

## ELECTROMAGNETIC FIELDS: A KAP STUDY IN A COHORT OF YOUNG ADULTS

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### ABSTRACT

The available data about the role of electromagnetic fields are incomplete and conflicting. An observational study was carried out through the administration of a questionnaire created ad hoc on a cohort of young adults from November 2022 to April 2023. 58% of the sample believes that electromagnetic fields are harmful. We didn't detect statistically significant differences for age, sex, income, educational level or prevention score. We observed statistically significant associations with a more frequent usage of PC and Wi-Fi in people with an intermediate knowledge score ( $p < 0.01$ ). The sample using electronic devices constantly have concentration difficulties, dizziness, and tired eyes. In agreement with the WHO data, we noticed the appearance of symptoms as headache, irritability, attention disorders, distress with low-levels exposure. At least, the potential appearance of a real addiction must make people think about the real advantages and benefits of using electronic devices for recreational purposes.

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opinion concerning the need to undertake precautionary actions (4).

### 1. Introduction

According to the definition by WHO, the risks for environmental health are "all the physical, chemical and biological factors external to a person and all the related factors conditioning behaviors" (1). Among them, in recent years, the exposure to low-frequencies and radio-frequency electromagnetic fields related to negative effects on health has become a topic of particular concern (2).

Electromagnetic radiation can be naturally sourced as sun radiation, or artificial, as the radio-frequency electromagnetic radiations emitted by broadcasting antennas, cell phones and Wi-Fi; and low-frequency electric and magnetic fields emitted by high-voltage power lines for electricity transport and by appliances.

The broadcasting field is of particular concern, leading in the last decades to a continuous increase of the presence of EMF sources.

According to some authors, radiofrequency electromagnetic fields promote oxidative stress, a condition involved in the outbreak of cancer, several acute and chronic diseases, and vascular homeostasis. Additionally, more recent studies show a probable effect on the reproductive sphere and the outbreak of metabolic and neurological diseases and the bacterial resistance to antibiotics (3).

It is worthwhile to consider that contradictory evidence are reported about this topic, demonstrating a disagreement about the effects of the electromagnetic fields on health. Therefore, there is not an unambiguous

Electromagnetic fields always and in any case cause a response by the human body. The main biological effect determined by electromagnetic waves on the human body is its heating, especially for radiofrequencies; nevertheless, the Italian law establishes exposure limits below the reported values, therefore too low to cause significative heating (5).

The International Agency for Research on Cancer (IARC) classified the radiofrequency electromagnetic fields (CRF) as Group 2B carcinogens, in other words, possibly carcinogenic for the human beings: agents for which there is limited evidence of carcinogenicity in human beings and insufficient evidence of carcinogenicity in laboratory animals. This judgment originates from the limited evidence of carcinogenicity in humans based on an increased risk of glioma in people using cell phones in an excessive way (6).

Several epidemiological and experimental studies carried out so far did not show significative associations between the exposure to the magnetic fields and an increased outbreak of cancer in children and in adults, even if others agree that it is necessary to better investigate the long-term effects (6-9).

But other authors confirm the association between the exposure to electromagnetic waves and the risk of developing certain types of cancer, even if these studies were in laboratory conditions or examined particularly high doses of electromagnetic fields (10, 11).

One survey suggested that a significant number of pregnant women

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suffered from addiction to mobile phone usage but were unaware of it.

More than two third of the sample (67.2%) have not changed their smartphone use habits since the beginning of their pregnancy, and even more significant data shows that almost all future mothers (98.3%) never speak with their doctor about smartphone use during pregnancy (12).

The WHO and other organizations started many research projects in order to evaluate the biological effects and the potential health risks. Moreover, the available data about the role of electromagnetic fields are incomplete and opposing.

Therefore, the aim of our study is to evaluate and verify knowledge, attitudes and risk perception in healthcare students regarding electromagnetic fields, the possible association of high levels of exposure with the onset of some symptoms (irritability, fatigue, anxiety, dizziness, etc.).

## 2. Methods

An observational study was carried out through the administration of an anonymous questionnaire spread online through a social network (Facebook ®) to the healthcare students belonging to a nursing course. The response rate was 100%. The period of administration was between October 2022 and April 2023. The study was developed in accordance with the Helsinki declaration.

