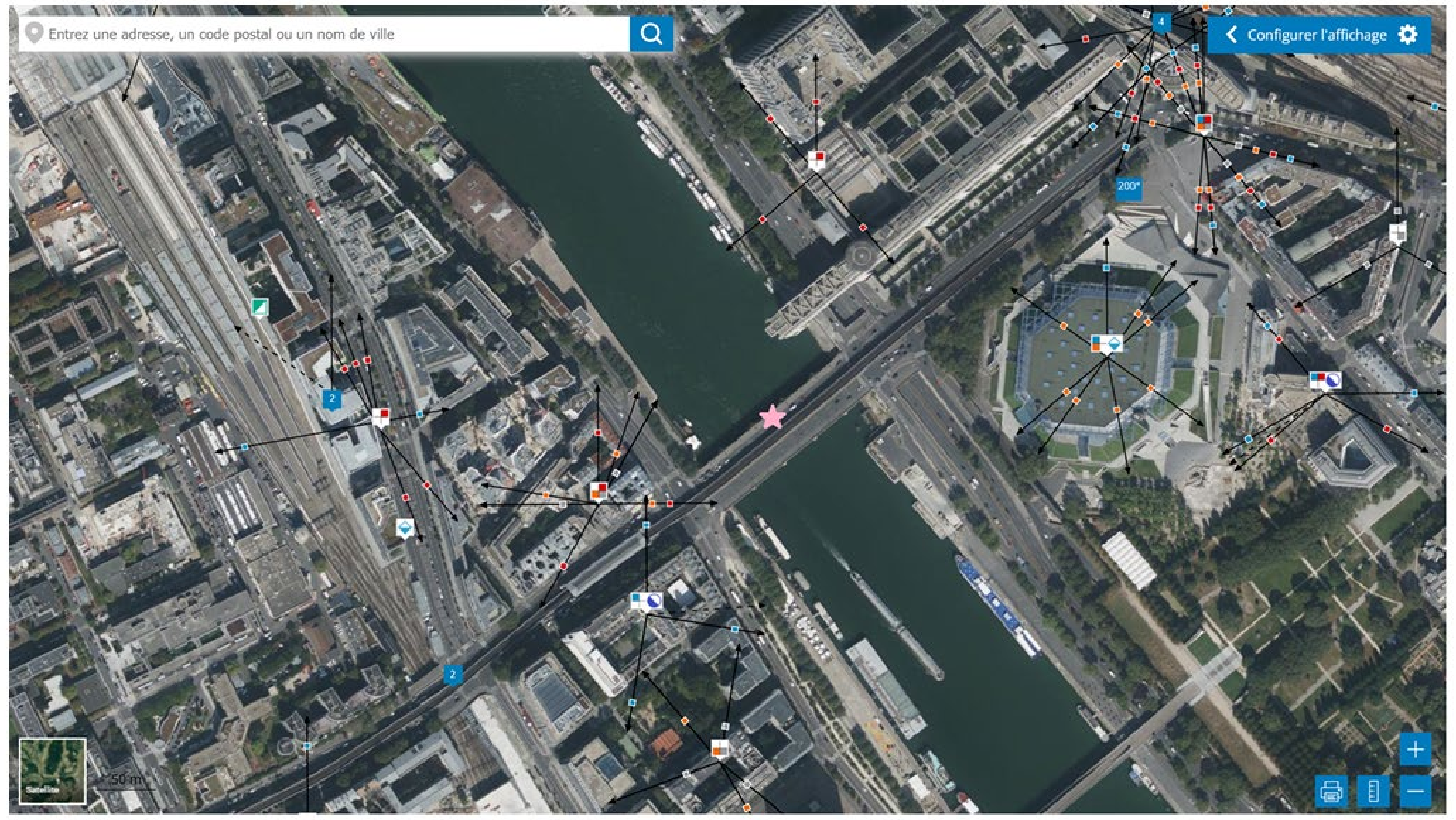
Monitoring of environmental EMF

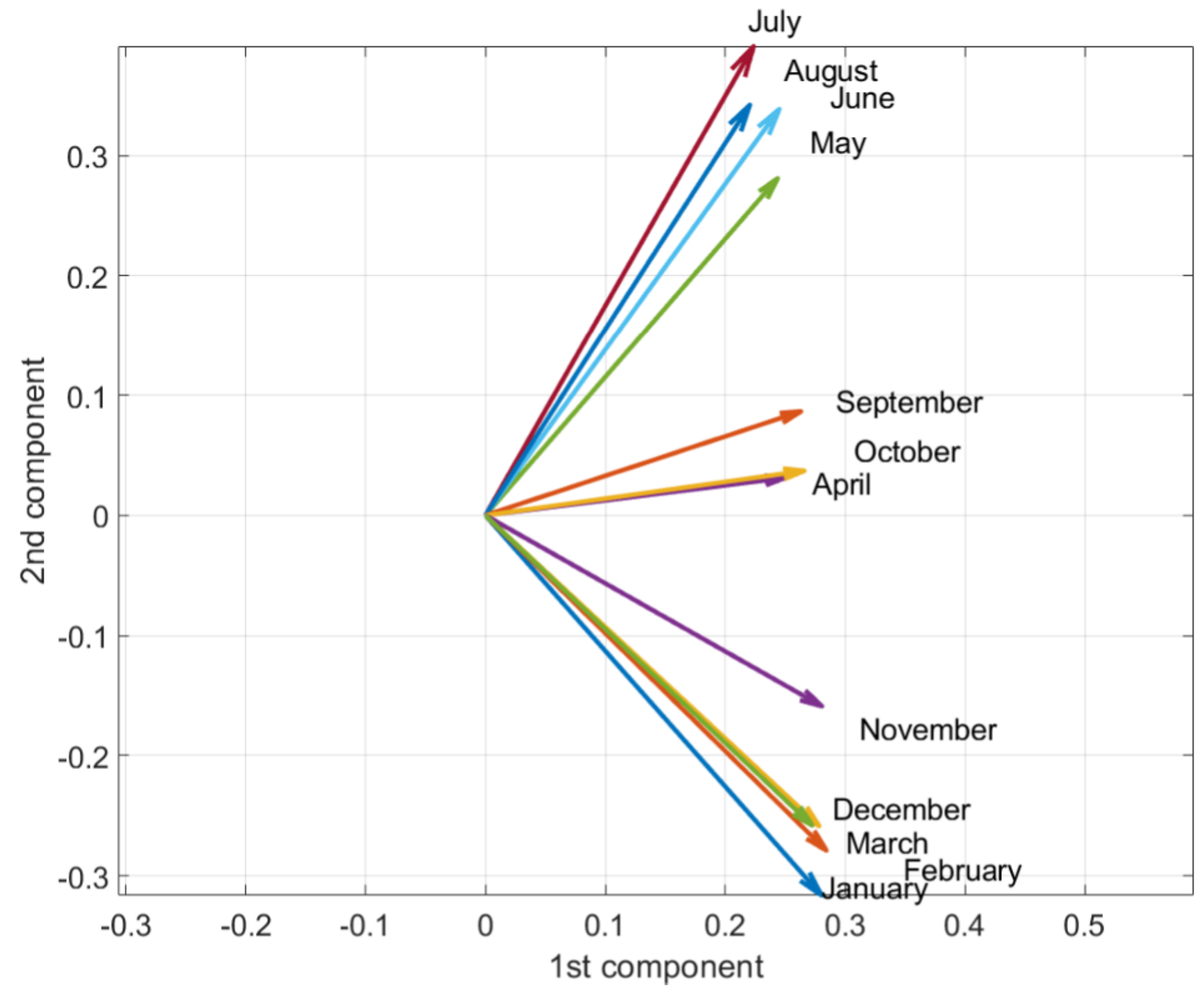


Principal Component Analysis (PCA) identifies two main components:

(a) Month

(b) Number of antennas around sensor





Ourouk Jawad; Emmanuelle Conil; Jean-Benoît Agnani; Shanshan Wang; Joe Wiart. Monitoring of the exposure to electromagnetic fields with autonomous probes installed outdoors in France. Reports. Physics, Online first (2024), pp. 1-21. doi:10.5802/crphys.182

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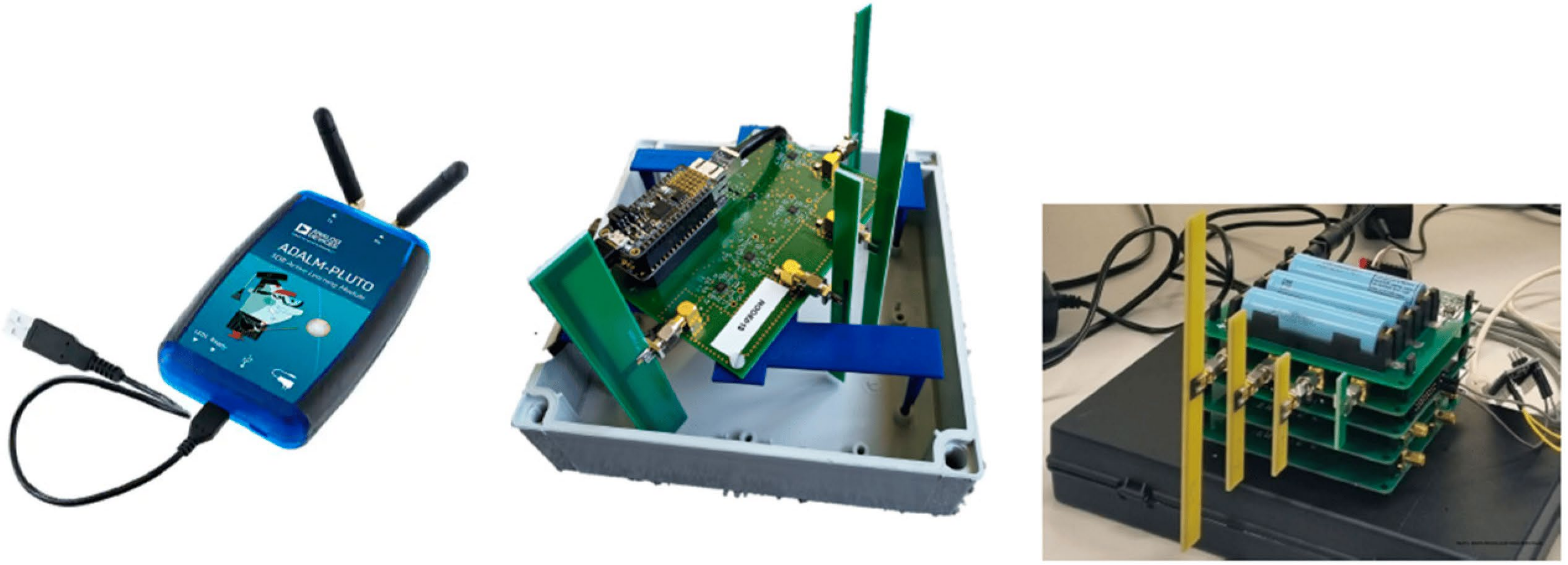

(a) (b) (c)

(a) Adalm Pluto SDR; (b) WAVES sensor; (c) S3R sensor.

The study compared low-cost hardware sensors and software defined radio (SDR) sensors with expensive verified measurement setups consisting of spectrum analyzer equipment for RF-EMF radiation.

The variability between the sensors was 1.78 dB on average, with a maximum deviation of 5.26 dB.

It must be kept in mind that these RF-EMF sensors only measured one vector component (purpose of temporal monitoring) of the field, and therefore, the given field will be an underestimation of the total field at that measurement location.

Deprez, K.; Colussi, L.; Korkmaz, E.; Aerts, S.; Land, D.; Littel, S.; Verloock, L.; Plets, D.; Joseph, W.; Bolte, J.
Comparison of Low-Cost 5G Electromagnetic Field Sensors. Sensors 2023, 23, 3312. https://doi.org/10.3390/s23063312

NextGEM

Monitoring of environmental EMF & Exposure assessment

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Environmental Research 260 (2024) 119524

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Environmental Research

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

ELSEVIER

Review article

A comprehensive review of 5G NR RF-EMF exposure assessment technologies: fundamentals, advancements, challenges, niches, and implications

Erdal Korkmaz [a,*], Sam Aerts [a], Richard Coesoij [b], Chhavi Raj Bhatt [c], Maarten Velghe [d], Loek Colussi [e], Derek Land [a], Nikolaos Petroulakis [f], Marco Spirito [b], John Bolte [a,d]

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[f] *Institute of Computer Science, Foundation for Research and Technology-Hellas, 70013, Heraklion, Greece*

ARTICLE INFO

Keywords:

ABSTRACT

This review offers a detailed examination of the current landscape of radio frequency (RF) electromagnetic

SEAWave

Exposure assessment
Downlink – Transportation

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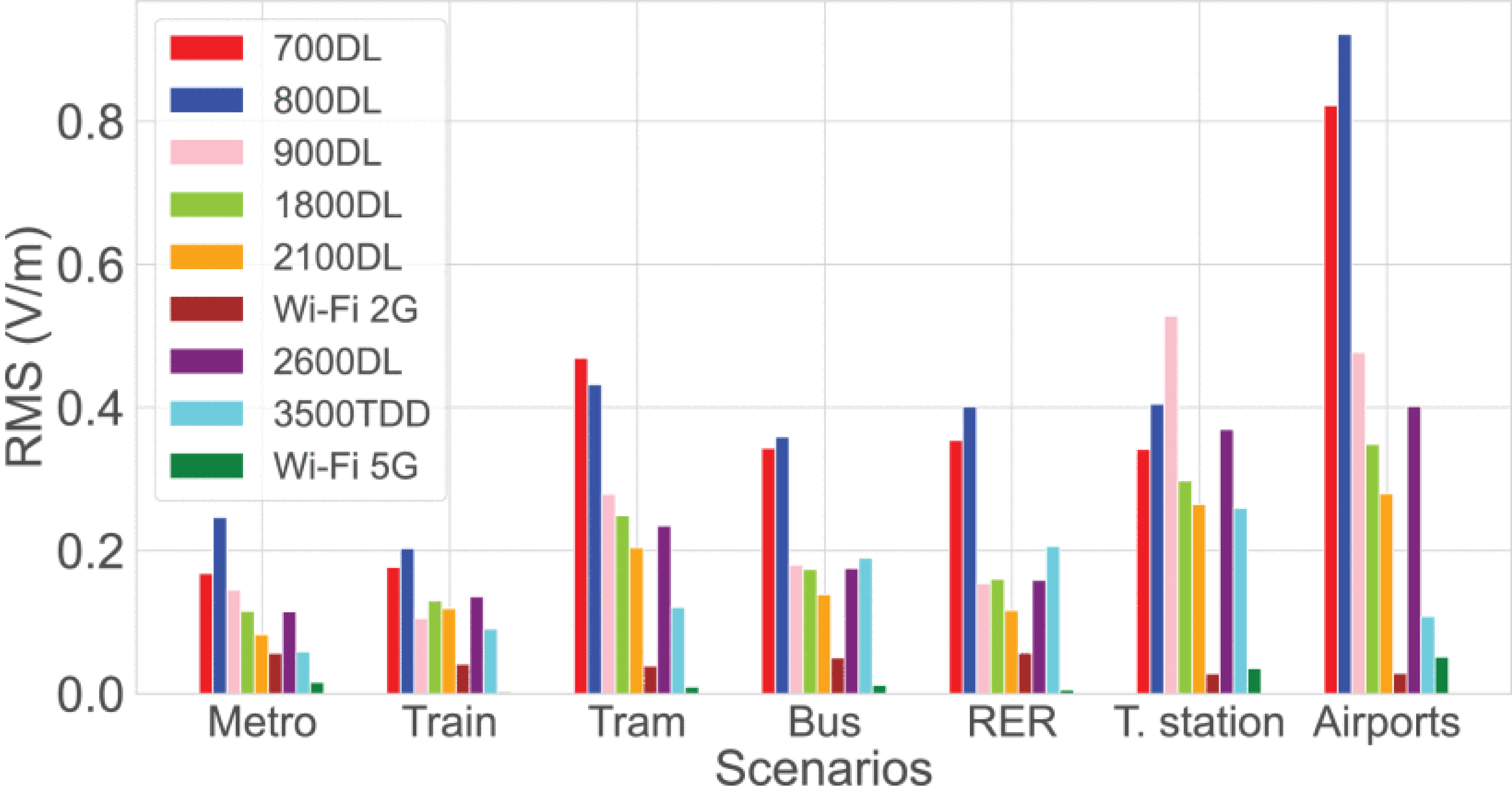
Technology	Frequency (MHz)	Sensitivity (V m^{-1})
LTE 700 DL+ 5G NR	758-803	0.045
LTE 800 DL	791-821	0.03
GSM+UMTS 900 DL	925-960	0.02
GSM+LTE 1800 DL	1805-1880	0.02
UMTS 2100 DL 5G NR	2110-2170	0.02
LTE 2600DL	2620-2690	0.03
5G NR 3500	3300-3800	0.02



Y. Zhang et al., "Statistical Analysis of RF-EMF Exposure Induced by Cellular Wireless Networks in Public Transportation Facilities of the Paris Region," in IEEE Access, vol. 12, pp. 79741-79753, 2024, doi: 10.1109/ACCESS.2024.3410090

