Environmental Pollution: Statistical Approach on Mobile Tower Radiation

Prisilla Jayanthi Gandam (M.tech)[1]*, Muralikrishna Iyyanki (PhD)[2]

[1]Department of Computer Science and Engineering, CMR Institute of Technology, Hyderabad, India
[2]India Academic Programs Director, UC Berkeley, India

ABSTRACT

Background: The Electromagnetic Field (EMF) effect is considered an alarming human health issue, dependent on the use of mobile phones. Several nationwide awareness programs on EMF Emissions & Telecom Towers were initiated by the Department of Telecom (DoT) to build a direct bridge between the number of investors and the information gap with scientific evidence. EMF interaction with humans has caused oxidative stress for brain physiological and pathological degeneration.

Objective: This study aimed to investigate the EMF's influence on oxidative stress and disorders of neurodegenerative.

Material and Methods: This analytical study is conducted on a generalized linear model, a supervised learning approach in machine learning, to understand mobile tower radiation. The data is obtained from open sources from two different states in India.

Results: Confidential Interval (CI) was obtained for measured value radiation for Andhra Pradesh in 2018-2019 as 95% CI [0.0045 to 0.0111] and for 2019-2020 as 95% CI [0.0016 to 0.0028]. Telangana -CI for Measured Value (MV) in 2018-2019 was found to be 95% CI [0.0500 to 0.0763] and 2019-2020 is 95% CI [0.0189 to 0.4345].

Conclusion: Generalized Linear Models (GLM) are the best statistical model to analyze the mobile tower radiation.

Citation: Jayanthi Gandam P, Iyyanki M. Environmental Pollution: Statistical Approach on Mobile Tower Radiation. *J Biomed Phys Eng.* 2025;15(3):231-238. doi: 10.31661/jbpe.v0i0.2402-1728.

Keyword

Generalized Linear Model; Mobile Towers; Radiation; Electromagnetic Field; Humans

Introduction

The study of non-ionization radiation deals with the Electromagnetic Field (EMF) radiation that eliminates an electron from an atom or molecule. However, Ionization Radiation (IR) carries sufficient energy for detaching electrons from atoms or molecules. However, IR is full of energetic subatomic particles, ions, or atoms moving at high speeds [1]. Moreover, large RF antennas can broadcast up to the range of 10 km or more and are mounted on rooftops above 70 meters above ground level, to avoid signal obstruction by tall buildings, dense vegetation, and hilly landscapes. The antenna uses relatively high power (60 W) and frequencies (above 800 MHz to 2200 MHz). The cell phone technologies (4G) use frequencies above 4000 MHz [2]. Now that one can see 5G paved its way with an average speed of about 1 GB per sec. Extremely Low Frequency (ELF), known as an EMF with a lower

*Corresponding author:
Prisilla Jayanthi Gandam
Department of Computer Science and Engineering, CMR Institute of Technology, Hyderabad, India
E-mail:
prisillaj28@gmail.com

Received: 12 February 2024
Accepted: 9 April 2024

frequency, is used in communications.

According to Dr. Davis, EMF is directly or indirectly linked with the risk of brain tumors and breast cancer. She correlates with the child's skin, which is very sensitive compared with the adults. When the child plays in the sun, even after applying the sunscreen, the skin turns reddish and the rash occurs. Similarly, when a child below 3 years holds the mobile and talks for just 6 minutes, the skin turns a red color around the eye and ear where the mobile was placed, showing the higher absorption of radiation. Cell phone radiation penetration is comparatively lower in adults than in small children. Moreover, teenage girls keep their mobiles near their breasts, which is claimed to be dangerous and causes breast cancer. Mobile phones even while not in use, penetrate the radiation into the human body, when kept very close, and touching the body.

The scientific study involves algorithms and statistical models, used to perform a certain task without the need for explicit instructions, and relying on patterns, and inference is referred to as Machine Learning (ML). Generalized Linear Models (GLM), an ML algorithm was implemented in this case study to understand the severity of mobile radiation from the towers. GLM provides a set of relationship procedures between the response variables to continuous and/or categorical predictors. A confidential interval, known as a statistical analysis, was performed on the response and predictor variables.