The questionnaire, created ad hoc (appendix 1) and based on multiple choice questions, was made up of these four sections:

- Socio-demographic characteristics (sex, age, nationality, civil status, level of degree, job).
- Knowledge (what an electromagnetic field is, if they are only artificial or also naturally sourced, if they are harmful to health, what electro-smog is, if there is a difference between electromagnetic field and electro-smog, what devices emit electromagnetic waves), formulating a specific score (knowledge score)
- Citizens attitudes and perceptions regarding the electromagnetic sources, especially towards ones of everyday usage (daily usage of several devices, reasons for use)
- Preventive attitudes (switching off devices and exposure reduction) formulating a specific score (prevention score).

### Statistical analysis

All the statistical variables surveyed were summarized by means of frequency distributions. To check for statistically significant differences in the variables detected in the sample, the chi-squared test for k independent samples was used with the relative partition model in the case of rejection of H0 (1). P values < 0.05 were considered for statistical significance. All synthesis and inferential analysis were performed using Epi info software.

## 3. Results

Our sample was made up of 317 individuals with an average age of 23.6 ± 6.71 DS, of which 29% were men and 71% were women (Table 1).

More than half of the sample (58%) is aware of the correct definition of electromagnetic field.

The results showed that 84.9% of the sample is aware of the possibility that an electromagnetic field can be natural or artificial.

More than half of the sample (55.8%) believe that electromagnetic fields are harmful to health, whereas about 1/10 (12.9%) have never considered the problem.

Habits of the sample such as daily usage in hours, main reason of use and switching off main electronic devices during the night is represented in Table 2.

	N	%
<b>Gender</b>		
Male	92	29
Female	225	71
<b>Mean age ± SD</b>	23.6 ± 6.71 SD	
<b>Employment</b>		
Public employee	10	3.2
Private Employee	46	14.5
Student	241	3.2
Not employed	20	6.3
<b>Educational level</b>		
Less 13 years	266	83.9
Above 13 years	51	16.1
<b>Income</b>		
<25.000 euros	182	57.4%
>25.000	135	42.6%
<b>Live in:</b>		
rural	34	10.7%
suburban	77	24.3%
urban	186	58.7%
road to other traffic close to an industry	18	5.7%
	2	0.6%

Table 1. Socio-demographic characteristics of the sample.

	Daily usage in hours	N (%)	Main reason	N (%)	Switching-off during the night
Smartphone	Never	2 (0.6)	Occupational	17 (5.4)	Yes 92 (29)
	1-2 hours	27 (8.5)	Recreational	67 (21.1)	No 223 (70.3)
	2-4 hours	73 (23)	Both the reasons	231 (72.9)	No use 2 (0.6)
	> 4 hours	101 (31.9)	Not use	2 (0.6)	
	Constantly	114 (36)			
TV	Never	60 (18.9)	Occupational	3 (0.9)	Yes 145 (45.7)
	1-2 hours	176 (55.5)	Recreational	237 (74.8)	No 152 (47.9)
	2-4 hours	56 (17.7)	Both the reasons	17 (5.4)	No use 20 (6.3)
	> 4 hours	18 (5.7)	Not use	60 (18.9)	
	Constantly	7 (2.2)			
Computer (desktop or laptop)	Never	42 (13.2)	Occupational	145 (45.7)	Yes 214 (67.5)
	1-2 hours	51 (16.1)	Recreational	14 (4.4)	No 86 (27.1)
	2-4 hours	90 (28.4)	Both the reasons	132 (41.6)	No use 17 (5.4)
	> 4 hours	99 (31.2)	Not use	26 (8.2)	
	Constantly	35 (11)			
Tablet	Never	236 (74.4)	Occupational	39 (12.3)	Yes 70 (22.1)
	1-2 hours	50 (15.8)	Recreational	23 (7.3)	No 77 (24.3)
	2-4 hours	19 (6)	Both the reasons	33 (10.4)	No use 170 (53)
	> 4 hours	10 (3.2)	Not use	222 (70)	
	Constantly	2 (0.6)			
Wi-Fi router	Never	19 (6)	Occupational	34 (10.7)	Yes 37 (11.7)
	1-2 hours	26 (8.2)	Recreational	18 (5.7)	No 260(82)
	2-4 hours	41(12.9)	Both the reasons	246 (77.6)	No use 20 (6.3)
	> 4 hours	58 (18.3)	Not use	19 (6)	
	Constantly	173 (54.6)			
Mouse and cordless keyboard	Never	164 (12.9)	Occupational	84 (26.5)	Yes 92 (29)
	1-2 hours	63 (19.9)	Recreational	15 (4.7)	No 223 (70.3)
	2-4 hours	36 (11.4)	Both the reasons	72 (22.7)	No use 2 (0.6)
	> 4 hours	36 (11.4)	Not use	146 (46.1)	
	Constantly	18 (5.7)			
Wireless games (for example, Wii)	Never	271 (85.5)	Occupational	6 (1.9)	Yes 92 (29)
	1-2 hours	34 (10.7)	Recreational	54 (17)	No 223 (70.3)
	2-4 hours	5 (1.6)	Both the reasons	12 (3.8)	No use 2 (0.6)
	> 4 hours	5 (1.6)	Not use	245 (77.3)	
	Constantly	2 (0.63)			