GOLIAT
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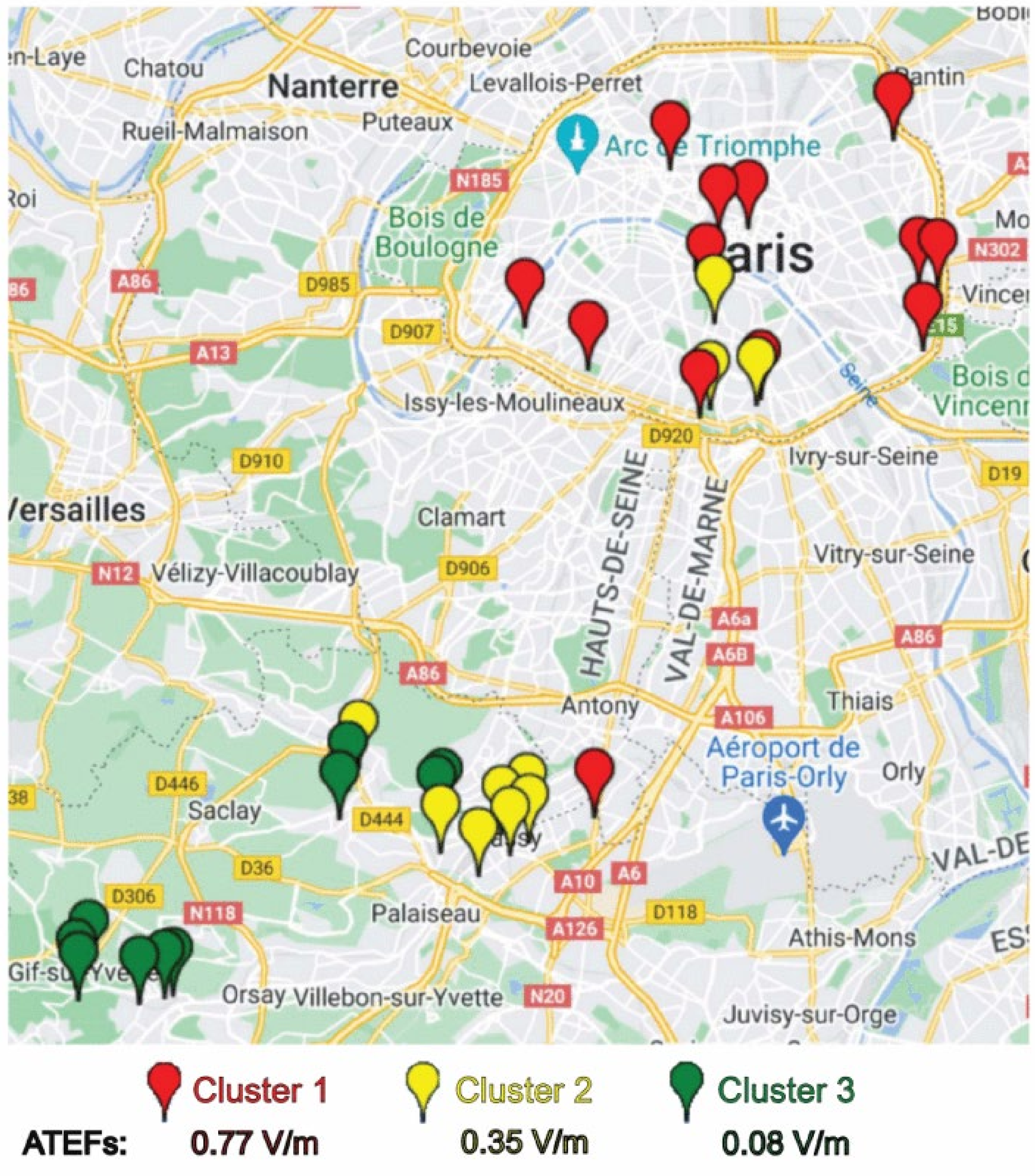
Exposure assessment
Downlink – Various environments

f (MHz)
700
800
900
1800
2100
2600
3500



K-means classifier.
ATEF = Average Total Electric Field

W. B. Chikha et al., "Assessment of Radio Frequency Electromagnetic Field Exposure Induced by Base Stations in Several Micro-Environments in France," in IEEE Access, vol. 12, pp. 21610-21620, 2024

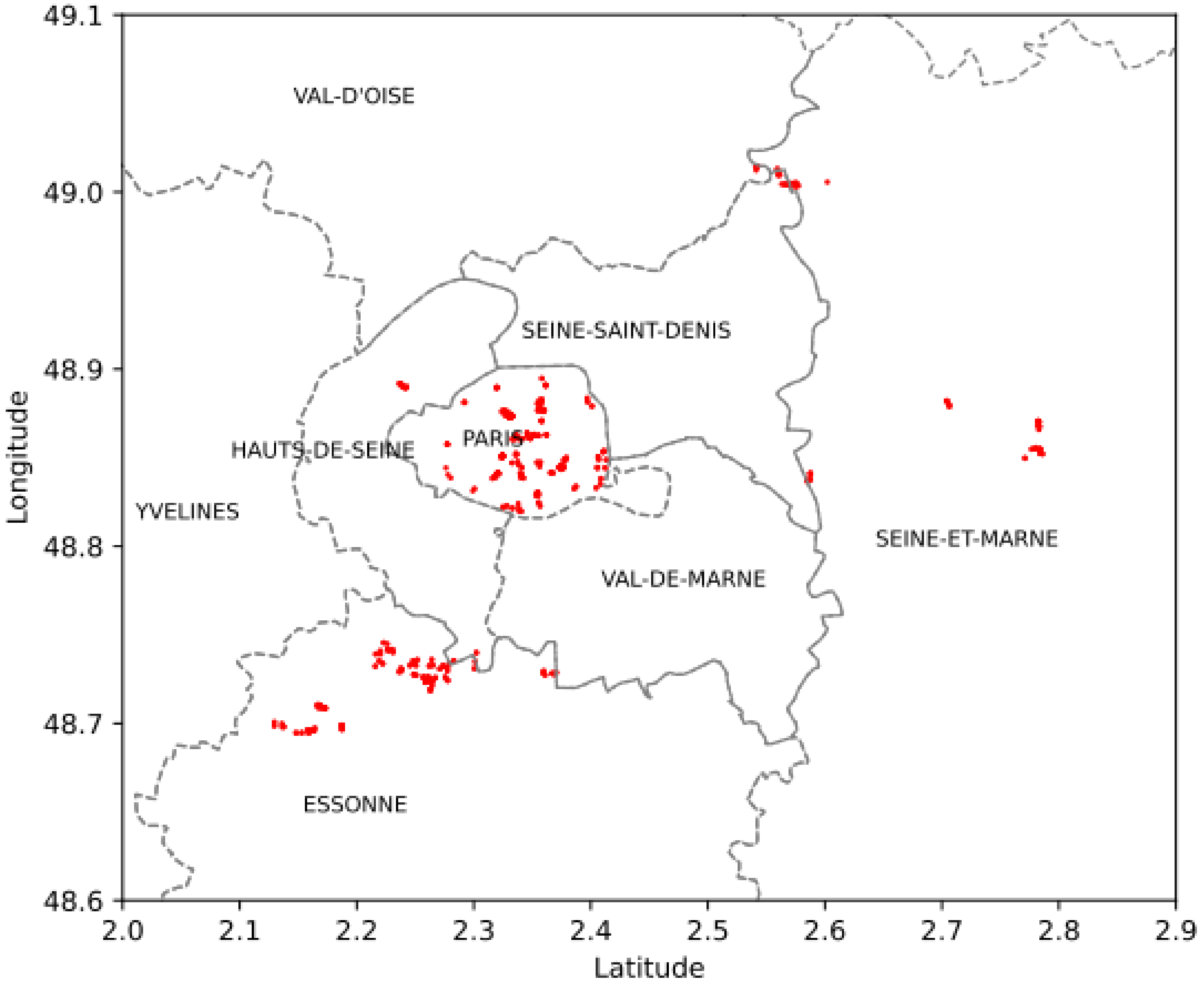
Exposure assessment
Uplink – User

TABLE 1: Measurement protocol

Nemo Commands	User Posture	Time	Attempt Timeout
Voice Call	Ear-Holding	1 min	30 s
WhatsApp Voice Call		1 min	30 s
WhatsApp Video Call	Face-Viewing	1 min	30 s
FTP Data Upload		< 5 min	30 s
If 5G is available, continue with 5G being disabled. Otherwise, stop.			
WhatsApp Voice Call	Ear-Holding	1 min	30 s
WhatsApp Video Call	Face-Viewing	1 min	30 s
FTP Data Upload		< 5 min	30 s

TABLE 3: Number of valid measurements for each tested service

Service	Number of Valid Measurements	2G exists	3G exists	4G exists	5G exists
Voice	378	1	48	330	
VoIP	361	0	5	356	261
Video	362	0	3	359	273
FTP	361	0	4	357	266



J. Liu et al., "Assessment of EMF Exposure Induced by Wireless Cellular Phones in Various Usage Scenarios in France," in IEEE Access, doi: 10.1109/ACCESS.2024.3424305.

Exposure assessment
Uplink – User

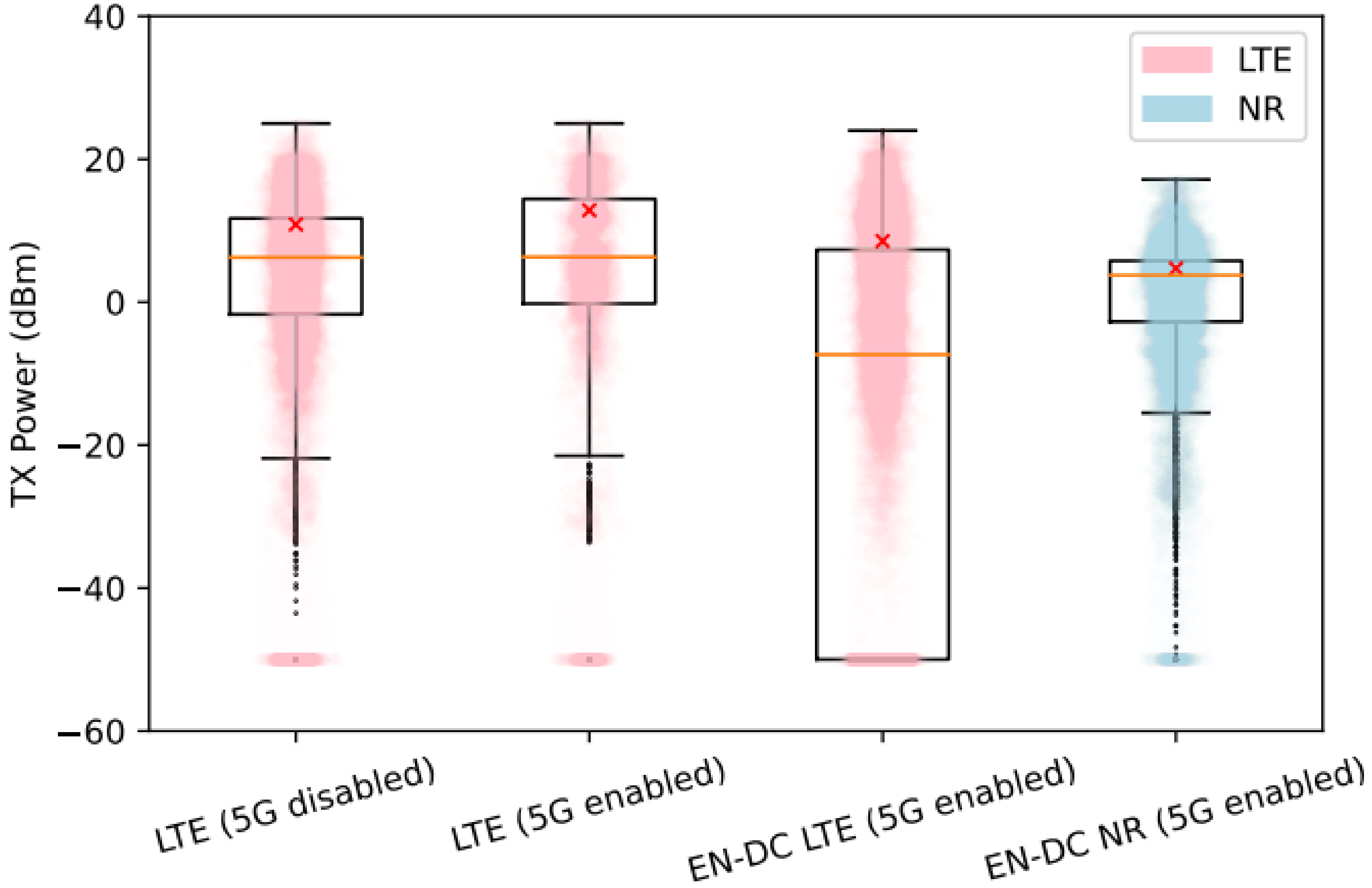


FIGURE 9: Box-plot of TX power during WhatsApp video calls, LTE and NR represent band 2600 MHz and 3500 MHz respectively

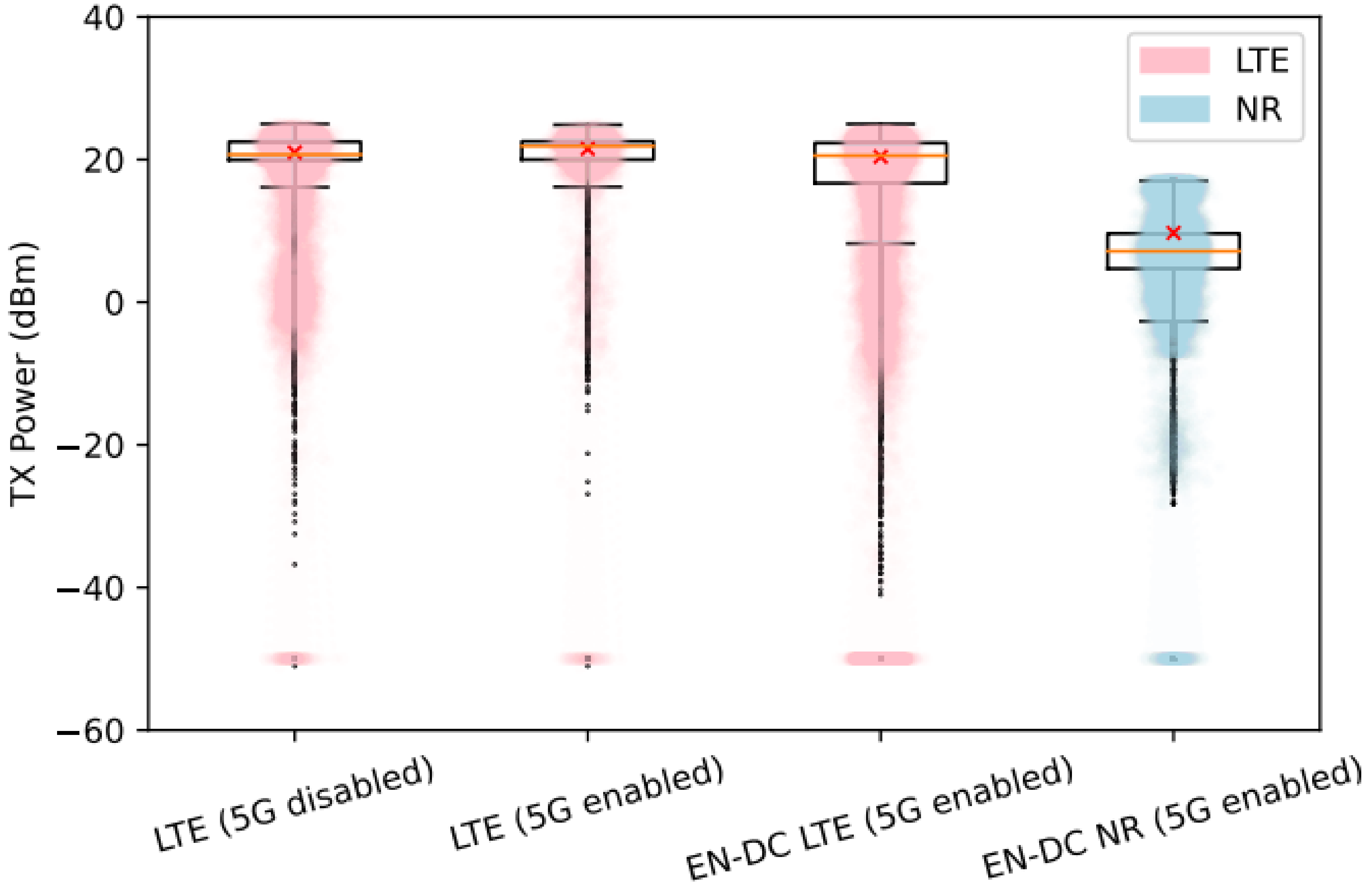


FIGURE 12: Box-plot of TX power during FTP, LTE and NR represent band 2600 MHz and 3500 MHz respectively

J. Liu et al., "Assessment of EMF Exposure Induced by Wireless Cellular Phones in Various Usage Scenarios in France," in IEEE Access, doi: 10.1109/ACCESS.2024.3424305.

Exposure assessment
Uplink – User

- The study analyzed different ways of placing a voice call, such as VoCS, VoLTE, and VoIP, with WhatsApp being used for VoIP. The Tx power and throughput behavior were compared for each band and technology with 5G enabled and disabled.

- More than 90% of the duration for all three forms of voice calls was conducted on 4G and beyond technology, with the usage of 3G in voice calls being barely less than 10%.

- Tx power in 5G bands is generally lower than in other bands, while throughput is higher.

