ELFES: Étude longitudinale à radiofréquences et problèmes du sommeil chez les enfants

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Background

- Major evolutions in mobile communications/connected technologies, devices, and uses → very rapid uptake of these particularly in children and adolescents

- Children and adolescents are at higher risk of RF-EMF exposure, although little is known about their real exposure

- Also, they are potentially more vulnerable to any potential harmful effects of RF-EMF exposure

Why study sleep?

- Crucial for the health and development of children and adolescents → restoration, energy conservation, brain processing and memory consolidation
- Inadequate sleep duration or quality leads to adverse physical and mental health
- 20-40% adolescents have insuficient sleep duration and daytime slepiness

Why is modern life affecting our sleep patterns?

Artificial light

19th century

Blue light

21st century

Sunset no longer meant the end of the day

Social life in later hours - Later bedtimes

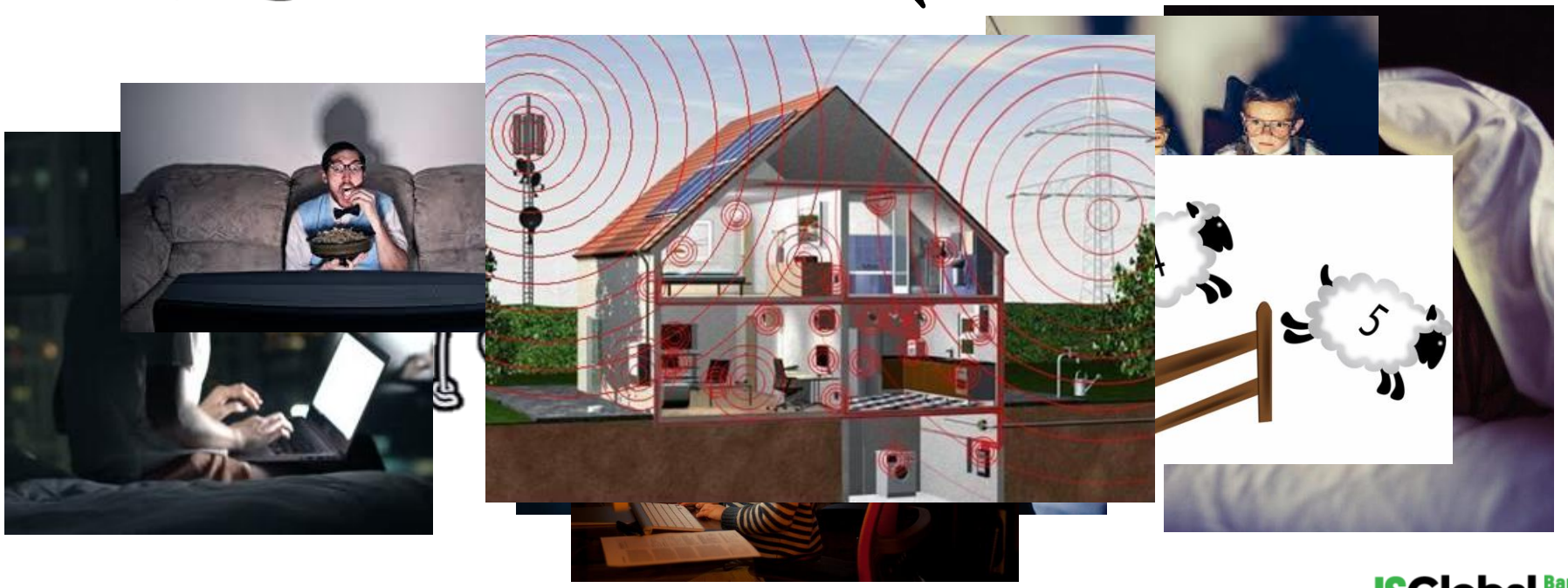
Less and poor sleep

Public health concern

Potential mechanisms

Displacement of the time
Mental load
Radiofrequency electromagnetic fields exposure

Sleep impairments



Objectives

To investigate the association between RF-EMF exposure and sleep in preadolescents

1. Cross-sectional asssociation between all-day brain RF-EMF doses and sleep disturbances

2. Cross-sectional asssociation between all-day brain RF-EMF doses and physiological sleep measures

3. Longitudinal association between evening brain RF-EMF doses and physiological sleep measures

Design and study population

- Spanish INMA Project (Sabadell, Gipuzkoa)
- Dutch Generation R Study

- Main sample N=1,599
  - INMA and Generation R
  - All-day RF-EMF brain exposure
  - Sleep disturbances and physiological sleep measures