Material and Methods

This analytical study claims the mobile tower radiation on human lives and its impact. The data was collected from 2018 to 2023 for analyzing the two states to compare the models on two different states i.e. Andhra Pradesh (AP) and Telangana (TS). GLM models were generated using two attributes namely, measured value and prescribed limit for the mentioned years.

The evaluation is carried out by the collection of data from the open source for two states to compare the models. The GLM models are generated with the measured value and prescribed limit for the different years.

Extremely Low Frequency

Extremely Low-Frequency (ELF) magnetic fields are present throughout the environment, originating from both natural and man-made sources. Naturally occurring time-varying ELF fields in the atmosphere arise from various factors, including the influence of solar and lunar activity on ion currents in the upper atmosphere. Studies have explored potential links between increasing exposure to ELF fields and cancer risk, particularly in electrical workers, focusing on leukemia and tumors of the nervous system.

The experiment specifies that the extremely low-frequency electromagnetic fields (ELF-MF) effects on cellular biochemistry and the structure are associated with the induced current density, with a majority of current density levels over 10mA/m^2. The growing body indicates that the cell membrane plays a major part in the transduction and amplification of ELF field signals. The correlation between the incidence of cancer exposure and cancer risk was present in children below age 14 [3].

According to the International Agency for Research on Cancer (IARC), ELF-EMF (category 2B) was considered to be carcinogenic to humans [4]. Moreover, the determinations of ELF signals were found in the range of 0.3 Hz - 0.3 kHz [5]. The cause for exposure of ELF-EF and ELF-MF [6] was considered to be a global issue [7]. While Torres-Duran initially suggested that low-level exposure to extremely low-frequency electromagnetic fields (ELF-EMF) is harmless, recent studies have challenged this perspective. Exposure to ELF-EMF has been shown to increase oxidative stress in certain models, such as chick embryos and human red blood cells (erythrocytes). Additionally, both environmental and artificial magnetic fields have been linked to

significant impacts on the cardiovascular systems of animals and humans [8].

The case study for extremely low-frequency electromagnetic field was conducted on the rats, exposed to a single stimulation of ELF-EMF (experimental group) and evaluated at 24h, 48h, and 96h on serum and liver lipid and liver lipo-peroxides measured in thiobarbituric acid reactive substances TBARS. The results showed that TBARS levels were increased at 24 hours after exposure [8]. In another case study, the exposure to Radio Frequency (RF) radiation from mobile phones has triggered a range of neurological effects, including headaches, sleeping patterns, modification in the neuronal electrical activity, and disturbance in the neurotransmitter. The increasing interest in research and epidemiological data provides the potential association between occupational exposures to ELF-EMFs and neurodegeneration. While some studies have raised concerns about potential health risks associated with long-term mobile phone use (over 10 years), the evidence linking them to brain tumors located specifically near the phone is currently inconclusive. Large-scale studies haven't found a definitive connection. The ELF-EMFs emitted by mobile phones operate at a much lower frequency than those implicated in some neurodegenerative diseases, such as Alzheimer's and Amyotrophic Lateral Sclerosis (ALS). The exact causes of these diseases are still under investigation [9].

The increasing use of 3G mobile phones has a concern over the human health effects of RF-EMFs emitted by WCDMA mobile. The study evidence reveals that WHO has categorized RF-EMFs as human carcinogenic (Group 2B). The eight symptoms, such as dizziness, nausea, throbbing, itching, headache, palpitation, warmth, and fatigue were listed.

For every five minutes, throughout the entire session, the EMF exposure was examined. It was found that no link was between 8 symptoms and short-term RF-EMF exposure in any group. However, the study is about the day-wise regular exposure to RF radiated by WCDMA mobile phones. A further study was examined for the long-term effects of repetitive and daily regular exposure, on teenagers [10]. In a case study of RF-EMF, the results obtained by kmeans nearest neighbor (91.17%) were good over RF (89.41%) for mean accuracy. Moreover, kNN had less computation time (3.38 s) to train a model over RF (248.12 s) [11].

ELF magnetic fields were calculated at home, in which the frequency was observed between higher fields where average >0.2 and T>0.6, and T indicates at the front door and resulted in spontaneous abortion in early pregnancy. However, the study showed no association between exposure to measured MF>0.2 and contrary pregnancy outcomes that include miscarriage and low birth weight or pre-term delivery. However, few studies have proved miscarriages as an outcome of occupational exposure of women to ELF-MF [12]. The radiation of the mobile tower mounted on a rooftop has various effects. The abundance of several insects was affected by EMR [13].

