ORIGINAL ARTICLE

The Relationship between Cell phone Usage and Sleep Quality among Hospital Staff

Majid Jadidi [1], Morteza Isa Abadi Bozcheloei [1], Majid Mirmohammadkhani [2,3], Abbas Ziari [2], Fatemeh Paknazar [2,3*]

[1] *Department of Medical Physics, Semnan University of Medical Sciences, Semnan, Iran*

[2] *Social Determinants of Health Research Center, Semnan University of Medical Sciences, Semnan, Iran*

[3] *Department of Epidemiology and Biostatistics, School of Medicine, Semnan University of Medical Sciences, Semnan, Iran*

*Corresponding Author: Fatemeh Paknazar
Email: paknazar2306@yahoo.com

Received: 18 March 2021 / Accepted: 03 August 2021

Abstract

Purpose: Despite the two decades of using cell phones, there are still considerable controversies about the biological effects of the Electromagnetic Fields (EMFs) produced by cell phones. Sleep disorder among hospital staff is an important issue for the health care system not only due to the health of its employees but also to the reduction of the staff performance quality and the increase in medical errors. This study aimed to explore factors that may affect the sleep quality of hospital staff and to examine the association between sleep quality and cell phone usage.

Materials and Methods: In this study, participants consisted of 288 employees (35.51 ± 8.42 years old) of two hospitals, and their sleep quality was assessed using the Pittsburgh sleep quality index.

Results: Sixty-six percent of participants had good sleep quality and nearly 68% of the employees worked in shifts. The cell phone use among participants averaged 10.74 ± 3.03 years, and less than half of the staff stated that call durations of their cell phones were less than 5 h/day. More than 90% of the staff mentioned no use of hands-free. There were no statistically significant differences between job characteristics, sleep quality, and items related to cell phones, except the use of hands-free.

Conclusion: In our study, using hands-free during phone calls was associated with poor quality sleep. Different factors, such as decreased levels of electromagnetic fields reaching the brain, can be involved in this effect. These results must be interpreted with caution due to the low number of subjects and the limitations of our study.

Keywords: Sleep Quality; Hospital Staff; Electromagnetic Field; Cell Phone; Hands-Free.

DOI: https://doi.org/10.18502/fbt.v9i1.8144

1. Introduction

Sleep is known as a factor of health and an aspect of improving people's daily functioning. Human resources are the most important part of any organization, and the progress of an organization depends on the physical, mental, social, and spiritual health of its human resources. Therefore, the staff members are one of the most important resources and assets of any hospital. Insomnia as one of the most common sleep disorders has a lot of difficulty in sleep initiation or maintenance and early morning awakening, which can cause fatigue, irritability, and a decrease in memory or concentration [1]. Sleep disorder among hospital staff is an important issue for the health care system not only due to the health of its employees but also to the reduction of the staff performance quality and the increase in medical errors. Therefore, it is important to identify and eliminate factors affecting the quality of sleep among hospital staff disorders and increase the quality of performance. In studies conducted by Shao *et al.* and Park *et al.*, sleep disorders and low sleep quality were reported among 57% and 79% of nurses, respectively [2,3].

Despite the growing number of cell phone users, there has been limited knowledge of the direct effect of cell phone usage on sleep and later daytime disorders. Considering the frequency of the waves and the location of the cell phone at the closest distance to the brain during the call, most of the energy of Electromagnetic Field (EMF) radiation is absorbed in the human brain [4]. Cell phone usage in a long time can cause neck pain, dry eyes, anxiety, phobias (nomophobia), and insomnia [5]. For this reason, symptoms such as depression, learning disabilities, decreased reaction time, and sleep disorders increase after cell phone use. In studies of Yioultsis, Hocking, Sandstrom, and Oftedal, exposure to cell phone EMF with normal power density or even less than the allowable limit (one mW/cm^2) caused headaches, heat in the ears, poor memory, and sleep disorder. These symptoms are directly related to the length and number of conversations per day [6-9]. In this regard, Borbely *et al.* studied the effect of cellphone EMF on human sleep. The results showed an increase in sleep and a change in Electroencephalography (EEG) during sleep [10]. Moreover, Jech *et al.* concluded that the reaction time of individuals after radiation of EMF decreased by 20 milliseconds and could increase the rate of sleep among individuals [11]. The results of a one-year study of high cell phone use showed that men had sleep disorders but women showed symptoms of depression [12]. Contrary to studies denoted above, Mann *et al.* found no changes in total sleep time after exposure to cell phone EMF [13]. Hence, this study aims to explore factors that affect the sleep quality of hospital staff and to examine the association between sleep quality and cell phone usage.