Table 2. Habits of the sample: daily usage in hours, main reason of use and switching off the main electronic devices during the night.

Moreover, we highlight that most of the sample is aware of the main devices of everyday usage emitting electromagnetic waves (computer: 85.8%; TV: 7.1%; Wi-Fi devices: 84.2%).

Regarding the knowledge score, we observed statistically significant associations with a more frequent usage (over 2 hours) of PC and Wi-Fi in people with an intermediate knowledge; while, apart from the reason for using, both recreational and professional, the knowledge score does not show statistically significant associations with long-term use.

Moreover, those with no knowledge as well as those with an intermediate knowledge do not turn off the phone during the night (p-value < 0.001). Only a small fraction of the people with a high knowledge score (23%) turns off the modem at night. In Table 3 we reported the main preventive measures adopted by the sample.

There are no statistically significant differences for age, sex, income, educational level and prevention score.

Additionally, we investigated the presence of statistically significant associations between the presence of sleeping disorders, headache, irritability, weakness, concentration difficulty, tinnitus, dizziness, limb pain, skin rashes, burning or tired eyes and the everyday usage of several devices (smartphone, TV, PC, tablet, modem or wireless gaming platforms). See Table 4 for the evaluation of symptoms.

We did not notice statistically significant associations between the presence of sleeping disorders, headache, tinnitus and the usage of the electronic devices.

Severe irritability resulted in association with the everyday usage of Wi-Fi router being over 4 hours or constantly (p-value < 0.001) and with the use of a mouse and cordless keyboard (p-value < 0.001).

Moreover, the sample using TV constantly has concentration difficulties (p-value < 0.05) and mild or moderate dizziness (p-value < 0.01); this outcome was also observed for the use of computer (p-value < 0.05) and the Wi-Fi router (p-value < 0.01).

Tired eyes are related to the continuous use of the following devices: smartphones (over 2 hours; p-value < 0.001), PC (p-value < 0.001), tablet (p-value < 0.001), router Wi-Fi and modem (p-value < 0.001), mouse and keyboard (p-value < 0.05).

More than half the sample (59.9%) uses smartphones for short-term calls and a high percentage (77.6%) uses, even if not constantly, hands-free and headset systems.

The majority (74.1%) is aware that the exposure can be reduced through individual behaviors; nevertheless, during the night, most of the sample (70.3%) does not switch off its own smartphone during the night; about half (47.9%) does not turn off the TV; approximately one quarter (24.3%) does not turn off the tablet and a wide majority (82%) does not turn off the Wi-Fi router; finally, 39.1% does not turn off other electronic devices.

Behaviors	N (%)*
I switch off wireless technologies	51.7
I disconnect devices from the mains	49.2
I don't use Bluetooth earphones	50.8
I keep the devices near my bed	43.8
I have plants able to absorb radiations at home	23.7

**Table 3. Behaviors and attitudes adopted to reduce the exposure to EMF (\* the respondent could insert more of an answer)**