The biological effects reported from low-level ELF-field and chronic exposure to static magnetic fields were identified that need replication to assess any possible health consequences. The

Attributable Fraction (AF) remains less with point estimates ranging from <1% to 4%. AF is highly associated with the distribution exposure and more data are needed on exposure levels that would be collected in a large systematic survey [14].

Some studies suggest that exposure to RF radiation might affect the eye's ability to regulate its temperature, due to reduced fluid circulation, leading to poorer cooling. However, the relationship between RF radiation and changes in water content within the eye is not fully understood. The children's eyes are very delicate and absorb between 2 to 5-fold higher doses of RF radiation than those of older individuals. Aged individuals over 76 years of

heavy usage of mobile need eye protection when the phone is used for longer conversation. Geometry model as well as dielectric constant change systematically with age, with greater head mass, and skull and skin thickness in adults compared with children [15]. High levels of EMF radiation are found in several medical applications. The medical devices used for magnetic resonance imaging, diathermy, several kinds of RF ablation, surgery, and diagnoses produce high levels of EMF that affect the patient or locally inside the patient's body [16]. Electromagnetic Hypersensitivity (EHS) person suffers from symptoms, such as headaches, loss of memory, insomnia, and nervousness, due to the radiation of Radio Frequency (RF) from cellular phones and/or base stations. EHS relies on a person's subjective judgment and is difficult to diagnose [17]. ICNIRP suggests how to protect from short and long–term exposures to non-ionization radiation [18].

Results

The number of observations were 39 and 52 for the years 2018-2019 and 2019-2020 for Andhra Pradesh (AP) state in Table 1. Similarly, the observations were 15 and 42 for the years 2018-2019 and 2019-2020 for Telangana (TS) in Table 1 and 40 observations for 2020-2023. Table 2 represents the GLM model for mobile tower radiations collected for both the states in India. The following respective graphs were obtained showing the linear prediction for the states AP and TS for two years as shown in Figures 1, 2, and 3.

Table 1: Confidential Interval (CI) for Andhra Pradesh and Telangana state

Year	Var.	Mean	S.E	95% CI
AP-2018-19	MV	0.0078	0.0016	0.0045-0.0111
	PL	1216.65	1216.14	-1245.28-3678.60
AP-2019-20	MV	0.0022	0.0002	0.0016-0.0028
	PL	0.4553	0.0022	0.4507-0.4599
TS-2018-19	MV	0.0632	0.0061	0.0500-0.0763
	PL	0.4659	0.0025	0.4604-0.4714
TS-2019-20	MV	0.0311	0.0060	0.0189-0.4345
	PL	0.4573	0.0022	0.4527-0.4619
AP/TS-2020-23	MV	0.0701	0.2091	0.0278-0.1124
	PL	0.4934	0.2211	0.4487-0.5381

AP: Andhra Pradesh, TS: Telangana, MV: Measured Value, PL: Prescribed Limit, CI: Confidential Interval

Discussion

The GLMs are a powerful statistical tool used to model the relationship between a response variable and one or more predictor variables. Unlike linear regression, GLMs can handle response variables that aren't normally distributed.

GLM and Confidential Interval CI were calculated using STATA/IC 12 software for the states of India i.e. AP and TS for two consecutive years 2018-2019 and 2019-2020. The two-parameter viz. Measured Value MV as dependent and Prescribed Limit PL as independent variables were considered. The computed mean, standard error, and 95% CI from the dataset are shown in Table 1.

The linear regression models were considered with a linear mapping between observed features and the outputs and hence predict the output. GLM are linear model (Table 2) classes that associate various models, including linear and logistic regression. The distribution over each output is supposed to be an exponential family distribution, in which natural parameters are a linear function of the inputs. The link function combines the expected values of the response to the linear combination of predictors. The variable function is expressed, as follows:

$$V\left(u\right)=u\times\left(1-\frac{u}{1}\right) \qquad \text{eq(1)}$$

Link function is denoted with

$$g\left(u\right)=\ln\left(\frac{u}{1-u}\right) \qquad \text{eq(2)}$$

One of the GLM forms is logistic regression, which services the logit-binomial link distribution pairing to model the effects of one

or more continuous or categorical predictor variables on a binary response variable.