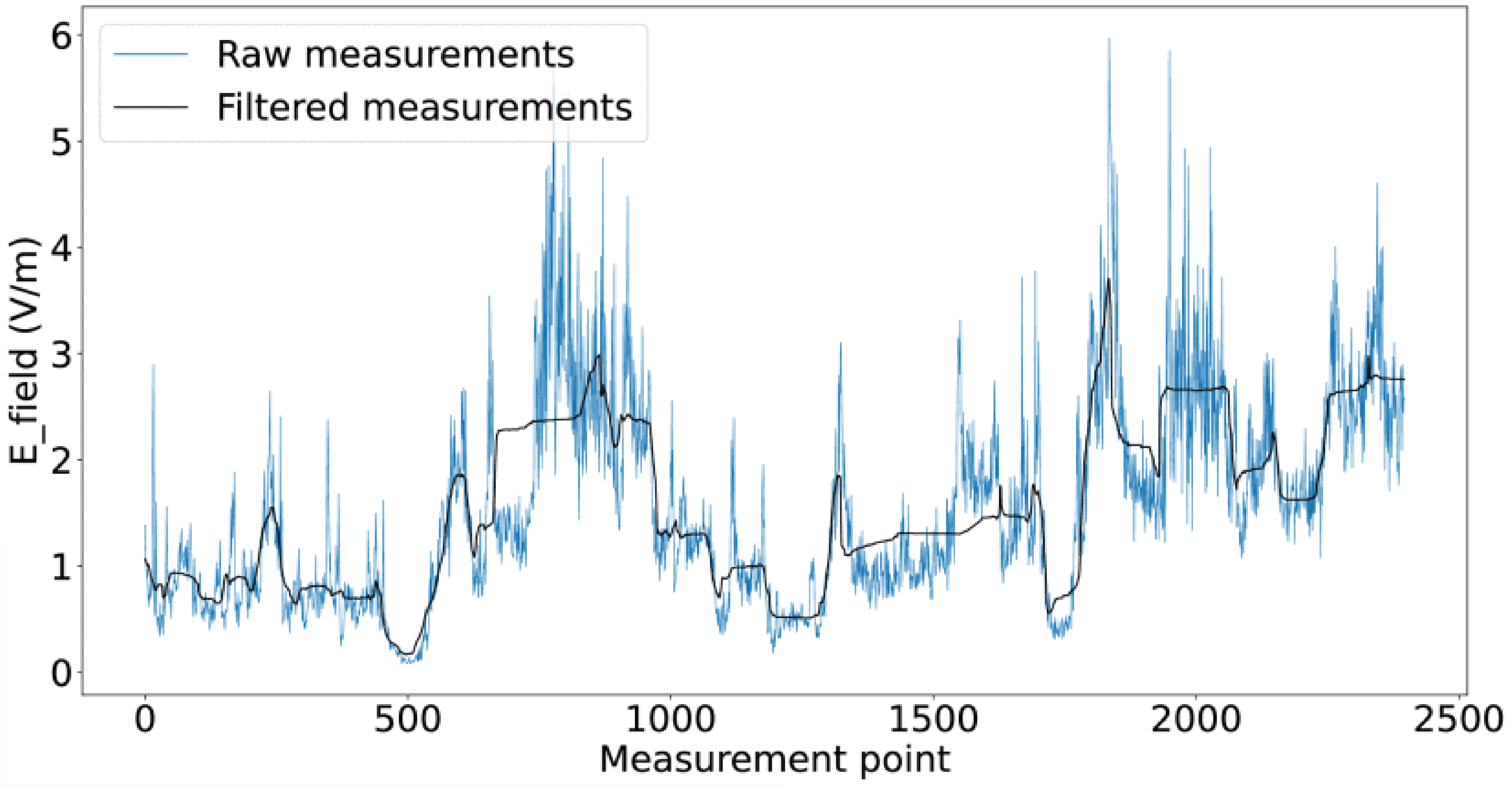
- The analysis of throughput during video calls and FTP uploads has shown a lower radiated energy per bit transmitted (REBT); for file uploading it was 9.65 mJ/Mb for 4G and 5.1 mJ/Mb for 5G.

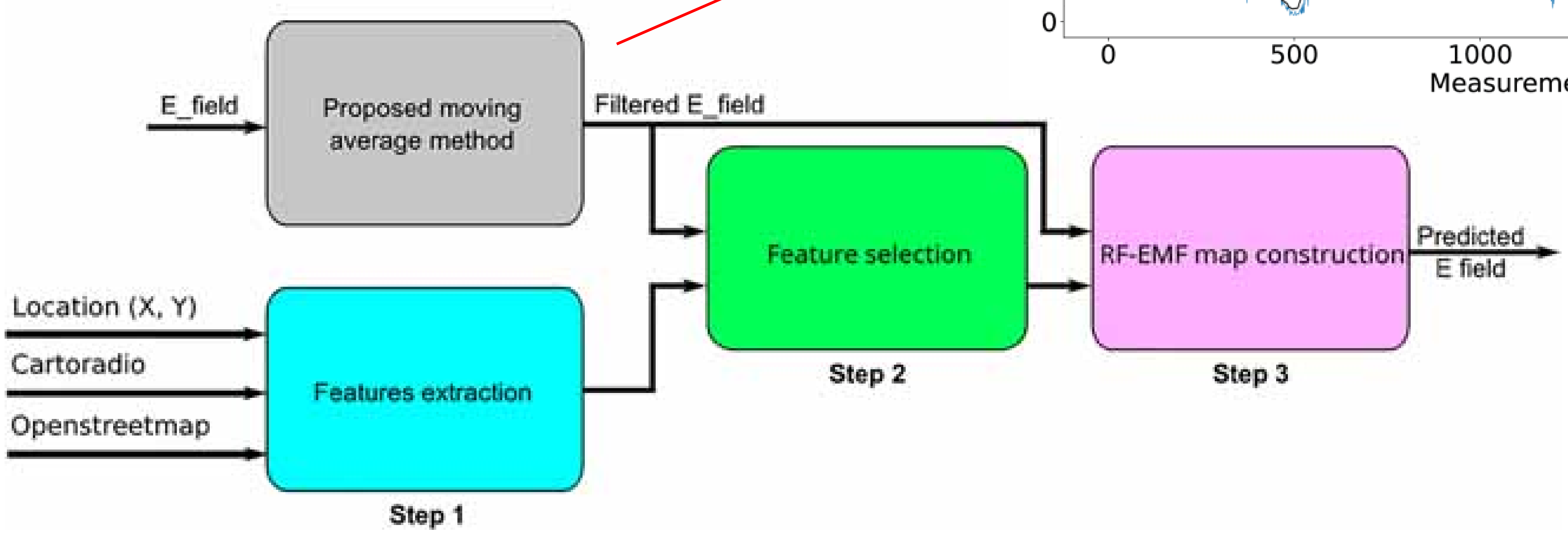
J. Liu et al., "Assessment of EMF Exposure Induced by Wireless Cellular Phones in Various Usage Scenarios in France," in IEEE Access, doi: 10.1109/ACCESS.2024.3424305.

SEAWave

CLUE-H EUROPEAN CLUSTER EMF AND HEALTH

Exposure assessment
Exposure prediction in urban environment using AI

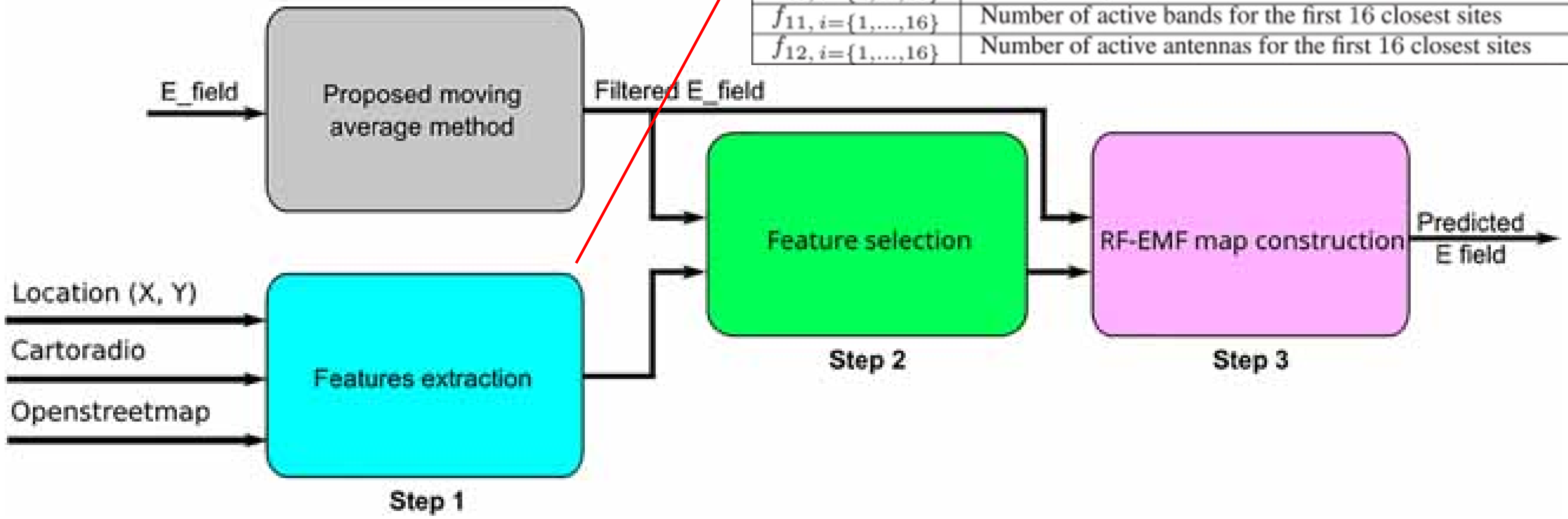




W. B. Chikha, S. Wang and J. Wiart, "An Extrapolation Approach for RF-EMF Exposure Prediction in an Urban Area Using Artificial Neural Network," in IEEE Access, vol. 11, pp. 52686-52694, 2023, doi: 10.1109/ACCESS.2023.3280125

Exposure assessment
Exposure prediction in urban environment using AI

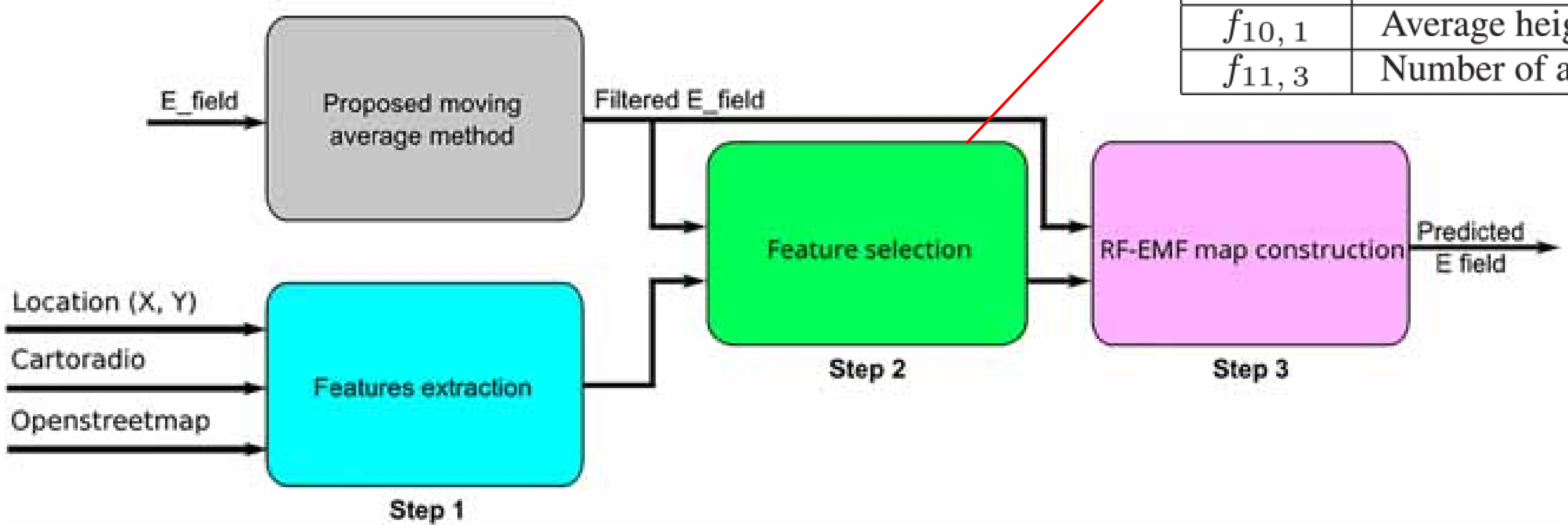
Feature	Description	Data Source
f_1	X	Geo Tracker
f_2	Y	
f_3	Measurement hour	Computer connected to Tektronix
f_4	Density of surrounding buildings	Openstreetmap: https://overpass-turbo.eu/
f_5	Height of closest building	
f_6	Distance to closest building	
f_7	Number of active bands inside a circle centered at each MP with a radius of 160 m	Cartoradio: https://www.cartoradio.fr/
f_8	Number of active antennas inside a circle centered at each MP with a radius of 160 m	
$f_{9,\ i=\{1,\ldots,16\}}$	Distance to first 16 closest sites	
$f_{10,\ i=\{1,\ldots,16\}}$	Average height of active antennas for the first 16 closest sites	
$f_{11,\ i=\{1,\ldots,16\}}$	Number of active bands for the first 16 closest sites	
$f_{12,\ i=\{1,\ldots,16\}}$	Number of active antennas for the first 16 closest sites	



W. B. Chikha, S. Wang and J. Wiart, "An Extrapolation Approach for RF-EMF Exposure Prediction in an Urban Area Using Artificial Neural Network," in IEEE Access, vol. 11, pp. 52686-52694, 2023, doi: 10.1109/ACCESS.2023.3280125

Exposure assessment
Exposure prediction in urban environment using AI

Feature	Description
f_4	Density of surrounding buildings
f_5	Height of closest building
f_6	Distance to closest building
f_7	Number of active bands inside a circle centered at each MP with a radius of 160 m
$f_{9\,2}$	Distance to second closest site
$f_{9\,3}$	Distance to third closest site
$f_{10,\,1}$	Average height of antennas for the first closest site
$f_{11,\,3}$	Number of active bands for the third closest site

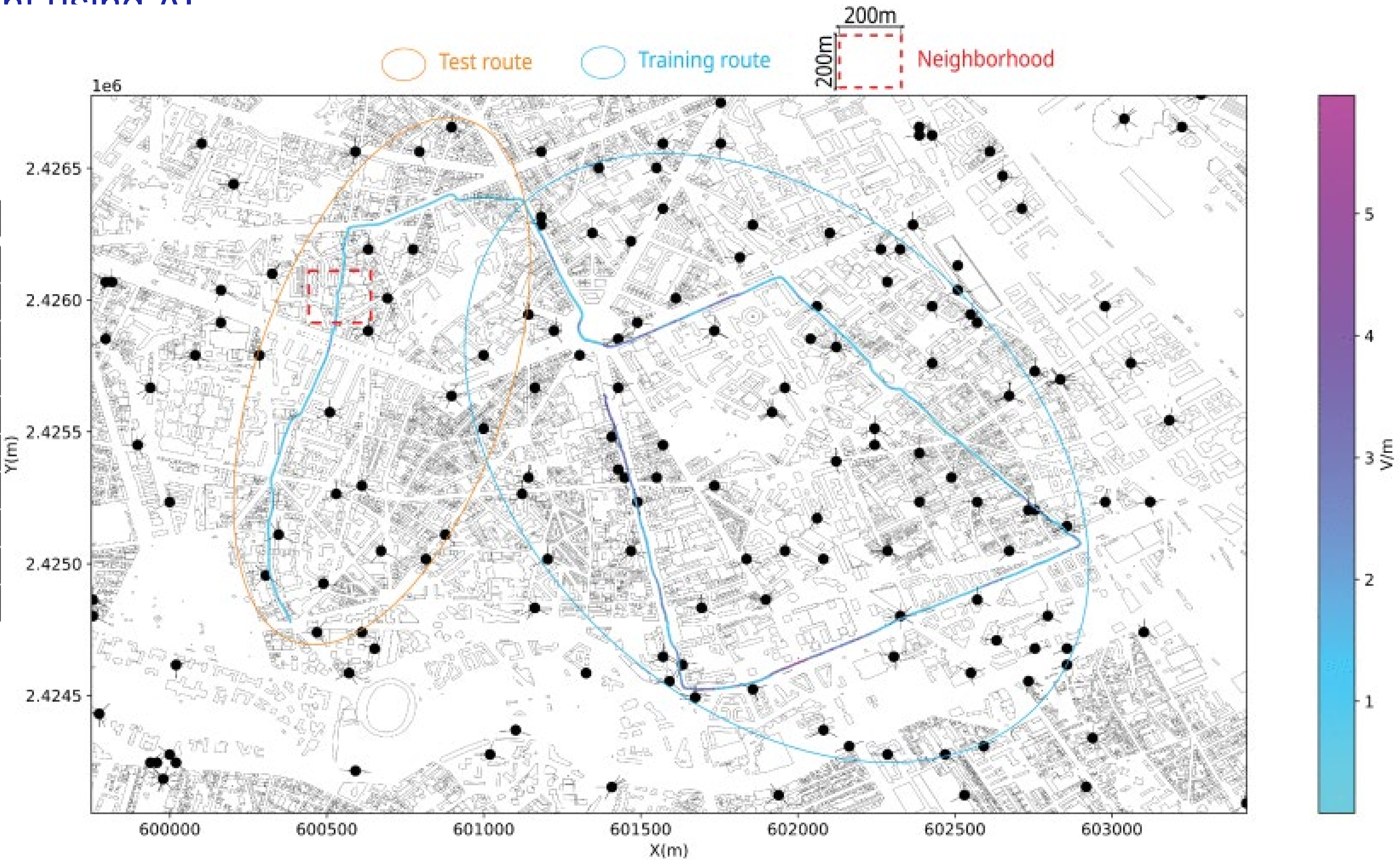


W. B. Chikha, S. Wang and J. Wiart, "An Extrapolation Approach for RF-EMF Exposure Prediction in an Urban Area Using Artificial Neural Network," in IEEE Access, vol. 11, pp. 52686-52694, 2023, doi: 10.1109/ACCESS.2023.3280125

Exposure assessment

Exposure prediction in urban environment using AI

Hyper-parameters	Values
Pre-processing of inputs	Standardization
Number of hidden layers	2
Number of neurons	50
Optimizer	Adamax
Activation function	Relu
Learning rate (l_{ini})	0.01
Number of epoch	75
Learning Rate decay	$l = l_{ini} \exp(-kEpoch)$
Batch size	32
Loss function	Mean squared error