	Grade	N (%)
Sleep disorders	No	197 (62.1%)
	Mild	88 (27.8%)
	Moderate	20 (6.3%)
	Severe	10 (3.2%)
	Very severe	2 (0.6%)
Headache	No	119 (37.5%)
	Mild	120 (37.9%)
	Moderate	58 (18.3%)
	Severe	17 (5.4%)
	Very severe	3 (0.9%)
Irritability / distress	No	55 (17.4%)
	Mild	120 (37.9%)
	Moderate	114 (36.0%)
	Severe	23 (7.3%)
	Very severe	5 (1.6%)
Weakness	No	233 (73.5%)
	Mild	53 (16.7%)
	Moderate	19 (6.0%)
	Severe	11 (3.5%)
	Very severe	1 (0.3%)
Concentration difficulties	No	118 (37.2%)
	Mild	120 (37.9%)
	Moderate	60 (18.9%)
	Severe	14 (4.4%)
	Very severe	5 (1.6%)
Tinnitus	No	238 (75.1%)
	Mild	57 (18.0%)
	Moderate	20 (6.3%)
	Severe	0 (0.0%)
	Very severe	2 (0.6%)
Dizziness	No	224 (70.7%)
	Mild	70 (22.1%)
	Moderate	18 (5.7%)
	Severe	2 (0.6%)
	Very severe	3 (0.9%)
Limb pain	No	187 (59.0%)
	Mild	80 (25.2%)
	Moderate	37 (11.7%)
	Severe	12 (3.8%)
	Very severe	1 (0.3%)
Rashes	No	208 (65.6%)
	Mild	71 (22.4%)
	Moderate	31 (9.8%)
	Severe	5 (1.6%)
	Very severe	2 (0.6%)
Burning or tired eyes	No	70 (22.1%)
	Mild	129 (40.7%)
	Moderate	96 (30.3%)
	Severe	18 (5.7%)
	Very severe	4 (1.3%)

**Table 4. Disorders reported by the study sample**

	p-value
Not turning off the phone at night in subjects with low knowledge score	< 0.001
Not turning off the phone at night in subjects with intermediate knowledge score	< 0.001
Severe irritability in subjects that use Wi-Fi routers over 4 hours a day	< 0.001
Severe irritability in subjects that use mouse and cordless keyboard over 4 hours a day	< 0.001
Concentration difficulties in subjects using TV constantly	< 0.05
Moderate dizziness in subjects using TV constantly	< 0.01
Moderate dizziness in subjects using computer constantly	< 0.05
Moderate dizziness in subjects using Wi-Fi router constantly	< 0.01
Eye tiredness in subjects using smartphones over 2 hours a day	< 0.001
Eye tiredness in subjects using PC over 2 hours a day	< 0.001
Eye tiredness in subjects using router Wi-Fi and modem over 2 hours a day	< 0.001
Eye tiredness in subjects using mouse and keyboard over 2 hours a day	0.05
Symptoms associated with an extended daily use of phones	< 0.05
Symptoms associated with an extended weekly use of Wi-Fi	< 0.05

**Table 5. Statistically significant findings at the univariable analysis**

#### 4. Discussion

In 1996 the WHO started the EMF project to evaluate the effects over time on health and environment caused by exposure to the electromagnetic fields for frequencies ranging from 0 to 300 GHz. For the purposes of the EMF project, this range was divided in static (0 Hz), extremely low frequencies (0-300 KHz), intermediate frequencies (IF, >300Hz to 10MHz) and radiofrequency (RF, 10 MHz – 300 GHz).

Indeed, the WHO stated that the electromagnetic fields above specific levels can determine biological effects. By means of studies conducted on healthy volunteers, it was observed that the short-term exposure to the levels present in the environment or at home does not determine any apparent harmful effect (12).

Our first aim was to evaluate knowledge, risk perception and attitudes regarding EMF. We found that our sample is aware of the definition of electromagnetic field and is informed about the main sources of daily use as opposed to previous studies conducted in Europe that show an incomplete knowledge of the meaning of electromagnetism and the main sources emitting electromagnetic fields (1). According to research by Eurobarometer, one third of EU citizens thinks that the base stations of cell phones, EMF and the high voltage power lines influence their health “to a great extent”, whereas a further 25-37% think that their health could be influenced at least “to a certain extent”. There are huge differences among the countries regarding the perceived risk rates, ranging from more than 80% (Greece, Italy) to 16-17% (Denmark, Sweden) (14).

More than half of our sample (55.8%) believes that the electromagnetic fields can be harmful to health, in agreement with other Italian studies, showing a higher level of concern compared to Europe (15).

Besides, we observed that our interviewees having no or scarce knowledge do not switch off their own smartphones during the night ( $p < 0.01$ ), as also highlighted by Gavrilas et al (16).

In our sample, a low knowledge score is not statistically significant in association with a more continuous use, except for an association between an intermediate knowledge and the use of PC and Wi-Fi over two hours, in contrast with a study carried out in 8 European countries (Italy not included) highlighting that a better knowledge of the risks related to the exposure determines a higher risk perception (15-16).

As regards the protective behaviors adopted by our sample, we found that a high percentage uses smartphones with hands-free and earphones systems; however, a high percentage of the people we interview does not adopt easy preventive measures such as the switching off of devices during the night. This finding agrees that reported by another study (17) relating the use of smartphones, in which the first preventive measure was to move the smartphone away from the body (78%), followed by reduction in the frequency of the use of smartphones (76.3%) and, finally, to use hands-free and earphone systems (respectively 45.8% and 30.5%).