Akaike information criterion AIC is an estimator of the relative quality of statistical models for a given data set. The Bayesian information criterion BIC is a standard for model selectors among the finite set of models.

Table 2: Generalized Linear Model Binomial –logit

GLM Optimization										
AP 2018-19	MV	Coef.	S.E	z	p>|z|	95% CI	AIC	BIC	Dev.	Pear
	PL	7.78e-08	0.0004	0.0	1.00	-0.001-0.001	0.1177	-139.215	0.0001	0.0001
LL=-1.296										
AP 2019-20	PL	-10.524	187.66	-0.06	0.95	-378.343-357.293	0.104	-197.498	0.064	0.094
	Cons	-1.317	85.003	-0.02	0.988	-167.922-165.284	-	-	-	-
LL=-0.7112										
TS 2018-19	PL	-7.508	1.939	-3.87	0.00	-11.310-3.706	0.269	-151.550	1.694	2.066
LL=-4.6623										
TS 2019-20	PL	0.158	2.282	0.07	0.945	-4.315-4.631	0.479	-37.912	0.0004	0.0004
LL=-2.5934										
AP/TS2020-23	PL	0.395	0.139	2.83	0.005	0.121 -0.668	-1.324	-139.613	0.564	0.564
	Cons	-0.124	0.714	-1.75	0.081	-0.265-0.0153	-	-	-	-
LL=28.4839										

AP: Andhra Pradesh, TS: Telangana, df: degree of freedom, LL: Log Likelihood, MV: Measured Value, PL: Prescribed Limit, AIC: Akaike Information Criterion, BIC: Bayesian Information Criterion, Dev.: Deviance, Pear: Pearson, CI: Confidential Interval

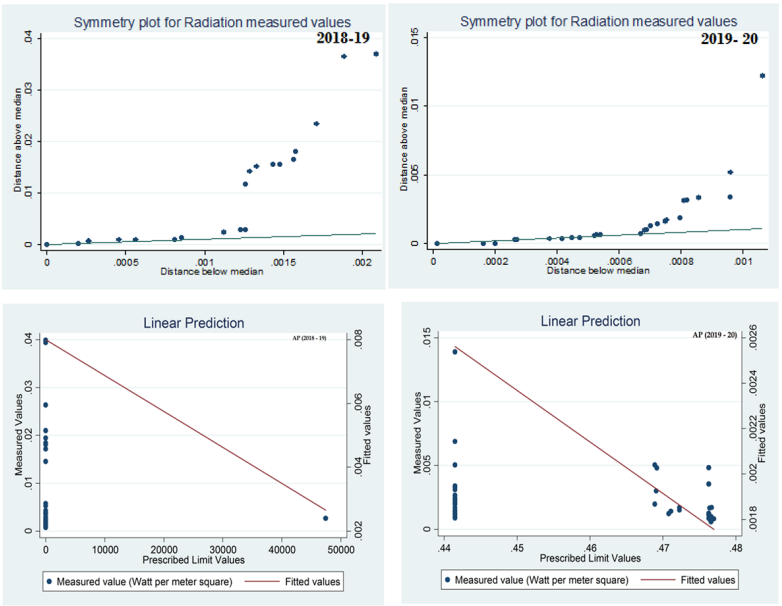

Figure 1: Andhra Pradesh (AP) state Symmetry plot & Linear Prediction for **a**. 2018–19 (left) **b**. 2019-20 (right)