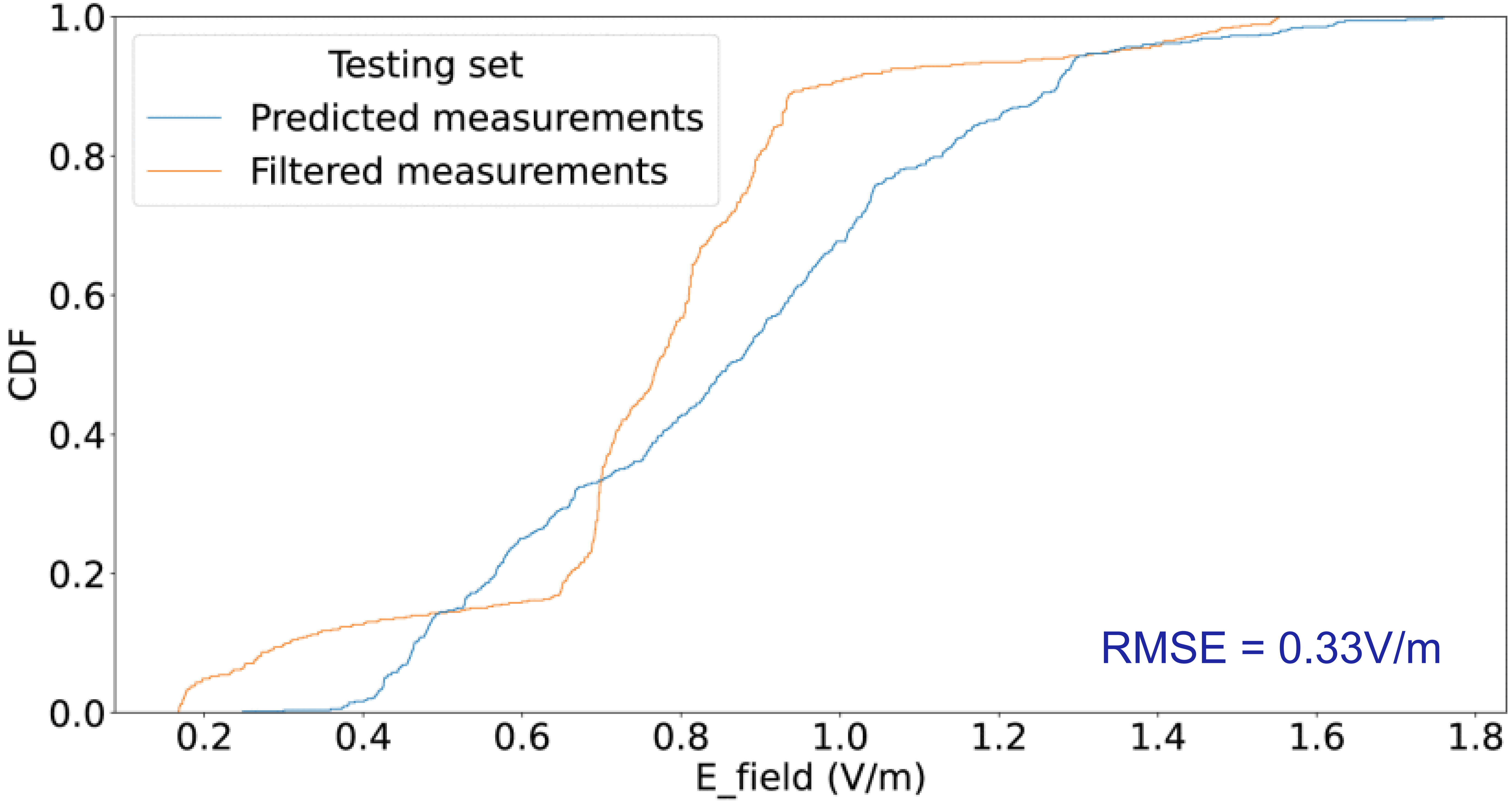


W. B. Chikha, S. Wang and J. Wiart, "An Extrapolation Approach for RF-EMF Exposure Prediction in an Urban Area Using Artificial Neural Network," in IEEE Access, vol. 11, pp. 52686-52694, 2023, doi: 10.1109/ACCESS.2023.3280125

SEAWave

Exposure assessment
Exposure prediction in urban environment using AI

CLUE – H
EUROPEAN CLUSTER
EMF AND HEALTH



W. B. Chikha, S. Wang and J. Wiart, "An Extrapolation Approach for RF-EMF Exposure Prediction in an Urban Area Using Artificial Neural Network," in IEEE Access, vol. 11, pp. 52686-52694, 2023, doi: 10.1109/ACCESS.2023.3280125

ETAIN

Exposure assessment
Dose calculator

CLUE – H
EUROPEAN CLUSTER
EMF AND HEALTH

Call with a mobile phone step 1 of 8

How many minutes per day do you call with your mobile phone (on average per day)?
(incoming and outgoing voice calls, WhatsApp voice calls, etc)

Duration:

0 600

7 min

When you make a voice call, what is the percentage of time you hold the phone against your ear (compared to using headphones or speaker)?

Usage: **66%**

When you do not hold the phone against your ear while calling, indicate the % of time you use headphones or speaker mode.

Headphone: **Speaker: 50%**

When you are using headphones during a call, where do you have your phone?

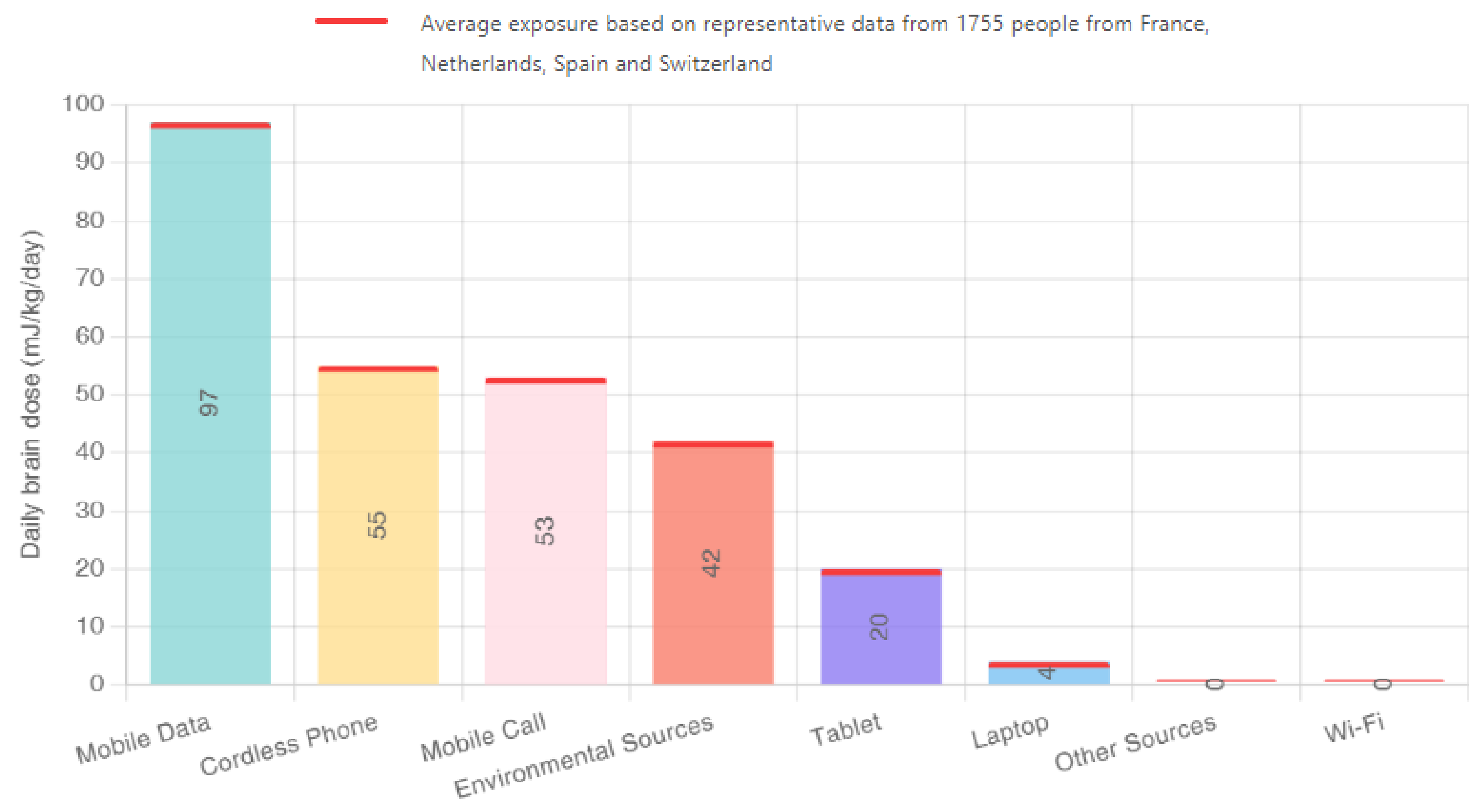
- Front of face
- On the body (e.g. trouser pocket)
- Further away from body (e.g. on a nearby table, handbag)

back | reset values | next

Contribution of different sources compared to the average public exposure (red bar)

This figure shows your personal exposure compared to average public exposure, and the contributions of different exposure sources.

Want to learn more about the Dose Calculator?



Download graph

https://www.etainproject.eu/dose-calculator

ETAIN

CLUE – H
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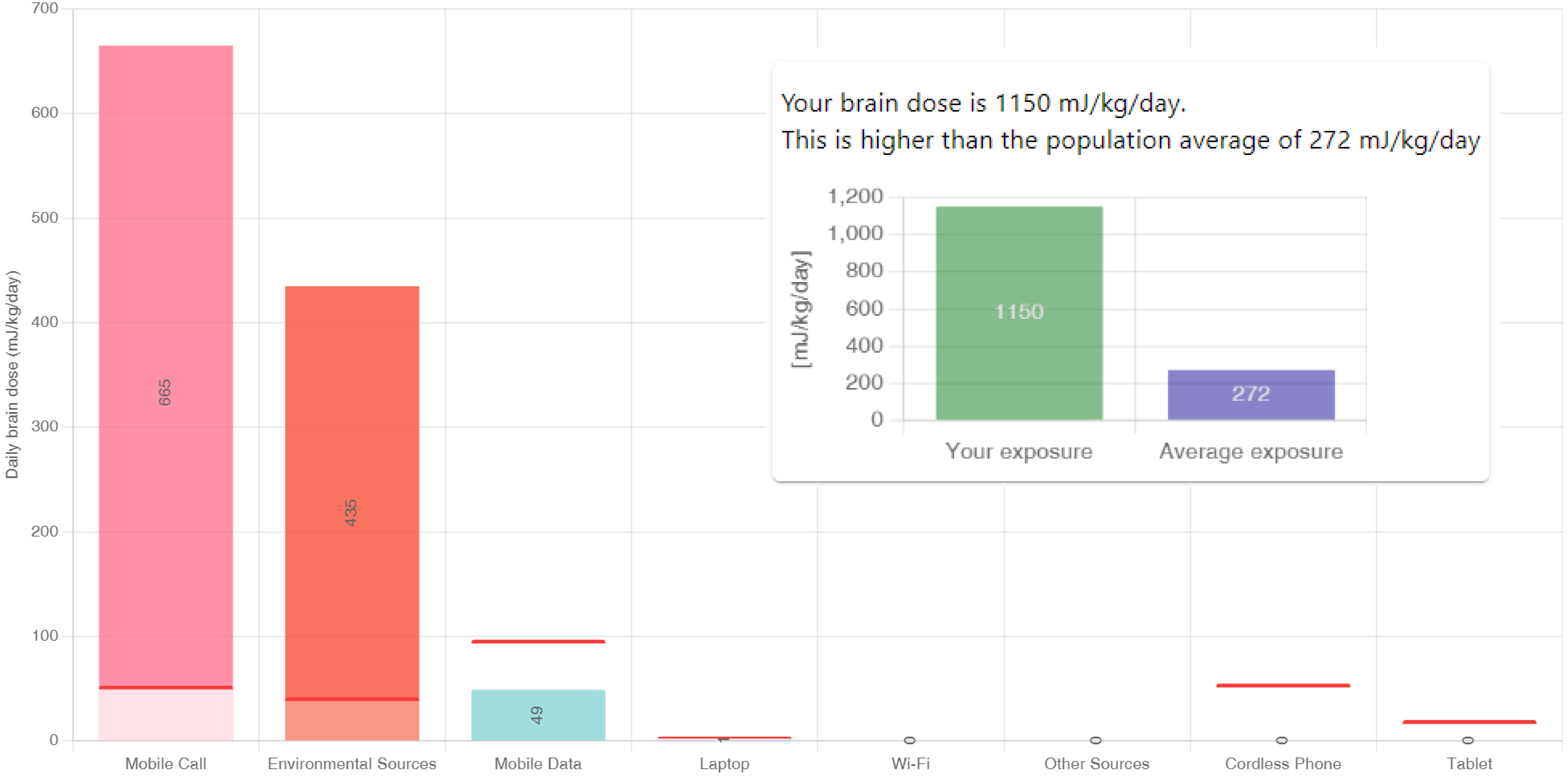
EMF AND HEALTH

Exposure assessment
Dose calculator

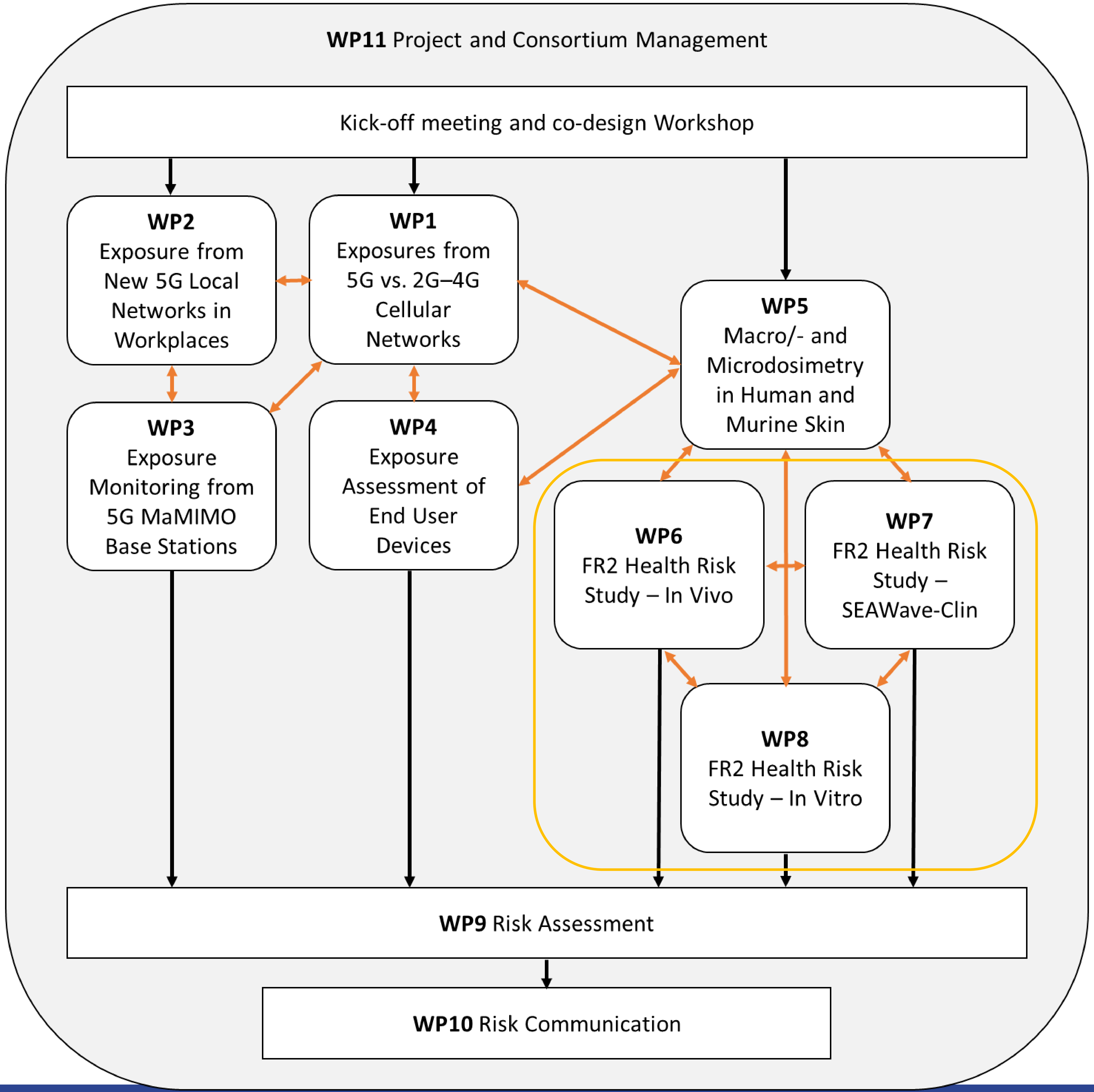


https://www.etainproject.eu/dose-calculator

Conclusions
on Exposure Assessment

- Two projects appear to be leading exposure assessment and monitoring within CLUE-H: SEAWave and GOLIAT, with SEAWave in a more advanced state, due to the shortest project lifetime
- A large amount of data has been collected and has not been analyzed, yet, from various SEAWave partners in countries other than France (Greece, Belgium, Switzerland, Germany, Serbia).
- Although data were collected with the same protocol, their homogenization remains a challenge and the main area of work currently.
- Taking an integrative approach, all exposure components (downlink, uplink, bystander) are measured and analyzed. Calculations to convert exposure to organ-specific SAR are under way.
- SEAWave will implement a tool for calculating the “global exposure index” (see Project LEXNET), whereas ETAIN has already implemented a tool to calculate, again in an integrative approach, the dose in the brain (energy per tissue mass per day).