- Sub-study sample N=335
  - INMA
  - Evening RF-EMF brain exposure
  - Physiological sleep measures

RF-EMF exposure assessment

Phone calls
(mobile phone and DECT phone)

Screen activities
(mobile phone, tablet while wirelessly connected to internet, laptop while wirelessly connected to internet)

Far-field
(microenvironments (home, school, commuting, outdoors) & frequency bands (FM, TV, downlink, uplink, DECT, WiFi))

Maternal-reported questionnaire
+
Daily diary 7-days

3D geospatial radio wave propagation model NISMap and personal measurements ExpoM

All-day and evening brain RF-EMF dose

Source-specific all-day whole brain RF-EMF dose $(mJ/kg/day)_{\text{source}} =$

$$\left(\frac{\text{SAR}\left(\frac{\text{W}}{\text{kg}}\right)\text{source}}{\text{normalized output power 1 W}} \times \text{Output power (W) source} \times \text{Duration}\left(\frac{\text{min}}{\text{day}}\right)\text{source} \right)$$

Source-specific evening whole-brain RF-EMF dose $(mJ/kg/day)_{\text{source,day}} =$

$$\left(\frac{\text{SAR}\left(\frac{\text{W}}{\text{kg}}\right)\text{source}}{\text{normalized ouput power 1W}} \times \text{Output power (W) source} \times \text{Duration}\left(\frac{\text{min}}{\text{evening}}\right)\text{source, day} \right)$$

→ For each specific source and overall

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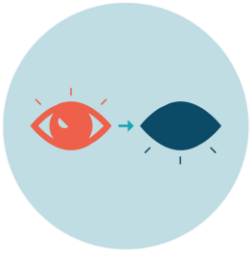
Parental-reported sleep disturbances

Sleep Disturbance Scale for Children (SDSC)



Problems of initiating and maintaining sleep

Sleep arousal problems

Excessive somnolence

Physiological sleep measures

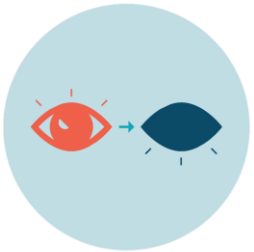
GeneActiv

Placed on wrist for 7 nights

Total sleep time (min)

Sleep efficiency (%)

Wake After Sleep Onset (min)



Sleep onset latency

→ 7-days average and daily repeated measures

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Population characteristics

	Study sample[a]	Sub-study sample[b]
	(n = 1599)	(n = 335)
Maternal characteristics		
Maternal education		
High	56.8	42.8
Medium	35.8	35.9
Low	7.4	21.2
Maternal country of birth (country of the cohort vs. others)	88.1	96.8
Preadolescents' characteristics		
Sex (female vs. male)	52.0	52.2
Age, in years	10.2 (0.7)	10.9 (0.5)
Self-perceived general health		
Excellent	33.6	21.0
Very Good	44.3	53.7
Good/bad/very bad	22.1	25.2
Body mass index, in kg/m2	17.9 (3.0)	19.5 (3.8)
Television viewing per day, in min	90.5 (68.3)	84.0 (68.2)
Preadolescents habits after 7 p.m.[c]		
How many minutes do you play console/ computer games?	–	20.7 (30.3)
How many minutes do you watch television?	–	65.7 (57.2)
Do you intake caffeinated drinks? (yes vs. no)		23.3
Do you sleep alone in your bedroom? (yes vs. no)	–	63.2

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All-day and evening brain RF-EMF doses in preadolescents

	All-day dose (mJ/kg/day)			Evening dose (mJ/kg/evening)[a]		
	(n = 1599)			(n = 335)		
	Mean (SD)	Median (IQR)		Mean (SD)	Median (IQR)	
Overall dose	166 (700)	60 (20; 118)		283 (1046)	68 (11; 185)	
Source-specific doses			%[b]			%[b]
Phone calls[c]	129 (692)	21 (2; 72)	78	217 (1046)	2 (0; 71)	77
Screen activities[d]	2 (2)	2 (1; 3)	1	3 (11)	0 (0; 1)	1
Far-field sources[e]	35 (82)	11 (7; 25)	21	63 (118)	13 (5; 66)	22