2. Materials and Methods

2.1. Participants

This Cross-sectional analytic study was performed between two active educational hospitals affiliated with Semnan University of Medical Sciences, Iran (Kosar and Amir al-Momenin). Each of the hospital staff had the chance to participate in the study considering some inclusion criteria. Regarding the main objective of the research, the present study was performed among only hospital staff members, including nurses, hospital service workers (behkar), operating room technicians, nurse assistants (behyar), official staff, anesthesia technicians, lab staff, secretary, and radiology staff. The staff who entered the study agreed to participate, and those who reportedly had illnesses that directly or indirectly affected their sleep or were taking sleeping pills chronically were excluded from the study.

Sampling was performed by the stratified random sampling method in proportion to the number of staff in each of the two hospitals. The sample size was set to at least 265 people using the Cochran's formula for a finite population (N = 850, p = 0.5, q = 0.5, Z = 1.96, d = 0.05).

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N}\left[\frac{z^2 pq}{d^2} - 1\right]} \quad (1)$$

The employee's information was collected by retaining a three-part self-statement questionnaire. The first and second parts of the questionnaire were developed as data gathering forms. The first part was developed to gather some information on the personal and professional characteristics of participants, including the name of the hospital, age, gender, work experience, job, and shift work. Within the second part, participants answered questions on the quantity of cell phone use. These questions included years of cellphone use, average usage time, the number of calls per day, hands-free usage, cell shutdown before bedtime, and head-handset distance during sleep. The items

were developed, evaluated, and validated qualitatively by a panel of experts. The face validity of the items was assessed in a pilot study of 10 people. The third part was associated with sleep quality assessment using the Pittsburgh Sleep Quality Index (PSQI), developed by Buysse *et al*. (1989) at the Pittsburgh Institute of Psychiatry, which is one of the simplest tools designed and built to measure sleep quality. The tool has nine items, but since question 5 alone contains 10 sub-items, the whole questionnaire has 19 items, which are scored on a 4-point Likert scale from 0 to 3. The questionnaire has seven subscales or components as follows: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbance, 6) use of sleeping medication, and 7) daytime dysfunction. Buysse *et al.* first developed and introduced this questionnaire and obtained the internal consistency of the questionnaire using a Cronbach's alpha of 0.83 [14]. Within the Persian version of this questionnaire, the validity and reliability were evaluated, with the latter obtained by a Cronbach's alpha (0.90) and the purification method (0.88) [15]. The individual score will be between 0 and 3, which are interpreted as follows: lack of sleep problem (0), medium sleep problem (1), serious sleep problem (2), and very serious sleep problem (3). The entire score or the PSQI global score may be a sum of seven subscales, which can be between 0 and 21. Gaining a total score above 5 within the whole questionnaire means poor sleep quality and otherwise means good sleep quality. The Research Ethics Committee of Semnan University of Medical Sciences approved all procedures of this study (IR.SEMUMS.REC.2016.85).

2.2. Statistical Analysis

The numerical variables were described using mean, standard deviation, median, and intermediate-range (Inter Quartile Range (IQR)). The number and percentage of participants were reported separately from the studied characteristics and variables in the form of frequency distribution tables. All participants were divided into two groups according to the Pittsburgh questionnaire in terms of sleep quality: good and poor quality (based on a total score above 5 as the cut-off). The relationship between each of the studied characteristics with sleep quality was investigated using simple logistic regression models and crude Odds Ratio (OR) was reported afterward. To match the main effect of the variables, a multiple logistic regression module was fitted to the data, and the adjusted odds ratio (adj. OR) was estimated and used in the final interpretation. The statistical tests were done using SPSS-18 software at a significance level of 5%.

3. Results

In this study, participants consisted of 288 employees of two educational hospitals (Kosar and Amir al-Momenin) of Semnan University of Medical Sciences, Iran. The mean age of the participants was 35.51 ± 8.42 years. Median and Inter Quartile Range (IQR) was 6 (3, 12) years of work experience. Among participants, 45.8% (132 people) were employed as nurses in the hospitals and 181 people (62.8%) had a bachelor's degree. Nearly 68% of the participating employees worked in shifts. The frequency distribution of staff in terms of hospital, place of employment, gender, education, occupation, and type of shift work is presented in Table 1.