Scientific-based **E**xposure and risk **A**ssessment of radiofrequency and mm-**Wave** systems from children to elderly (5G and Beyond)



SEAWave

Update on animal studies (WP6)

CLUE – H
EUROPEAN CLUSTER
EMF AND HEALTH

Determining skin immunoresponse and nociceptors activation	12 Feb 2024 - 4 Mar 2024		
Development of Squamous Cell Carcinoma (CAR-S mice)		30 Mar 2024 - 3 Jul 2024	
Development of Basal Cell Carcinoma (Ptch1+/- mice)			8 Jul 2024 - 8 Jan 2025
Investigation of non-cancerous endpoints (male fertility, lens opacity, hippocampal neuro-genesis and inflammation)			8 Jul 2024 - 8 Jan 2025

***Ptch1*$^{+/-}$ and WT mice**

P1 → irradiation 23 out of 24 hours → P21

3 groups:

- **Sham** (N=48)
- **Low power density (LPD)** (N=48) **(6.67W/m²)**
- **High power density (HPD)** (N=48) **(20W/m²)**

P1 → Start date of exposure: 12 Feb. 2024

P21 → End date of exposure: 04 Mar. 2024

4 Cages per group
(12 pups per cage)

Update on animal studies (WP6)

Determining skin immunoresponse and nociceptors activation	12 Feb 2024 - 4 Mar 2024		
Development of Squamous Cell Carcinoma (CAR-S mice)		30 Mar 2024 - 3 Jul 2024	
Development of Basal Cell Carcinoma (Ptch1+/- mice)			8 Jul 2024 - 8 Jan 2025
Investigation of non-cancerous endpoints (male fertility, lens opacity, hippocampal neuro-genesis and inflammation)			8 Jul 2024 - 8 Jan 2025

5µg/100µl DMBA-initiated Car-S mice
n=140 (n=70 for each sex)

1µg/100µl TPA-treated group n=32
(n=16 for each sex)

exposure 100 days
(23 out of 24 hours)

Group K
n = 36 (n= 18 for each sex)

Group Q
n = 36 (n= 18 for each sex)

Group V
n = 36 (n= 18 for each sex)

12 Cages per group
(3 animals per cage)

SEAWave

Update on human study (WP7)

CLUE – H
EUROPEAN CLUSTER
EMF AND HEALTH

1) Healthy (6M/6F)

18-25 years old
No skin disease or fam. history
Photo-protected

2) Thin/aged skin (6M/6F)

60-80 years old
Dermatoporotic skin
Sun exposed

3) Cancer prone (3M/3F)

Skin tumor syndromes
18-80 years old

4) Pre-inflamed (6M/6F)

Atopic Dermatitis
18-80 years old

Genetic diseases selected for group 3) Cancer prone:

Xeroderma Pigmentosum variants
Familial Cylindromatosis or Spiegler Brook syndrome
Gorlin-Goltz szndrome

42 Volunteers →

2 Arms:
Double-blind exposure

2 Biopsies:
1h, 24h

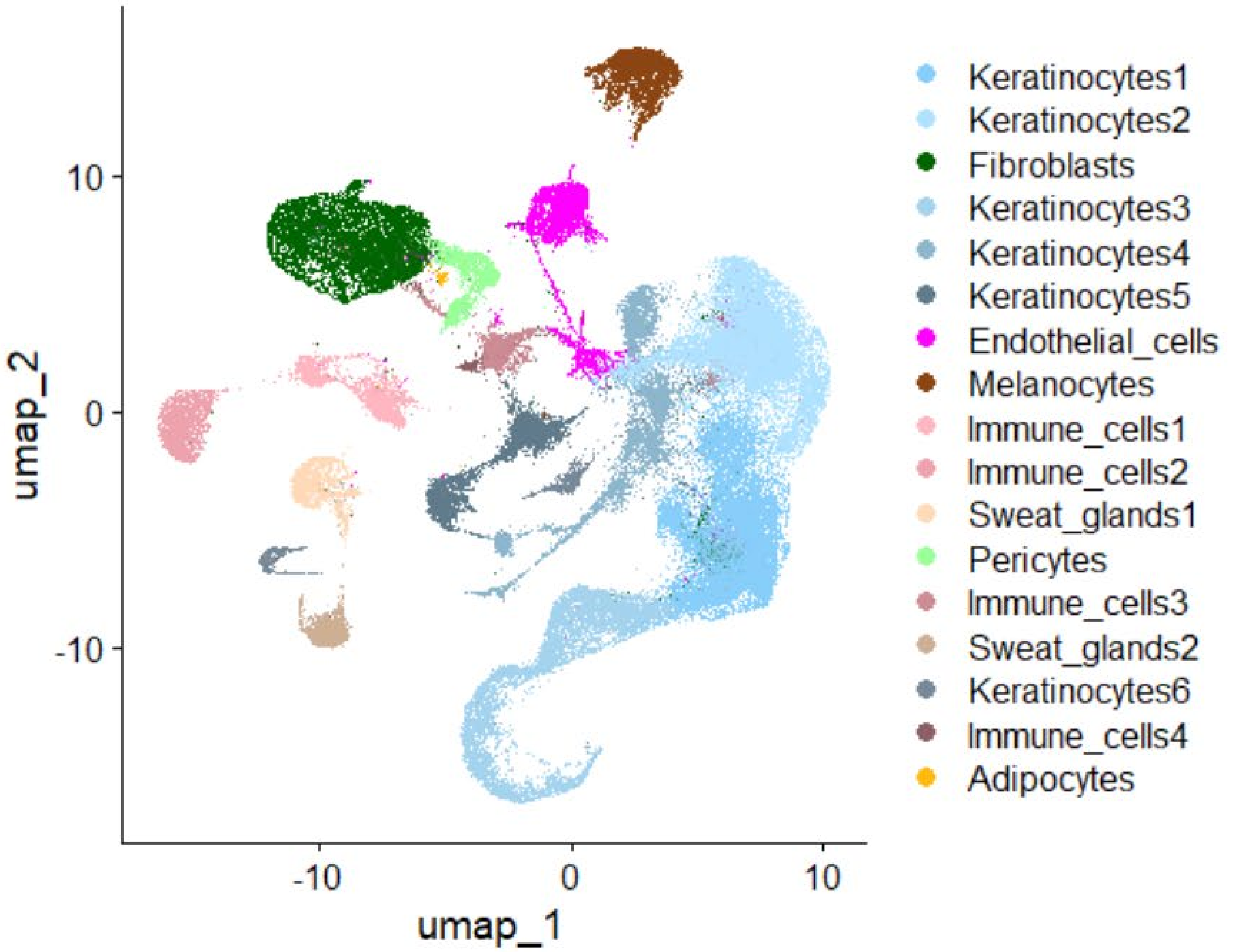
Fixed skin protocol

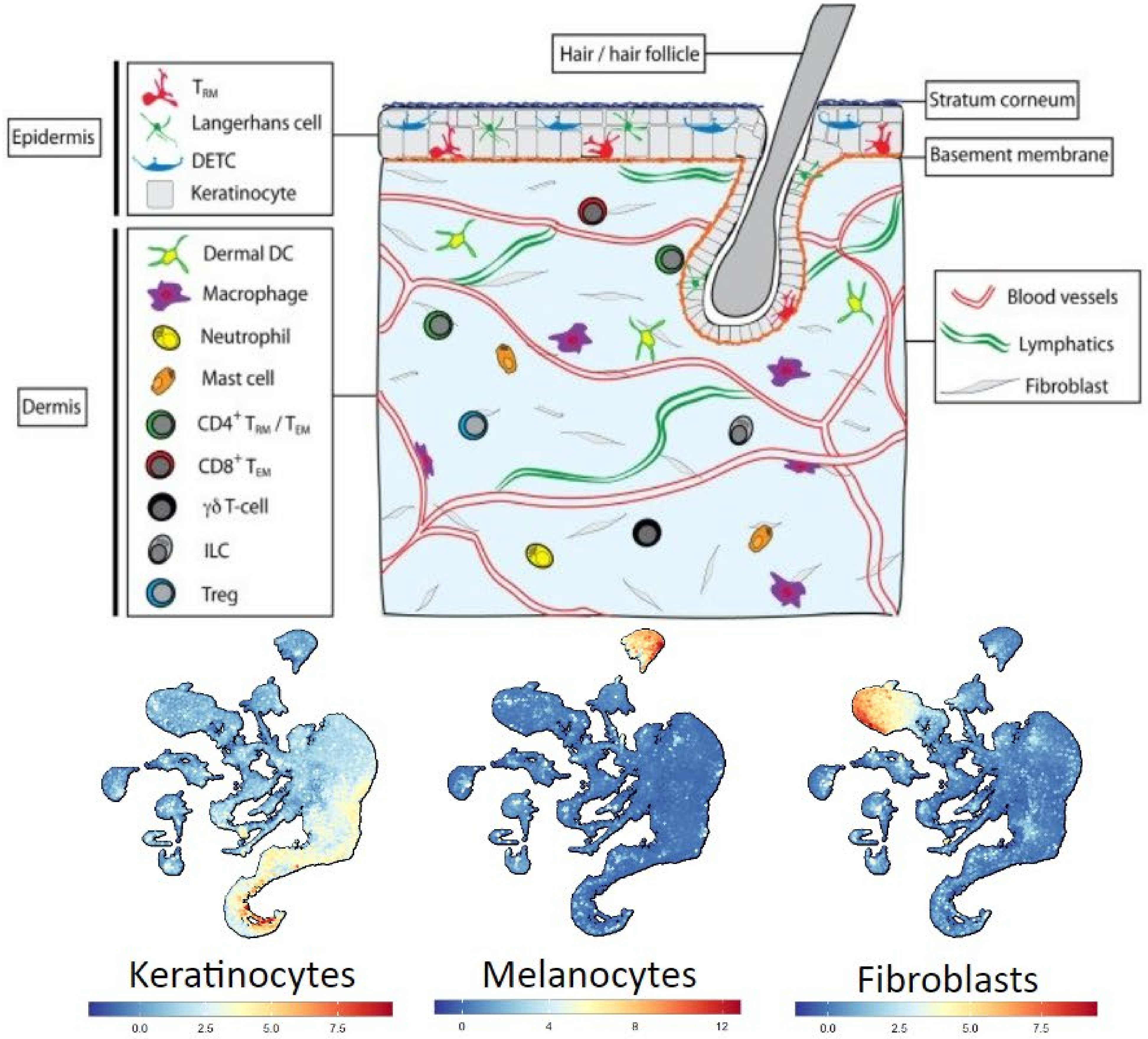
168 samples for scRNA seq

SIB Swiss Institute of Bioinformatics

→ **Data stockage**
→ **Data analysis**

Update on human study (WP7)





All types of cells are present in all subjects' samples.
Homogeneous cell distributions exist from all 8 healthy subjects until now.

Conclusions
on Health Risk Studies

- Results from the animal study on 21 days postnatal exposure are ready to be published (pending dosimetry verification/validation with on site measurements).
- The human study progresses at a good pace. The more biopsies the strongest the signals/results from scRNA sequencing. Comparison between health condition groups cannot be performed yet.
- Oxidative comet assay test concluded for keratinocytes (@4h of exposure). This test had not been planned in the GA but was added at the suggestion of the External Advisory Board of SEAWave.

SEAWave

CLUE – H
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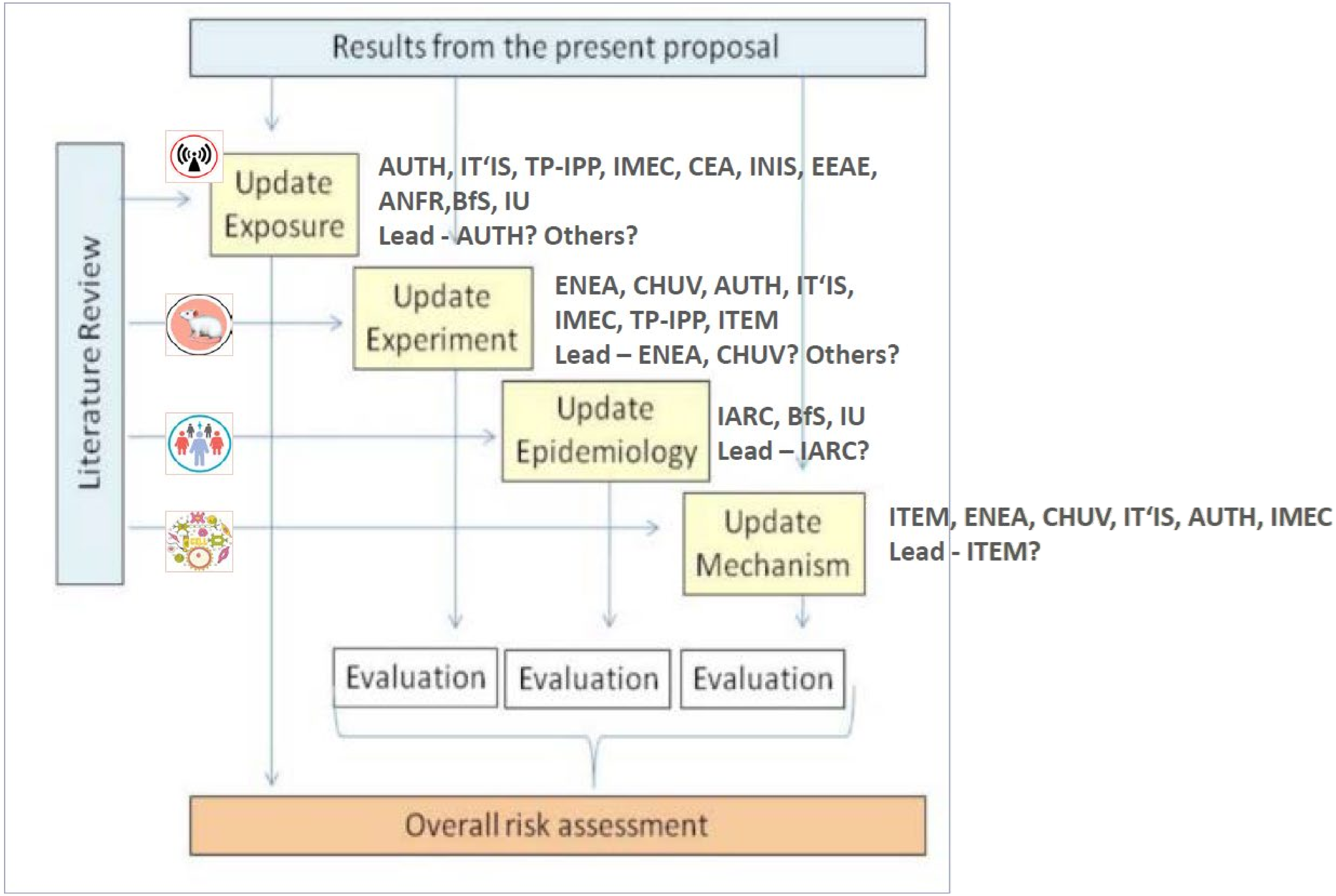
EMF AND HEALTH

Other activities:
IARC-like evaluation (WP9)



Thank you for your attention!

theosama@auth.gr

seawave-project.eu

Q&A: The science perspective

Prof Akimasa Hirata
Nagoya Institute of Technology, Japan and International Commission on Non-Ionizing Radiation Protection (ICNIRP) Chair 2024-2028

Dr Dan Baaken
German Federal Office for Radiation Protection and ICNIRP Scientific Secretary 2024-2028

Prof Maria Feychting
Institute of Environmental Medicine, Karolinska Institute, Sweden

Prof Theo Samaras
Aristotle University of Thessaloniki, Greece, coordinator of SEAWave, and member of the European Commission Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)

DI Manfred Ruttner, A1
Telekom Austria - Deputy Chair GSMA EMF and Health

Coffee break

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Dr Emilie van Deventer
Head, Radiation and Health Unit
World Health Organization

The World Health Organization (WHO) Task Group on Radiofrequency Fields and Health

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Monograph on Radiofrequency Fields and Health Risks