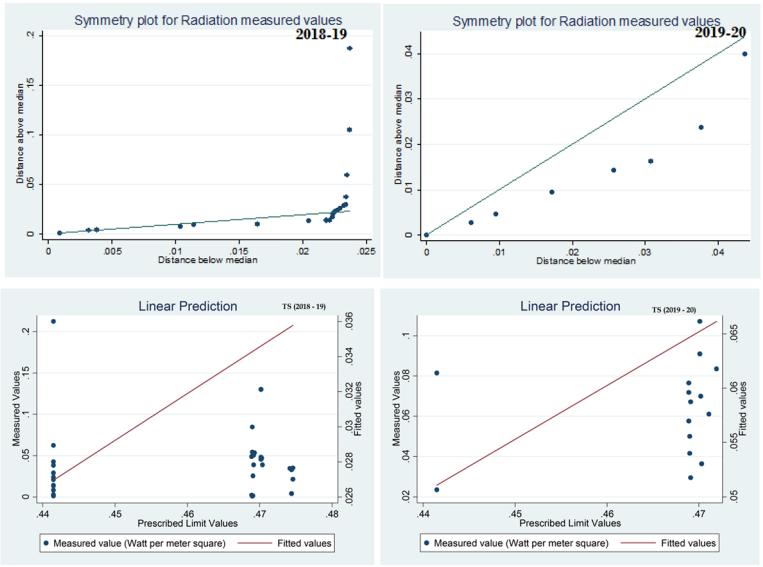

Figure 2: Telangana (TS) Symmetry Plot & Linear Prediction for **a**. 2018 – 2019 (left) **b**. 2019-20 (right)

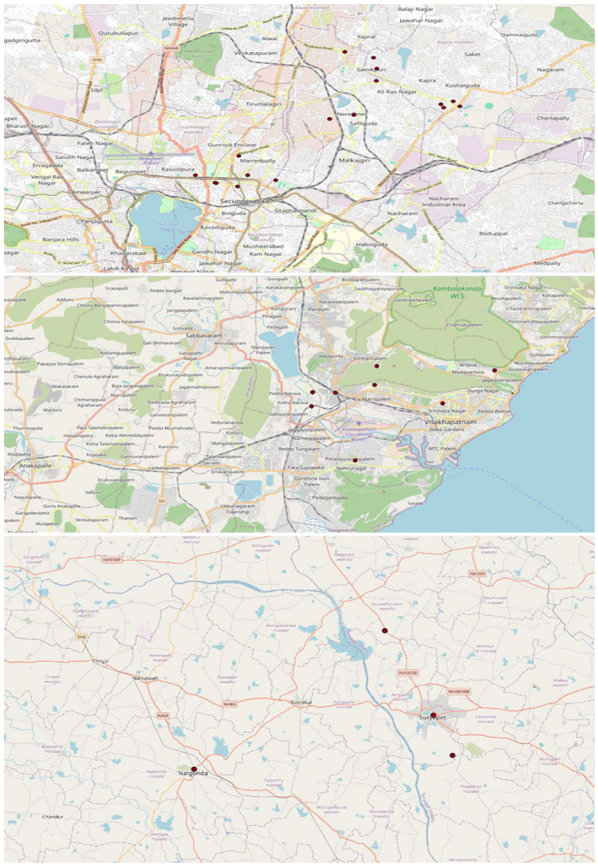

Figure 3: Mobile Towers mapping using Geographical Information System for 2020-2023 for both the states. Geographic Information System (GIS) mapping for mobile towers for 2020-2023

From Table 2, the p>|z| value tests the null hypothesis, where the parameter is nearly=0 or <=1. The p>|z| test compares each *P*-value to the preselected value of alpha. Coefficients with *P*-values less than alpha are statistically significant.

Linear prediction graph (Figures 1 and 2), xb computes the linear prediction from the fitted model. All the models are estimation sets of parameters $b_1,b_2,\ldots, b_k$, and the linear prediction is given as $by_j=b_1x_{1j}+ b_2x_{2j}+...+ b_kx_{kj}$ expressed in matrix form as $b_{yj}=x_jb$.

In a symmetric plot, like the ones shown in Figures 1 and 2, data points that fall close to the diagonal reference line indicate a symmetrical distribution of the measured values. Then the points in the plot lie above the reference line, indicating the distribution of MV. If MV is distributed symmetrically if $median - MV_{[i]} = MV_{[N+1-i]} - median$, where $MV_{[i]}$ indicates the ith-order of the statistic of the MV variable, and the graph is plotted $x = MV_{[N+1+i]} - median$ and $y = median - MV_{[i]}$.

The scatter plot is an excellent tool for analyzing the two quantitative variables relationship. For each observation placed on the graph point at the location corresponds to the variable of X and Y. Figure 3 depicts the

mobile towers' geographical mapping using GIS in few regions of AP and TS. The location of the mobile tower is represented by red color dots.