Table 1. Frequency distribution of staff regarding the personal and job characteristics

Characteristics		Number	%
Hospital	Kosar	223	77.4
	Amir al-Momenin	65	22.6
Gender	Male	106	36.8
	Female	182	63.2
Education	<High-school	23	8.0
	High-school	39	13.5
	Technician	22	7.6
	Bachelor	181	62.8
	Master	23	8.0
Job	Nurse	132	45.8
	Hospital Service worker (Behkar)	38	13.2
	Operating room technician	8	2.8
	Nurse Assistant (Behyar)	11	3.8
	Official staff	84	29.2
	Anesthesia technician	6	2.1
	Lab staff	5	1.7
	Secretary	1	.3
	Radiology staff	3	1.0
Shift-work	Yes	196	68.1
	No	92	31.9
Total		288	100.0

The mean and standard deviation of cell phone use among participants averaged 10.74 ± 3.03 years (range: 3-25 years). Less than half of the participants stated that their cell phone call duration was less than 5 h a day, and more than 90% mentioned no use of hands-free. The

frequency distribution of participants was considerable in terms of average call duration, the number of calls per day, hands-free use, handset turn off during sleep, and head-handset distance (Table 2). According to the overall score of the PSQI, 192 (66.7%) and 96 (33.3%) individuals of the employees had good and poor sleep quality, respectively. Sleeping medication during workaday was not used in 91% (262) of the participants. The distribution of sleep quality in each of the Pittsburgh questionnaire subscales is shown in Table 3.

The results of logistic regression analysis to determine the relationship between each of the variables studied with poor sleep quality (Table 4) indicate that the type of hospital and the use of hands-free have a significant relationship with sleep quality (P<0.05). Hence, employment in Amir al-Momenin Hospital and the use of hands-free showed decreases of 60% and 74% in the chance of having poor quality sleep, respectively.

Table 2. Frequency distribution of staff regarding the mobile phone usage information

Information		Number	%
Conversation time per day	<30 min	184	63.9
	30-60min	76	26.4
	1-1.5h	18	6.3
	1.5-2h	5	1.7
	>2h	5	1.7
Number of calls per day	<5	136	47.2
	5-9	95	33.0
	10-14	39	13.5
	15-19	9	3.1
	20 and more	9	3.1
The common use of hands-free	Yes	17	5.9
	No	271	94.1
Turn off during sleep	Yes	54	18.8
	No	234	81.3
Distance from the device while sleeping	<1meter	182	63.2
	1 meter and more	106	36.8
Total		288	100.0

4. Discussion

According to the results of low quality of sleep, a significant difference was observed between two hospitals' staff members ($P < 0.05$), which can be attributed to differences in the wards and the number of patients in Kosar Hospital, leading to lower sleep quality among the staffs. Medium sleep disturbance and medium subjective sleep quality were observed among 63.2% and about 80.6% of the hospital staff while 41.7% of all participants had medium daytime dysfunction. Chien *et al.* examined the quality of sleep among 156 female nurses using the Pittsburgh Questionnaire and reported that most nurses had poor sleep quality [16]. Park *et al.* studied the relationship between efficiency and sleep quality among 188 nurses in South Korean hospitals. The prevalence of poor sleep quality among nurses was reported to be 79% (3). In a study to investigate sleep disorders among nurses, 57% had poor sleep quality [2]. Since all hospital staff and not only nurses were surveyed in our study, the results are slightly different from the abovementioned studies.

In the present research, no significant relationships were found between age, gender, and education with sleep quality. Likewise, Liu *et al.* observed no significant relationships between age, level of education, and sleep quality [17]. According to the results of our study, there were no significant relationships between job duties, shift-work, work experience, and sleep quality. Ma *et al.* (2018) examined the relationship between work shifts and sleep quality among Chinese employees, and found a higher risk of sleep disorders among workers with flexible

Table 3. Frequency distribution of staff regarding the severity of the sleep problems