Dr Emilie van Deventer, WHO Technical officer

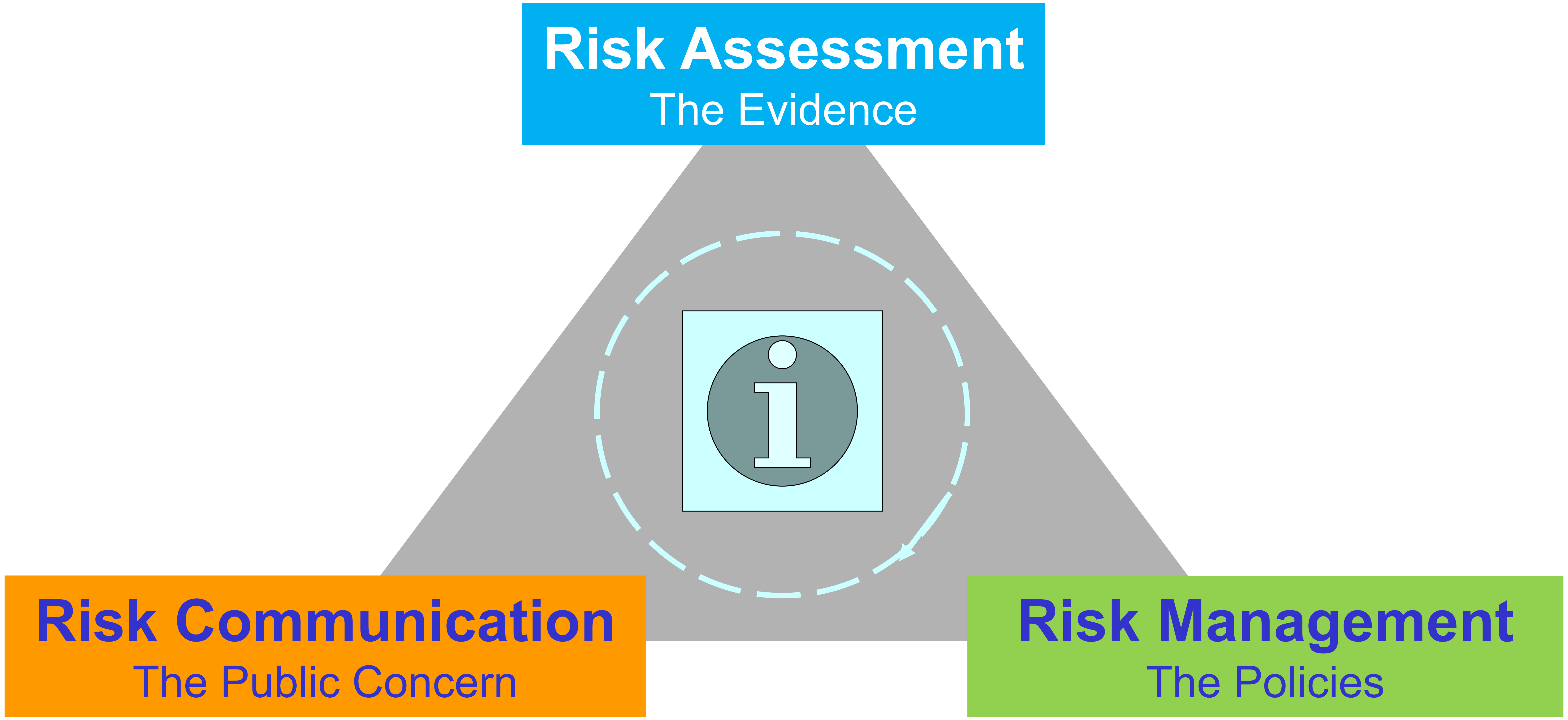
Dr Jos Verbeek, Methodologist

Professor Hajo Zeeb, Task Group Chair

World Health Organization 75 HEALTH FOR ALL

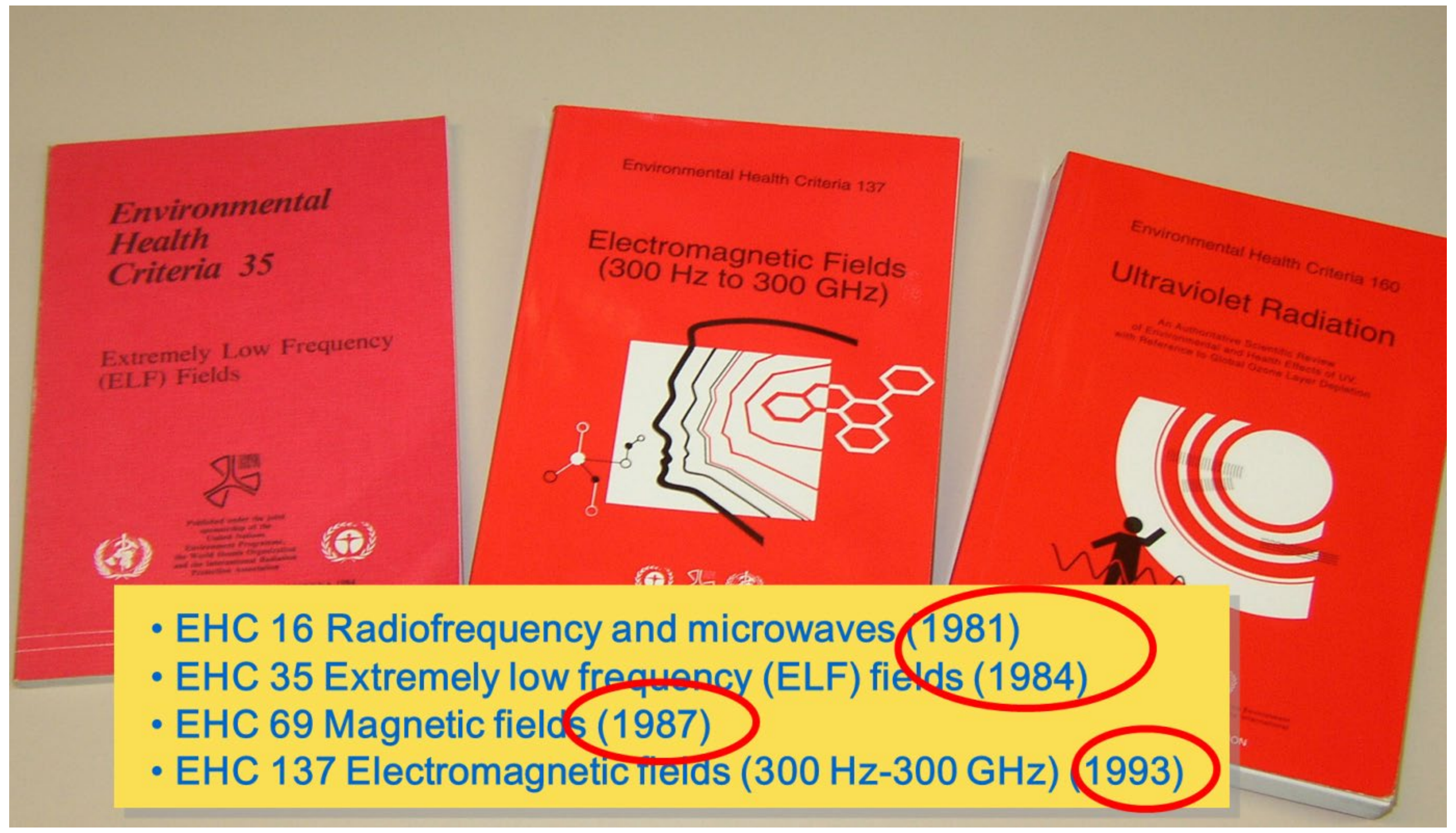
13th GSMA EMF Forum, 1 October 2024, Brussels, Belgium

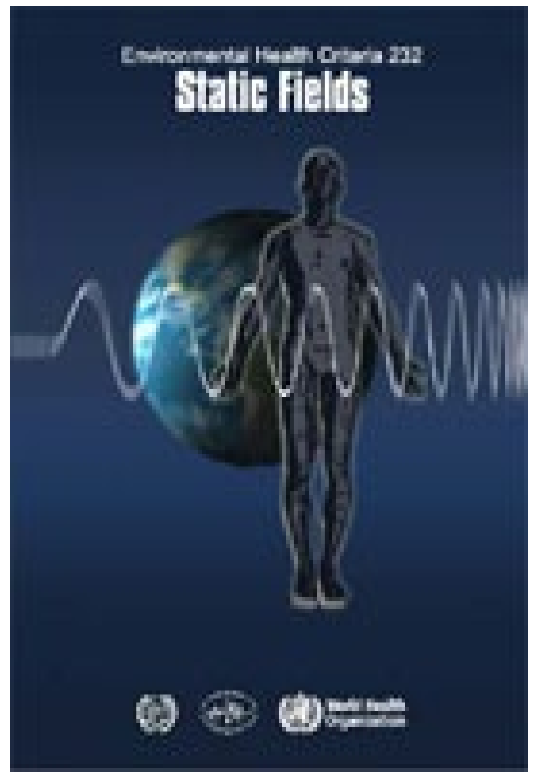
Do EMFs pose a heath risk?



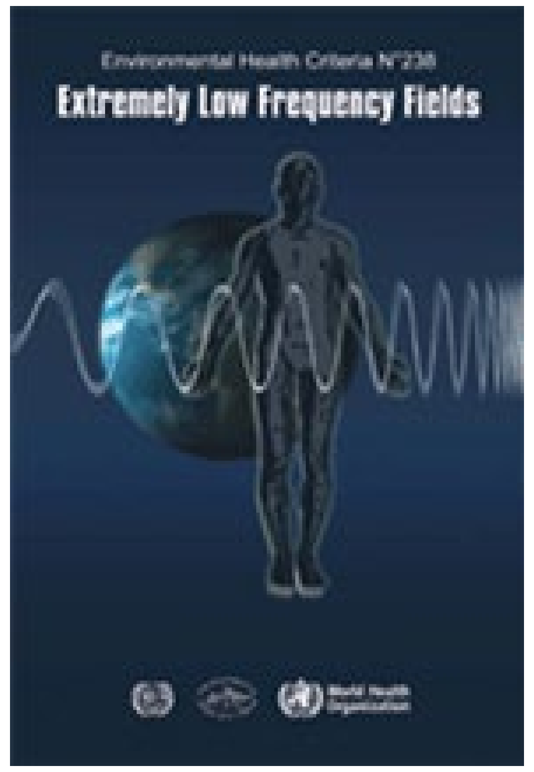
WHO Environmental Health Criteria monographs on radiation

- WHO EHC monographs (health risk assessment)





2006



2007

RF

World Health Organization

75 HEALTH FOR ALL

Health Risk Assessment

Problem Formulation

Hazard Identification

Review key research to identify any potential health problems that an agent can cause

Exposure Assessment

Determine the amount, duration and pattern of exposure to the agent

Exposure-Response Assessment

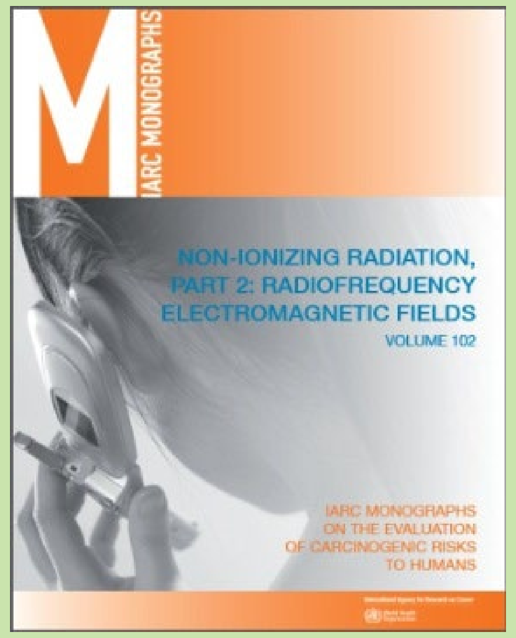
Estimate how much of the agent it would take to cause varying degrees of health effects that could lead to illnesses

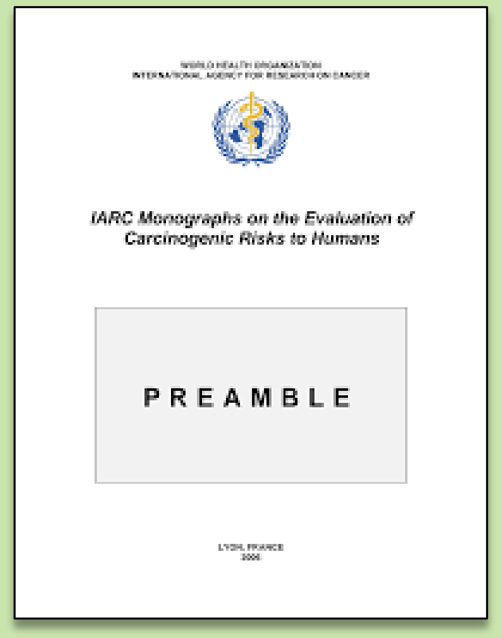
Risk Characterization

Assess the risk for the agent to cause cancer or other illnesses in the general population

International Agency for Research on Cancer (IARC)

Centre International de Recherche sur le Cancer (CIRC)





RF fields classified as "*possibly carcinogenic to humans*" (*Group 2B*)

World Health Organization

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Health Risk Assessment

International EMF Project

Problem Formulation

Hazard Identification

Review key research to identify any potential health problems that an agent can cause

Exposure Assessment

Determine the amount, duration and pattern of exposure to the agent

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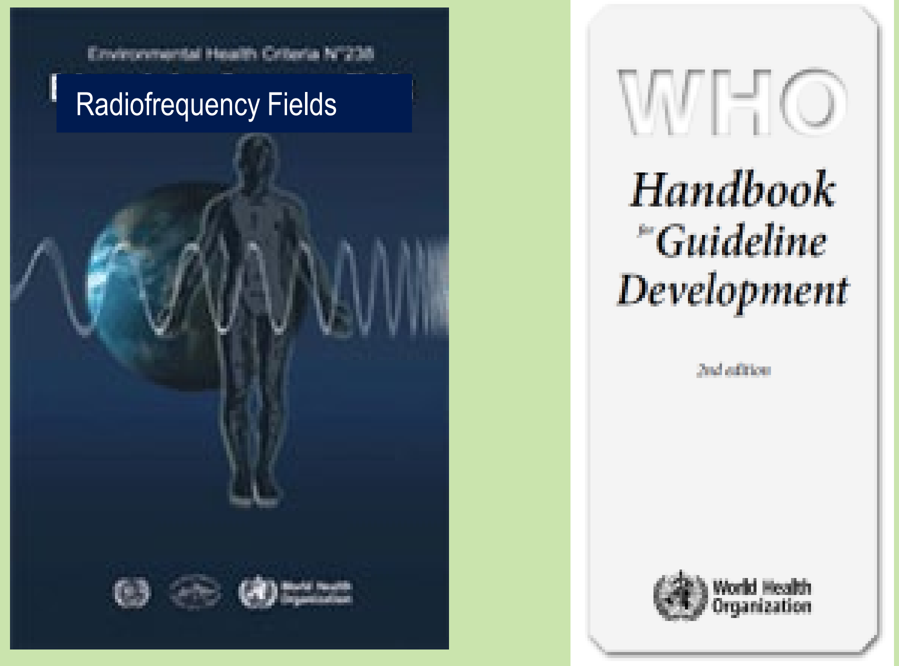
Estimate how much of the agent it would take to cause varying degrees of health effects that could lead to illnesses

Risk Characterization

Assess the risk for the agent to cause cancer or other illnesses in the general population

All studied outcomes



World Health Organization

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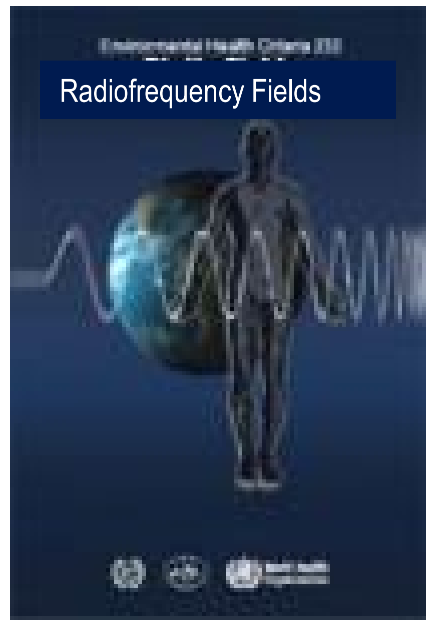
RF Environmental Health Criteria
Objectives

- To review the scientific literature regarding **adverse health effects** from exposure to radiofrequency fields
- To perform a **health risk assessment** of all studied health endpoints, as far as the evidence can offer
- To compile a **summary of national policies** around the world (based on a survey performed in Fall 2012 and current update)
- To identify **gaps in knowledge**



Scope and target audience

- Scope
  - Radiofrequency fields from 100 kHz to 300 GHz
  - Public and occupational exposures (not medical exposures)

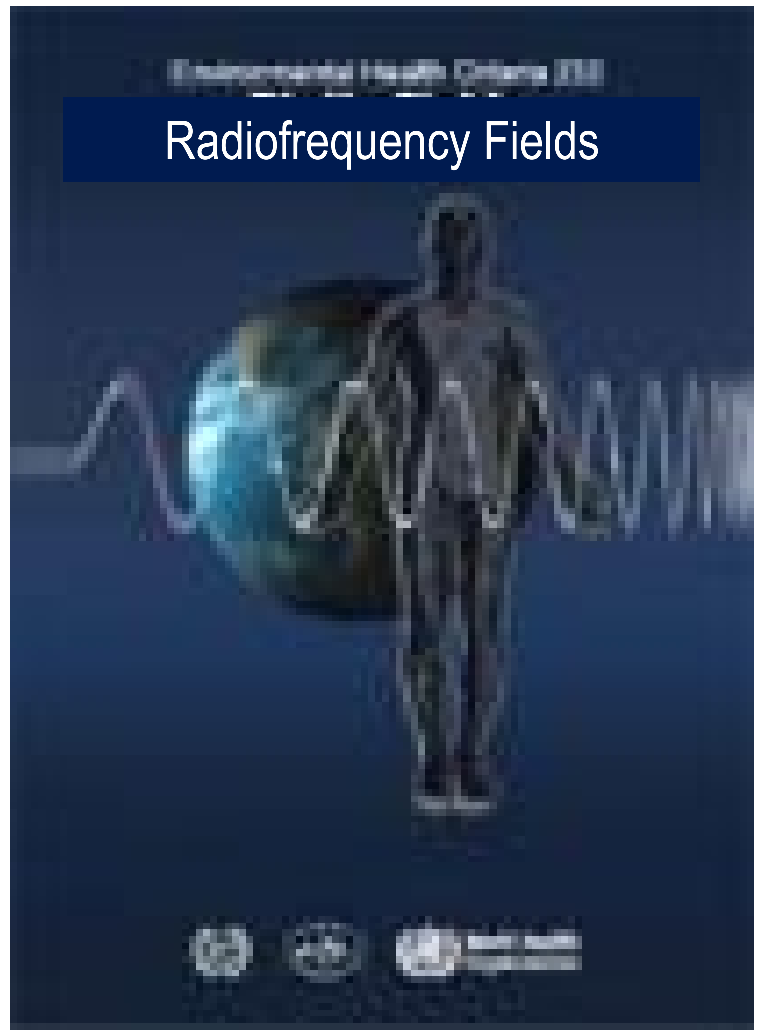
- Target audience
  - National policy-makers in Ministries of Health, Environment, Labour, Telecommunications, ...
  - Bodies involved in recommending or setting exposure guidelines for RF EMF, such as non-governmental organizations
  - Professional societies and academics studying the health effects of RF EMF

Technical outputs

- The appraisal of the evidence for health risks associated with exposure to RF fields to result in