One of the excellent tools for examining the two quantitative variables' relationship is a scatter plot. For each observation placed on the graph point at the location corresponding to the variable of Y and X. Figure 3 depicts the geographical mapping of the mobile towers in the few regions of AP and TS. The red points in the map indicate the location of the mobile tower in the region.

Accordingly, ELF fields' exposure at high field strengths [19] and RF-EMF are dangerous for the human body [20]. However, ELF -EMF waves, ranging in the frequency band of 0.01 Hz - 100 Hz [21] and RF fields with frequencies about 10 MHz to 300 GHz were considered [22].

Conclusion

The evaluation suggests that the exposure to static and ELF electric and MF was able to identify the knowledge gaps to improve health risks. GLM model proved Z and p|z| to be zero and less than one, and thereby statistically significant. The confidental interval obtained for measured value for Andhra Pradesh (2018-2019) was 95% CI [0.0045 – 0.0111] and for 2019-2020, it was found to be 95% CI [0.0016 - 0.0028]. Similarly, the CI for the measured value for Telangana in 2018 -2019 was 95% CI [0.0500 – 0.0763] and for 2019-2020, it was found to be 95% CI [0.0189 – 0.4345].

We suggest that the exposure to static and ELF electric and MF can identify gaps to improve health risk. GLM is the best statistical model that proved Z and p|z| to be zero and less than one. Coefficients with lower P-values than alpha are statistically significant values. The confidential interval was calculated for measured value radiation for Andhra Pradesh (2018-19) was 95% CI [0.0045 - 0.0111] and for 2019-20 (95% CI [0.0016 - 0.0028]). Next, the CI for the measured value for Telangana in 2018-19 was 95% CI [0.0500 - 0.0763] and for 2019-20 (95% CI [0.0189 - 0.4345]).

Authors' Contribution

P. Jayanthi Gandam conceived the idea, datasets, results and script. The research work was proofread by M. Iyyanki. The authors read, modified, and approved the final version of the manuscript.

Ethical Approval

This article does not contain any study with humans or animals performed by the author.

Funding

None

Conflict of Interest

None

References

1. Ballard JS. Radiation Safety. Chapter Ionization & units of Measurement. Open Oregon Educational Resources; 2016.
2. Wasilewska M, Bogucka H. Space-time-frequency machine learning for improved 4G/5G energy detection. *International Journal of Electronics and Telecommunications*. 2020;**66**(1):217-23. doi: 10.24425/ijet.2020.131866.
3. Tenforde TS. Biological interactions and potential health effects of extremely-low-frequency magnetic fields from power lines and other common sources. *Annu Rev Public Health.* 1992;**13**:173-96. doi: 10.1146/annurev.pu.13.050192.001133. PubMed PMID: 1599584.
4. Touitou Y, Selmaoui B. The effects of extremely low-frequency magnetic fields on melatonin and cortisol, two marker rhythms of the circadian system. *Dialogues Clin Neurosci.* 2012;**14**(4):381-99. doi: 10.31887/DCNS.2012.14.4/ytouitou. PubMed PMID: 23393415. PubMed PMCID: PMC3553569.
5. Garcia RM, Novas N, Alcayde A, El Khaled D, Fernandez-Ros M, Gazquez JA. Progress in the knowledge, application and influence of extremely low frequency signals. *Applied Sciences*. 2020;**10**(10):3494. doi: 10.3390/app10103494.
6. Bonato M, Chiaramello E, Parazzini M, Gajšek P, Ravazzani P. Extremely low frequency electric and magnetic fields exposure: Survey of recent find-

ings. *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*. 2023;**7**(3):216-28. doi: 10.1109/JERM.2023.3268555.