In our study only few individuals (23%) having a high knowledge score switch off the Wi-Fi router during the night, in agreement with a Greek study in which a similar percentage (18.9%) do this. Probably, as reported by Lee et al. regarding cigarette smoking, a good knowledge of the damages related to the exposure to harmful factors does not necessarily result in healthy and adequate behaviors (18).

A preventive measure scarcely applied by our sample is the positioning of plants able to absorb radiation at home. Indeed, after the exposure to low-powered electromagnetic fields, many metabolic activities undergo a change, gene expression is modified, and growth is reduced (19).

Almost all the sample (84.9%) knows that electromagnetic fields can have both natural and artificial sources.

As regards the symptoms reported by our sample after the exposure to electromagnetic fields, we observed an association between severe irritability with the constant or over four hour usage of the Wi-Fi router ( $P < 0.001$ ) and cordless mouse and keyboard ( $p < 0.001$ ), in agreement with the WHO data (20), in which some individuals ascribe several symptoms of the low-level exposure to electromagnetic fields at home.

In fact, these symptoms included headache, anxiety, suicide and depression, nausea, fatigue and loss of libido.

However, scientific evidence do not show a clear relationship between these symptoms and the exposure to electromagnetic fields, and some of these health problems could be caused by noise or other environmental factors, or even by anxiety related to the use of new technologies.

Other symptoms reported by our sample were a concentration of difficulties and dizziness, similarly to what Frick et al. observed in 2002 (21).

Our sample frequently noticed mild or severe headache (24.8%), severe sleep disorders (3.8%) and from mild to severe joint pain (40.7%). These symptoms were found in other studies in which the number of migraine episodes and its severity were significantly related to an extended use of cell phones throughout the day and of Wi-Fi throughout the week ( $p < 0.05$ ) (22-23).

Eye symptoms were reported after high levels of exposure; a similar result was obtained by other authors demonstrating the association between eye irritation, cataracts and the occupational exposure to high level radiofrequencies and microwaves radiations (24-25).

These symptoms are widespread in the general population having a prevalence ranging from 70% to 90%, defining the so-called “Computer Vision Syndrome” (CVS), caused by the blue light of electronic devices; it is also characterized by neurological and muscular-skeletal symptoms (26).

Investigating the habits of our sample regarding the use of devices emitting EMF, we observed a greater use of smartphones compared to other devices. It is used more than 4 hours by most of the sample (68%) both for recreational and occupational purposes, whereas, PC is used more than 2 hours for occupational purposes by seven out of ten people (70%). TV is used for about 1-2 hours mostly for recreational purposes. The less used devices are tablets followed by wireless devices. The continuous use of smartphones could be framed as “problematic use”, or problematic smartphone use (PSU) and should make people think about the need to give greater attention to its compensative functions, motivations and gratifications (27)

In a systematic review of the literature, the median prevalence of PSU in the examined subjects is 23.3% (14.0-31.2%) and it is associated with an increased probability of depression (OR = 3.17; IC 95% 2.30-4.37%), of anxiety (OR = 3.05 IC 95% 2.64-3.53), with a higher perceived stress (OR = 1.86; IC 95% 1.24-2.77) and with a more inadequate sleep quality (OR = 2.60; IC 95%; 1.39-4.85) (28).

Finally, variables such as age, sex, income, and educational level are not associated with a higher adoption of preventive measures.

The limitations of the present study are those of the observational study: for instance, the possible presence of bias in the data interpretation, represented first by the lacking possibility to highlight causal relations. Other possible bias is represented by non-response bias; but not-to-volunteer bias are not present because the questionnaire was administered to all the healthcare students.

## 5. Conclusions

In the present study was observed that the sample is aware of the definition of electromagnetic fields and their impact on human health, adopting, generally, protective behaviors such as the use of hands-free and headset systems and, among the students with a high level of knowledge, the turning-off of electronic devices during the night.

According to WHO data, exposure to low levels of EMF is related to several symptoms such as headache, irritability, attention disorders; moreover, distress and tired eyes are related to the use of electronic devices such as modem Wi-Fi.

At least, the potential appearance of a real addiction must make people think about the real advantages and benefits of using electronic devices for recreational purposes. Therefore, the evaluation of the risk perception throughout the population together with the spread of the culture of prevention has a key role from childhood in every field of public health (29-31).

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