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Sleep in preadolescents

	Study sample	Sub-study sample
	(n = 1599)	(n = 335)
Sleep disturbances		
Problems with initiating and maintaining sleep[a]	4.3 (3.4)	–
Excessive somnolence[b]	2.7 (2.3)	–
Arousal problems (yes vs. no)	26.5	–
Objective sleep measures		
Total sleep time (hours)	7.6 (0.7)	7.4 (0.8)
Sleep efficiency (%)	84.2 (4.4)	84.9 (4.3)
Sleep onset latency (min)	39.2 (39.1)	13.1 (13.3)
Wake after sleep onset (min)	71.4 (30.2)	55.2 (30.1)

All-day brain RF-EMF dose and sleep disturbances – cross-sectional association

	Problems with initiating and maintaining sleep[d]	Excessive somnolence[d]	Arousal problems (yes vs. no)
	B (95% CI)	B (95% CI)	PR (95% CI)
Overall dose	0.0 (−0.0; 0.0)	0.0 (−0.0; 0.0)	1.0 (0.9; 1.0)
Source-specific doses			
Phone calls[a]	0.0 (−0.0; 0.0)	0.0 (−0.0; 0.0)	0.9 (0.9; 1.0)
Screen activities[b]	1.6 (−0.3; 3.6)	**2.2 (0.1; 4.3)**	2.2 (0.1; 68.8)
Far-field sources[c]	0.0 (−0.0; 0.1)	−0.0 (−0.1; 0.1)	1.0 (0.9; 1.1)

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All-day brain RF-EMF dose and physiological sleep measures –cross-sectional association

	Total sleep time (min)	Sleep efficiency (%)	Wake After Sleep Onset (min)	Sleep onset latency[c]
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Overall dose	0.0 (-0.4; 0.5)	−0.0 (−0.1; 0.0)	−0.0 (−0.3; 0.2)	0.0 (−0.0; 0.0)
Source-specific doses				
Phone calls[a]	0.0 (−0.4; 0.4)	−0.0 (−0.1; 0.0)	−0.0 (−0.3; 0.2)	0.0 (−0.0; 0.0)
Screen activities[b]	−30.7 (−162.3; 100.9)	10.3 (−3.5; 24.2)	−69.9 (−149.7; 10.0)	−0.5 (−8.1; 7.1)
Far-field sources[c]	0.1 (−3.6; 3.7)	0.2 (−0.2; 0.5)	−0.3 (−2.5; 1.8)	**0.3 (0.1; 0.5)**

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Evening brain RF-EMF dose and physiological sleep measures – longitudinal association

	Total sleep time (min)	Sleep efficiency (%)	Wake After Sleep Onset (min)	Sleep onset latency[c]
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Overall dose (Δ100 mJ/kg/evening)	−0.1 (−0.2; 0.1)	0.0 (−0.0; 0.0)	−0.2 (−0.4; 0.1)	−0.0 (0.0; 0.0)
Source-specific doses				
Phone calls[a]				
Null (0 mJ/kg/evening)	Ref.	Ref.	Ref.	Ref.
Low (0–2.3 mJ/kg/evening)	−6.2 (−14.8; 2.4)	0.2 (−0.8; 1.1)	0.4 (−6.5; 7.3)	0.0 (−0.3; 0.3)
High (>2.3 mJ/kg/evening)	**−11.9 (-21.2; -2.5)***	−0.3 (−1.3; 0.7)	−0.3 (−7.4; 6.8)	**0.3 (0.0; 0.7)**
Screen activities[b] **(Δ100 mJ/kg/evening)**	−11.8 (−32.5; 9.0)	−0.5 (−1.8; 0.8)	8.4 (−2.1; 18.8)	0.1 (−0.4; 0.6)

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Conclusion

- All-day brain RF-EMF doses were not associated with sleep disturbances or physiological sleep measures
- Evening brain RF-EMF dose from phone calls was related to shorter total sleep time
- Evening might be a potentially relevant window of RF-EMF exposure for sleep → results should be interpreted with caution (first study, small sample size, small effect estimates)

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Estimated all-day and evening whole-brain radiofrequency electromagnetic fields doses, and sleep in preadolescents

Alba Cabré-Riera [a,b,c], Luuk van Wel [d], Ilaria Liorni [e], M. Elisabeth Koopman-Verhoeff [f,o], Liher Imaz [c,h,i], Jesús Ibarluzea [c,h,i,j], Anke Huss [d], Joe Wiart [k], Roel Vermeulen [d], Wout Joseph [g], Myles Capstick [e], Martine Vrijheid [a,b,c], Elisabeth Cardis [a,b,c], Martin Röösli [l,m], Marloes Eeftens [l,m], Arno Thielens [g], Henning Tiemeier [f,n], Mònica Guxens [a,b,c,f,*]

Thank you!

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