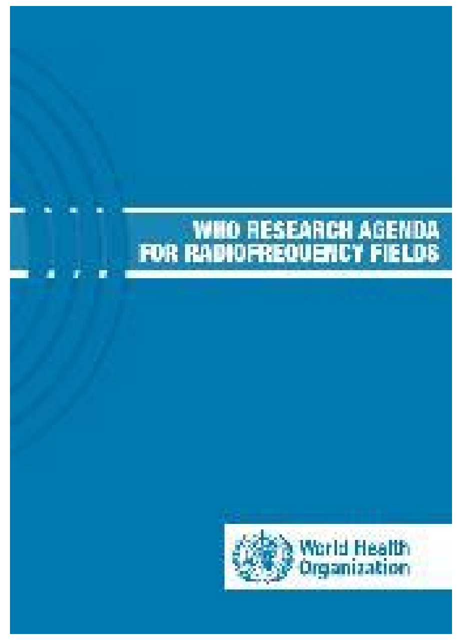
WHO Scoping review

Systematic reviews



EHC Monograph

…

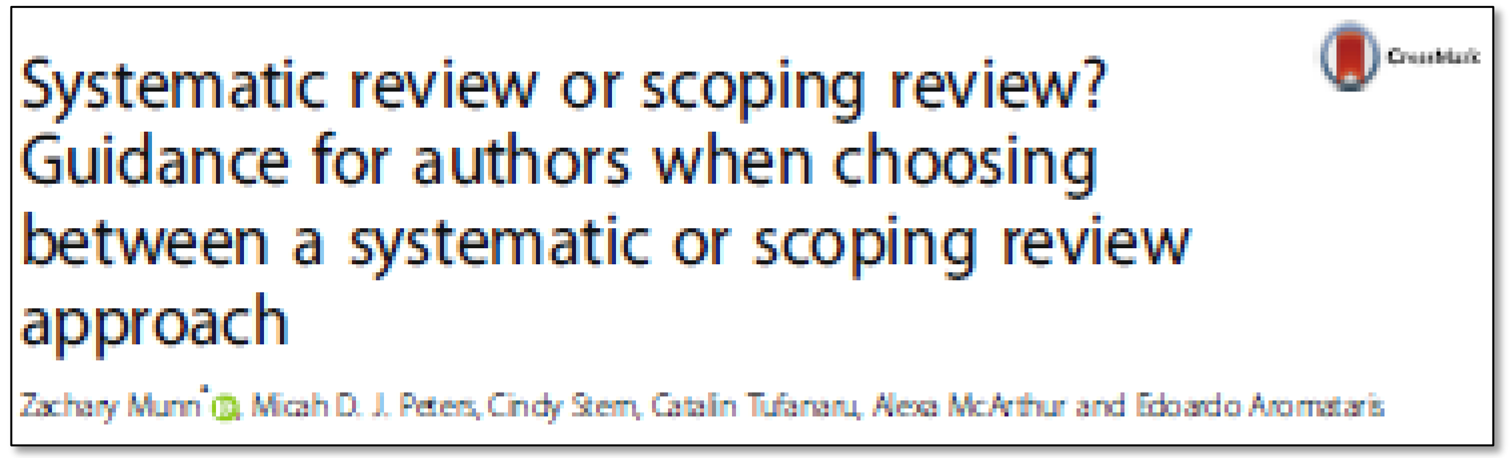


Research Agenda

1. Technical report -> A “scoping review”

WHO Scoping review

Scoping review


Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach

Zachary Munn*, Micah D. J. Peters, Cindy Stern, Catalin Tufanaru, Alexa McArthur and Edoardo Aromataris

- "... An ideal tool to determine the **scope or coverage of a body of literature** on a given topic and give clear indication of the volume of literature and studies available as well as **an overview (broad or detailed) of its focus**"
- Therefore, an assessment of methodological limitations or **risk of bias** of the evidence included within a scoping review **is generally not performed**
- Although conducted for different purposes compared to systematic reviews, **scoping reviews still require rigorous and transparent methods** in their conduct to ensure that the results are trustworthy.


WHO Scoping review

World Health Organization

75 HEALTH FOR ALL

Scoping vs. systematic reviews

Table 1 Defining characteristics of traditional literature reviews, scoping reviews and systematic reviews

	Traditional Literature Reviews	Scoping reviews	Systematic reviews
A priori review protocol	No	Yes (some)	Yes
PROSPERO registration of the review protocol	No	No[a]	Yes
Explicit, transparent, peer reviewed search strategy	No	Yes	Yes
Standardized data extraction forms	No	Yes	Yes
Mandatory Critical Appraisal (Risk of Bias Assessment)	No	No[b]	Yes
Synthesis of findings from individual studies and the generation of 'summary' findings[c]	No	No	Yes

[a]Current situation; this may change in time. [b]Critical appraisal is not mandatory, however, reviewers may decide to assess and report the risk of bias in scoping reviews. [c]By using statistical meta-analysis (for quantitative effectiveness, or prevalence or incidence, diagnostic accuracy, aetiology or risk, prognostic or psychometric data), or meta-synthesis (experiential or expert opinion data) or both in mixed methods reviews

https://doi.org/10.1186/s12874-018-0611-x

Table of Contents

1. Introduction
2. Description of methods
3. Thermal effects
4. Cancer
5. Symptoms and well-being
6. Brain physiology and function
7. Fertility, reproduction and childhood development
8. Neurodegenerative disorders
9. Cardiovascular diseases
10. Neuroendocrine system responses
11. Autonomous nervous system
12. Auditory and vestibular function
13. Ocular function
14. Immune system
15. Haematological changes
16. Biological mechanisms

Appendix A– Sources, measurements and exposures

Appendix B – Radiofrequency electromagnetic fields inside the body

Appendix C– Biophysical mechanisms

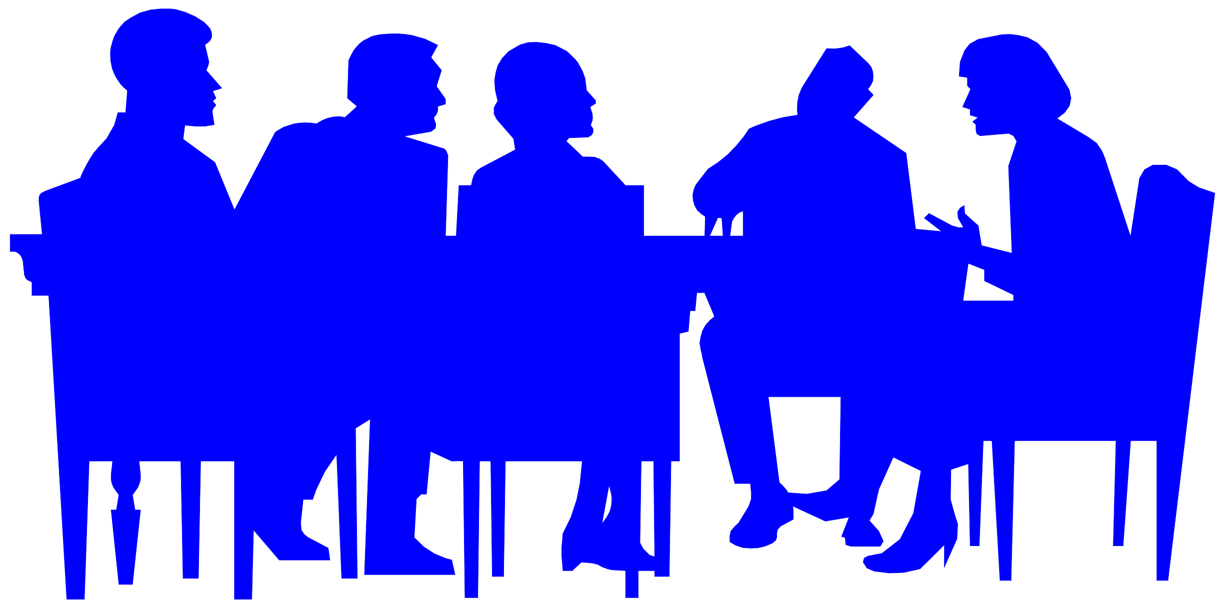
WHO Scoping Report

- 16 chapters, > 3000 references
- All published studies (in-vitro, animal and human) of health effects reported in the literature with sufficient quality - until about 2017-2020
- To be published as a WHO technical document

Contributors
Core Group

- Epidemiological studies: M. Feychting, Sweden
- Human experimental studies: G. Oftedal, Norway
- Animal studies: E. van Rongen, Netherlands
- In vitro studies: M. R. Scarfi, Italy
- Physics, dosimetry: S. Mann, UK
- Public health: D. Zmirou, France (until 2015)
- Methodology: J. Verbeek (since 2016)

+ Working group members (~ 20-30)

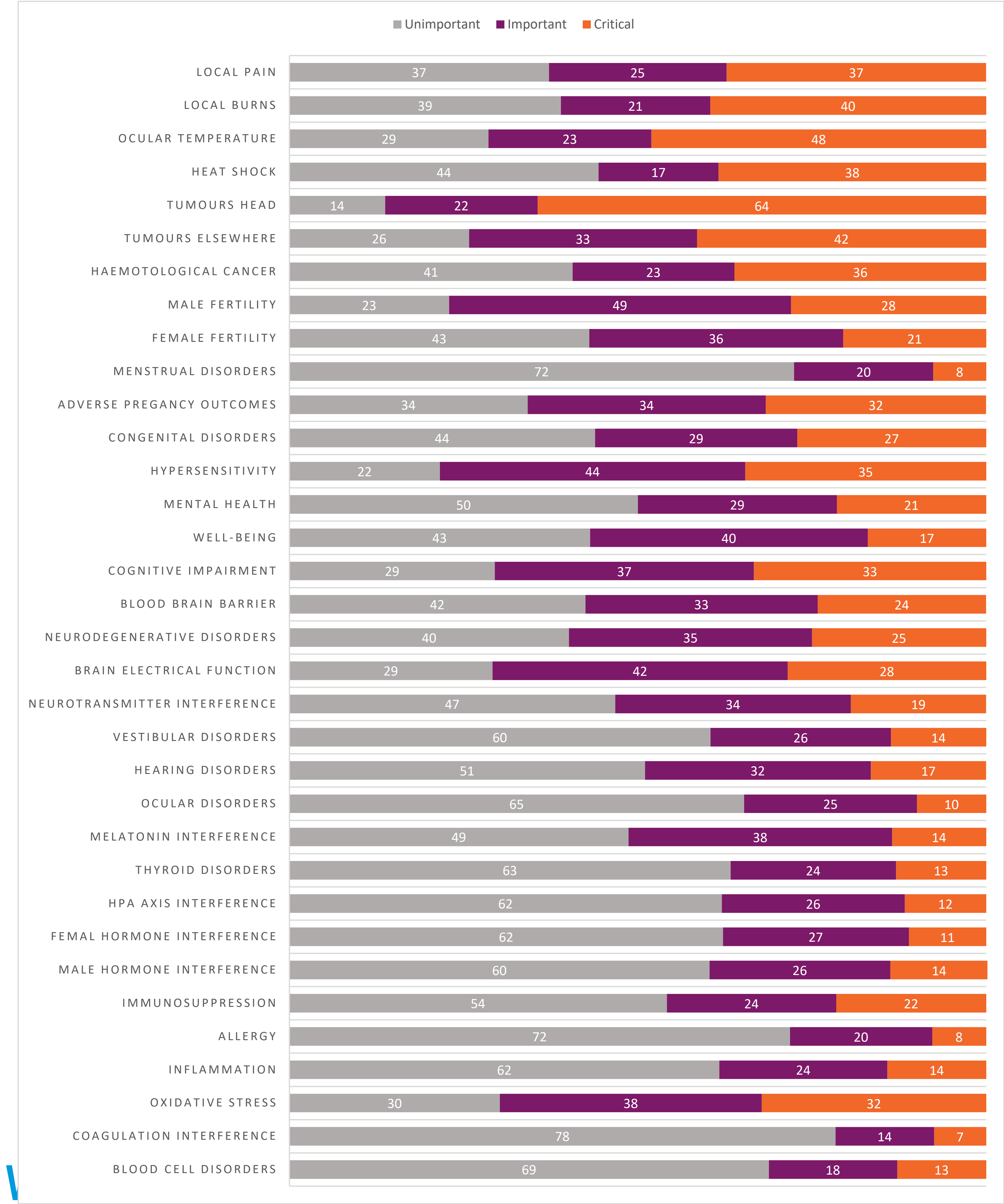


Monthly teleconferences (since 2012)
Annual face-to-face meetings (until January 2020)

2. Systematic reviews

Systematic reviews

Prioritizing the outcomes
International survey (2018)



Top priorities

1. Cancer (observational, experimental) — 2 SRs
2. Heat related — 1 SR
3. Fertility (observational, experimental) — 2 SRs
4. Symptoms (observational, experimental) — 2 SRs
5. Cognitive performance — 2 SRs (observational, experimental)
6. Oxidative stress — 1 SR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journal homepage: www.elsevier.com/locate/envint

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Prioritizing health outcomes when assessing the effects of exposure to radiofrequency electromagnetic fields: A survey among experts

Jos Verbeek [a,*], Gunnhild Oftedal [b], Maria Feychting [c], Eric van Rongen [d], Maria Rosaria Scarfi [e], Simon Mann [f], Rachel Wong [g], Emilie van Deventer [h]

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https://doi.org/10.1016/j.envint.2020.106300

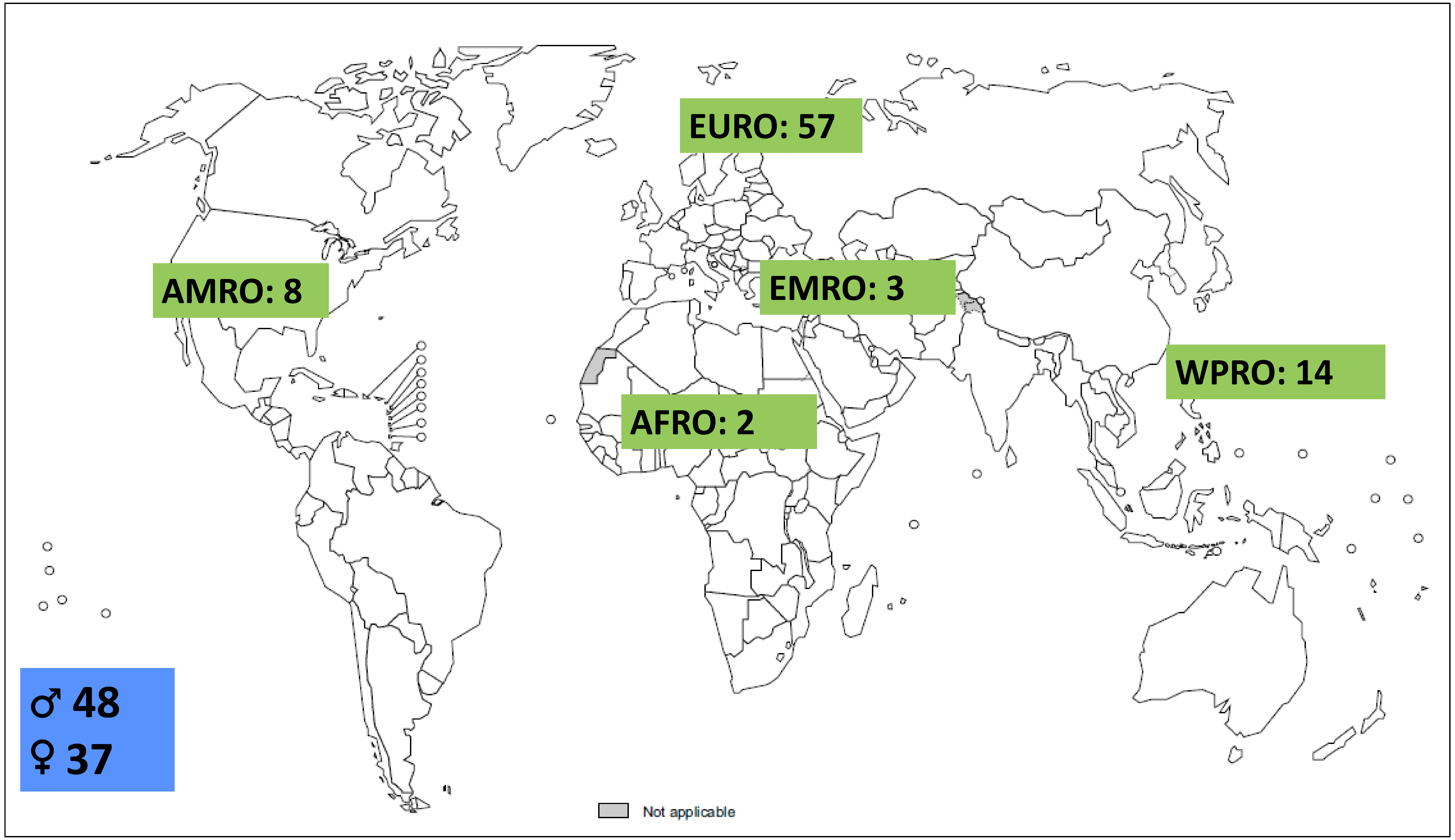
Systematic reviews

Observational and experimental studies

Observational studies	Human volunteer studies	Animal studies	In-vitro studies
SR1 - Cancer		SR2 - Cancer	
SR3 - Adverse reproductive outcomes		SR4 - Adverse reproductive outcomes	
SR5 - Cognitive impairment	SR6 - Cognitive impairment		
SR7 - Symptoms	SR8 - Symptoms		
		SR9 - Oxidative stress	
SR10 – Heat and ~~pain~~, burns, ~~cataract~~, etc.			