7. Gholipour Hamedani B, Goliaei B, Shariatpanahi SP, Nezamtaheri M. An overview of the biological effects of extremely low frequency electromagnetic fields combined with ionizing radiation. *Prog Biophys Mol Biol.* 2022;**172**:50-9. doi: 10.1016/j.pbiomolbio.2022.04.008. PubMed PMID: 35513112.
8. Torres-Duran PV, Ferreira-Hermosillo A, Juarez-Oropeza MA, Elias-Viñas D, Verdugo-Diaz L. Effects of whole body exposure to extremely low frequency electromagnetic fields (ELF-EMF) on serum and liver lipid levels, in the rat. *Lipids Health Dis.* 2007;**6**:31. doi: 10.1186/1476-511X-6-31. PubMed PMID: 18021407. PubMed PMCID: PMC2203969.
9. Consales C, Merla C, Marino C, Benassi B. Electromagnetic fields, oxidative stress, and neurodegeneration. *Int J Cell Biol.* 2012;**2012**:683897. doi: 10.1155/2012/683897. PubMed PMID: 22991514. PubMed PMCID: PMC3444040.
10. Choi SB, Kwon MK, Chung JW, Park JS, Chung K, Kim DW. Effects of short-term radiation emitted by WCDMA mobile phones on teenagers and adults. *BMC Public Health.* 2014;**14**:438. doi: 10.1186/1471-2458-14-438. PubMed PMID: 24886241. PubMed PMCID: PMC4108016.
11. Halgamuge MN, Davis D. Lessons learned from the application of machine learning to studies on plant response to radio-frequency. *Environ Res.* 2019;**178**:108634. doi: 10.1016/j.envres.2019.108634. PubMed PMID: 31450151.
12. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part 1: static and extremely low-frequency (ELF) electric and magnetic fields. IARC; 2002.
13. Lázaro A, Chroni A, Tscheulin T, Devalez J, Matsoukas C, Petanidou T. Electromagnetic radiation of mobile telecommunication antennas affects the abundance and composition of wild pollinators. *J Insect Conserv.* 2016;**20**(2):315-24. doi: 10.1007/s10841-016-9868-8.
14. Kheifets L, Afifi AA, Shimkhada R. Public health impact of extremely low-frequency electromagnetic fields. *Environ Health Perspect.* 2006;**114**(10):1532-7. doi: 10.1289/ehp.8977. PubMed PMID: 17035138. PubMed PMCID: PMC1626420.
15. Fernández C, De Salles AA, Sears ME, Morris RD, Davis DL. Absorption of wireless radiation in the child versus adult brain and eye from cell phone conversation or virtual reality. *Environ Res.* 2018;**167**:694-9. doi: 10.1016/j.envres.2018.05.013. PubMed PMID: 29884550.
16. Vecchia P, Matthes R, James Lin GZ, Saunders R, Swerdlow A. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). ICNIRP; 2009.
17. Nam KC, Lee JH, Noh HW, Cha EJ, Kim NH, Kim DW. Hypersensitivity to RF fields emitted from CDMA cellular phones: a provocation study. *Bioelectromagnetics*. 2009;**30**(8):641-50. doi: 10.1002/bem.20518. PubMed PMID: 19551766.
18. International Commission on Non-Ionizing Radiation Protection (ICNIRP). Principles for Non-Ionizing Radiation Protection. *Health Phys.* 2020;**118**(5):477-82. doi: 10.1097/HP.0000000000001252. PubMed PMID: 32251080.
19. Repacholi MH, Greenebaum B. Interaction of static and extremely low frequency electric and magnetic fields with living systems: health effects and research needs. *Bioelectromagnetics.* 1999;**20**(3):133-60. doi: 10.1002/(sici)1521-186x(1999)20:3<133::aid-bem1>3.0.co;2-o. PubMed PMID: 10194557.
20. Kim JH, Lee JK, Kim HG, Kim KB, Kim HR. Possible Effects of Radiofrequency Electromagnetic Field Exposure on Central Nerve System. *Biomol Ther (Seoul).* 2019;**27**(3):265-75. doi: 10.4062/biomolther.2018.152. PubMed PMID: 30481957. PubMed PMCID: PMC6513191.
21. Persinger MA, Ludwig HW, Ossenkopp KP. Psychophysiological effects of extremely low frequency electromagnetic fields: a review. *Percept Mot Skills.* 1973;**36**(3):1139-51. PubMed PMID: 4576236.
22. Repacholi MH. Low-level exposure to radiofrequency electromagnetic fields: health effects and research needs. *Bioelectromagnetics.* 1998;**19**(1):1-19. PubMed PMID: 9453702.