Contributors

9 SR teams



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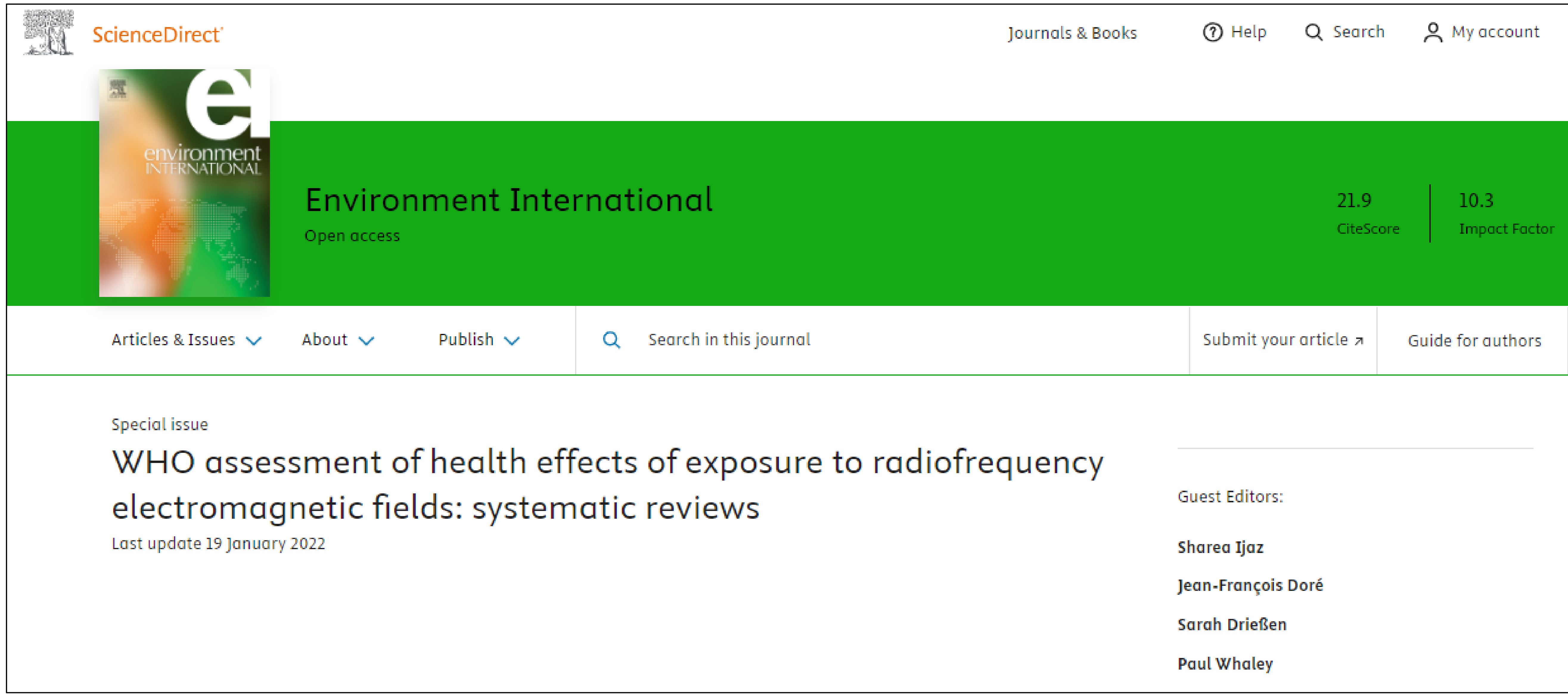
Systematic reviews
Deliverables

1. **Protocol** submission to *Environment International*
2. **Registration** of the protocol in Prospero (or other appropriate protocol database)
3. **Systematic review** submission to *Environment International*



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https://www.sciencedirect.com/journal/environment-international/special-issue/109J1SL7CXT

Protocols

Cancer	Fertility	Cognition	Symptoms	ROS
SR1 SR2	SR3 SR4	SR5 SR6	SR7 SR8	SR9

Environment International — The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A protocol for a systematic review of human observational studies

Environment International — Effects of radiofrequency electromagnetic fields (RF EMF) on cancer in laboratory animal studies: A protocol for a systematic review

Environment International — The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis

Environment International — Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on male fertility and pregnancy and birth outcomes: Protocols for a systematic review of experimental studies in non-human mammals and in human sperm exposed *in vitro*

Environment International — The effect of long-term radiofrequency exposure on cognition in human observational studies: A protocol for a systematic review

Environment International — The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: A protocol for a systematic review

Environment International — The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A protocol for a systematic review on human observational studies

Environment International — The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies

Environment International — The effect of radiofrequency electromagnetic fields (RF-EMF) on biomarkers of oxidative stress *in vivo* and *in vitro*: A protocol for a systematic review

Systematic Reviews

Environment International — The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies – Part I: Most researched outcomes

Environment International — The effects of radiofrequency exposure on adverse female reproductive outcomes: A systematic review of human observational studies with dose–response meta-analysis

Environment International — Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on pregnancy and birth outcomes: A systematic review of experimental studies on non-human mammals

Environment International — The effects of radiofrequency exposure on male fertility: A systematic review of human observational studies with dose–response *meta*-analysis

Environment International — Effects of radiofrequency electromagnetic field (RF-EMF) exposure on male fertility: A systematic review of experimental studies on non-human mammals and human sperm *in vitro*

Environment International — The effects of radiofrequency exposure on cognition: A systematic review and *meta*-analysis of human observational studies

Environment International — The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: Systematic review and *meta*-analyses

Environment International — The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A systematic review and meta-analysis on human observational studies

Environment International — The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A systematic review of human experimental studies

Journal Pre-proofs — The effects of radiofrequency electromagnetic field exposure on biomarkers of oxidative stress *in vivo* and *in vitro*: A systematic review of experimental studies

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As of 1 October 2024

Systematic reviews

- 1. ***Cancer, observational studies***:
  - “Most researched outcomes”
  - “Important outcomes” manuscript under review
- 2. ***Cancer, animal studies***: manuscript under review
- 3. ***Fertility, observational studies***:
  - Pregnancy: no effect on preterm birth, LBW, congenital malformations (18 studies, very low certainty)
  - Male: no effect on semen parameters (9 studies, very low certainty)
- 4. ***Fertility, animal studies:***
  - Pregnancy: no effect on litter, increase in dead fetuses, malformations, decrease in weight/length at high exposure (88 studies, low-high certainty)
  - Male: decreased fertility, sperm parameters, reproductive organ toxicity at high exposure (127 studies, low-moderate certainty)

Systematic reviews (cont'd)

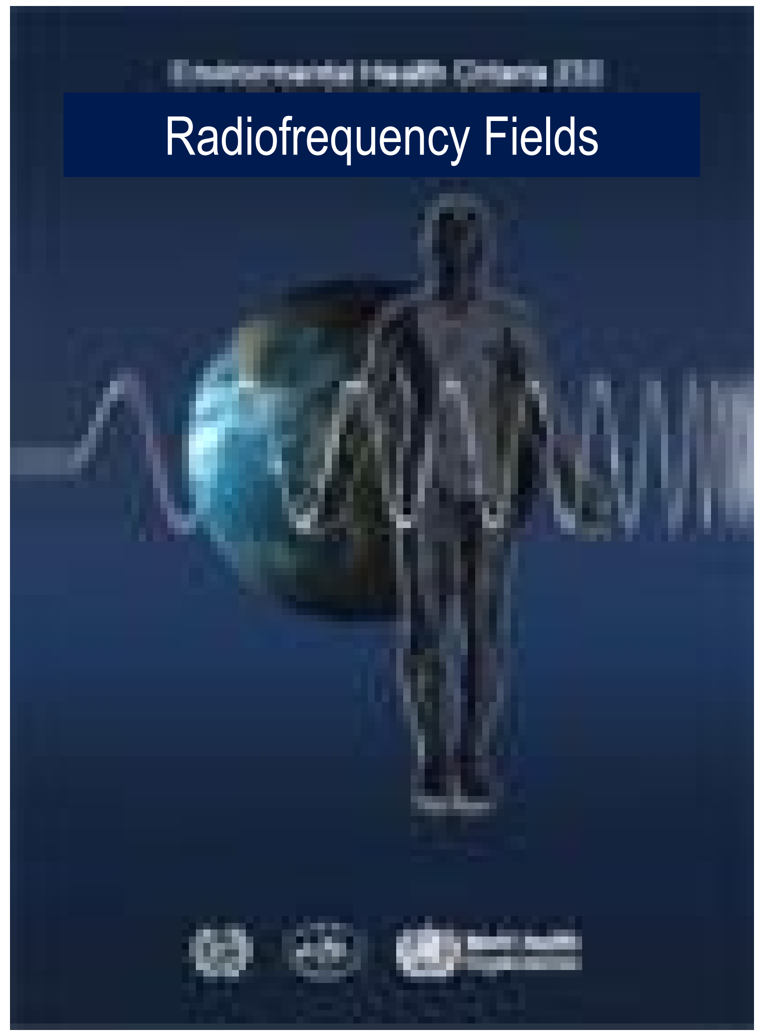
- 5. ***Cognition, observational studies:***
  - No effect of phone use in children on learning, executive function, attention; No effect of phone use on global functioning in elderly persons (5 studies, very low certainty)
- 6. ***Cognition, experimental studies:***
  - mostly moderate to high certainty of evidence that short-term RF-EMF exposure at SAR levels within the recommended limits … does not negatively affect the investigated domains of cognitive function
- 7. ***Symptoms, observational studies:***
  - No effect on tinnitus, migraine and headaches (exposure of the brain) or on sleep and symptom scores (wb RF-EMF exposure) (13 studies, very low certainty evidence)
- 8. ***Symptoms, experimental studies:***
  - No effect on headache, sleep, composite symptoms in general population or in IEI-EMF individuals (41 RCTs, low-high certainty)
- 9. ***Oxidative stress:***
  - Evidence for or against a relation between RF-EMF and biomarkers of oxidative stress overall of very low certainty' due to 'inconsistent overall study results

Critical appraisals of the SRs

Critical appraisals have since been published

- Related to SR8: Correspondence in *Environment International* by **Michael Bevington**, Chair of Trustees, Electrosensitivity UK
- Related to SR4: Miscellaneous in Reviews on Environmental Health by **Else K. Nordhagen and Einar Flydal**
- Related to SR7: Review in Reviews on Environmental Health by **John W. Frank , Ronald L. Melnick and Joel M. Moskowitz**

3. The RF Environmental Health Criteria monograph



EHC Monograph

Role of the Task Group

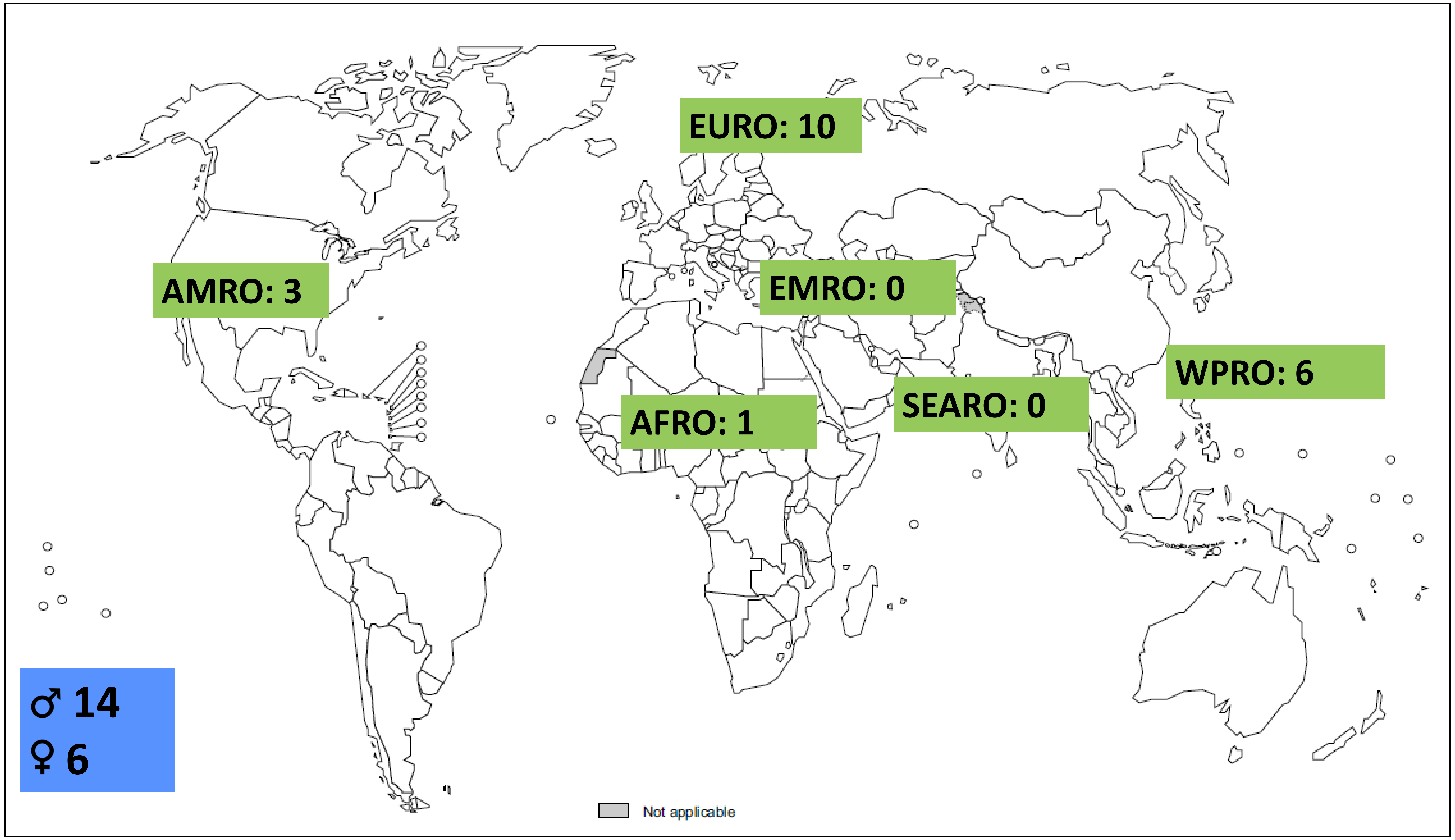
Overall

- In line with WHO processes for scientific evaluation, the Task Group will support WHO in developing an RF EMF monograph in the WHO Environmental Health Criteria (EHC) series

Specific

1. Draw **conclusions** on the effects of RF exposure on health based on the scoping report and the systematic reviews;
2. Formulate an **overall health risk assessment for each outcome** in the **EHC RF monograph** based on the conclusions of the scoping report and the systematic reviews [as far as the evidence allows];
3. Identify **research gaps**
4. Review [*rather than compile*] national good practice interventions

Task Group members



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Task Group meetings

- 1st online meeting (January 2023)
- 1st face-to-face meeting in Geneva (March 2023)
- 2nd online meeting (October 2023)
- 3rd online meeting (November 2023)
- 4th online meeting (February 2024)
- 2nd face-to-face meeting in Geneva (March 2024)
- 5th online meeting (April 2024)
- 6th online meeting (April 2024)

+

- **Monthly meetings** with teams
- **Weekly RF cafés** for individual experts for Q&As with the methodologist (AM/PM)

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Kick-off meeting (March 2023)

Discussion points included

- Consensus needed on the elements of a conclusion and on the process of drawing a conclusion
- Adverse health effect and grouping of adverse health outcomes
- How to combine findings from scoping report and systematic reviews
- How to combine and weigh different evidence streams
- Health risk assessment methodology

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2nd Face-to-face meeting (March 2024)

1. Team review of chapters
2. Feedback from overall Task Group
3. Polling on drafted conclusions
4. Project management
5. Involvement of Core Group
6. Call with Systematic Review Principal Investigators

Decisions

- Exposure level classification for different streams of evidence (local and whole-body exposure)
  - high, moderate, low
- Evidence integration (epidemiological and experimental streams of evidence)

- Health risk assessment
  - Hazard identification
  - Exposure-response response for specific outcome
  - Exposure assessment
  - Risk characterization

Current status and next steps

- 10 chapters based on scoping report:
  - Conclusions developed
  - Poll performed in March showed a high level of agreement with drafted conclusions
- 4 chapters based on systematic reviews and scoping report (cancer, fertility, symptoms, cognitive function)
  - Still awaiting some of the SRs on cancer

RF EHC Monograph

Chapter on RF Policies

- **Compilation of national regulations and good practice interventions**
- Based on 2012 survey (benchmark)
  - Data from 86 countries
  - Summary in peer-reviewed journal (RPD)

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Risk Management Policies regarding Radiofrequency Electromagnetic Fields

There has been growing concern about the possibility of adverse health effects resulting from exposure to radiofrequency (RF) electromagnetic fields, such as those emitted by wireless communication devices and networks. In response to such concern, the World Health Organization is assessing health risks that may be associated with exposure to RF fields in the frequency range of 100 kHz to 300 GHz.

This survey seeks to gather information on current risk management policies on RF fields at national level from relevant governmental bodies (e.g. Ministry of Health, Ministry of Environment, Ministry of Telecommunications, Ministry of Labor, Radiation Protection Agency, ...). Please feel free to forward this survey to whom it may concern in your country.

The survey has 3 sections reflecting the following RF exposure categories

- **personal exposures** associated with the use of mobile devices (such as cell phones)
- **environmental exposures** associated with fixed installations transmitting signals from radio, television and wireless communication networks, and
- **occupational exposures** in the telecommunication, industrial and medical sectors

Radiation Protection Dosimetry (2014), pp. 1–6 doi:10.1093/rpd/ncu324

RISK MANAGEMENT POLICIES AND PRACTICES REGARDING RADIO FREQUENCY ELECTROMAGNETIC FIELDS: RESULTS FROM A WHO SURVEY

Amit Dhungel[1,*], Denis Zmirou-Navier[1,2] and Emilie van Deventer[3]

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Teens, screens and mental health

New WHO report indicates need for healthier online habits among adolescents

25 September 2024 | Media release |Reading time: 4 min (1195 words)

Copenhagen, 25 September 2024

17:53

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The debate: Should smartphones be banned for under 16s?

2 days ago

Chris Vallance
Senior technology reporter

Smartphones have worked their way deep into our lives and have become indispensable for work and socialising

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Thank you

For more information, please contact:
E. van Deventer
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Q&A: The experience of five years of 5G EMF evaluations

Dr Teruo Onishi
NICT Japan
Chair International Electrotechnical Commission (IEC) TC 106

Christophe Grangeat
Nokia – Convenor, IEC TC106 MT 3

Dr Ourouk Jawad
Radiofrequency Engineer, Market surveillance and public exposure division, ANFR France

Dr Lidia Stepinska-Ustasiak
T-Mobile, Poland

Prof Wout Joseph
Ghent University, Belgium

Moderator:
Sami Gabriel
Vodafone and Deputy Chair GSMA EMF and Health

Mike Wood
Telstra
Chair GSMA EMF and Health

Summary and conclusions

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