Components	No problem		Medium		Serious		Very serious	
	Number	%	Number	%	Number	%	Number	%
Subjective sleep quality	55	19.1	182	63.2	42	14.6	9	3.1
Sleep latency	69	24.0	134	46.5	58	20.1	27	9.4
Sleep duration	169	58.7	64	22.2	37	12.8	18	6.3
Habitual sleep efficiency	177	61.5	46	16.0	30	10.4	35	12.2
Sleep disturbance	56	19.4	232	80.6	-	-	-	-
Use of sleeping medication	262	91.0	17	5.9	7	2.4	2	.7
Daytime dysfunction	92	31.9	120	41.7	57	19.8	19	6.6

Table 4. The relationship between each of the variables of interest with poor sleep quality using simple and multiple models of logistic regression

Variables	P	Crude OR	95% CI		p	Adj. OR	95% CI	
			Lower	Upper			Lower	Upper
Hospital (Amir al-Momenin vs Kosar)	.005*	.37	.18	.74	.016*	.40	.19	.84
Age (year)	.275	.98	.95	1.01	.366	.98	.94	1.02
Gender (female vs male)	.388	1.25	.75	2.09	.320	1.36	.74	2.51
Job (nurses vs others)	.316	1.28	.78	2.10	.931	1.02	.54	1.96
Shift-work (no vs yes)	.655	.88	.52	1.50	.784	1.09	.58	2.05
Years of service (year)	.359	.98	.95	1.01	.990	1.00	.95	1.04
Education	.263	1.14	.90	1.44	.925	1.01	.73	1.40
Mobile phone use duration (year)	.160	1.05	.97	1.14	.123	1.07	.98	1.17
Conversation time (per day)	.136	.78	.56	1.08	.059	.65	.42	1.01
Number of calls (per day)	.933	.98	.77	1.26	.575	1.10	.78	1.55
Common use of hands-free	.028*	.32	.12	.88	.016*	.26	.08	.78
Turn off during sleep	.522	1.23	.64	2.34	.519	1.25	.62	2.53
Distance from the device while sleeping	.262	.74	.44	1.24	.571	.85	.48	1.49

shifts [18]. Similarly, Shao *et al.* reported that 57% of nurses had poor sleep quality [2]. McDowall *et al.* looked at the effect of shift work on sleep quality among nurses. After controlling factors such as age, sex, and work experience, shift nurses had significantly more sleep disorders than those with a fixed shift job. The difference in the results of our study with prior research can be attributed to the large number of samples (888 people) in the study of McDowall [19].

Based on the results of the present study, no significant differences were observed between the items related to sleep quality and exposure to cell phone EMF (including the history of cell phone use, average call time in 24 h, duration of call time in 24 h, turning off the phone during sleep, and the phone-head distance during sleep). Nevertheless, a 74% decrease in the chance of having poor-quality sleep was detected among employees who used hands-free for calling time. This shows a large discrepancy between the present data and others. Borbely *et al*. and Wagner *et al*. concluded that an EMF in the cell range could have significant effects on sleep time [10, 20]. In a cross-sectional study, Sahin *et al.* observed a significant relationship between the score obtained from the problematic cell phone use scale and sleep disorder [21]. Moreover, Liu *et al*. report that EMF radiation causes poor sleep quality and affects sleep quality more than sleep duration among the workers [22]. Lee *et al.* evaluated the cell addiction questionnaire and found that high cell addiction increased the risk of poor quality sleep but had no effect on sleep duration [23]. In addition, the prevalence of difficulties of falling asleep and maintaining sleep increased with increasing exposure to short-wave broadcast transmitter EMF. Sleep quality improved after disruption of the EMF exposure [24] and limiting cell phone use before bedtime was effective in dropping sleep latency and increasing sleep duration [25]. However, an increase in the brain tissue temperature generated by a cell phone EMF similar to the increased temperature due to hyperthermia or fever could create brain dysfunction [26].

Cell phone EMF delivers considerable changes in the level of dopamine, norepinephrine, and serotonin in the mice's brains [27]. Likewise, melatonin secretion (as the main hormone of the circadian timing system) is influenced by EMF radiation. The effects of these fields on pineal activity have been investigated using different studies [28]. In a study by Burch *et al.*, the call duration of more than 25 min a day decreased the level of melatonin secretion in populations of male electric utility workers [29]. In studies rodents, the exposure of rats to the 900-MHz cell phone EMF (2 h/day) resulted in a statistically significant decrease in pineal melatonin content [30]. Besides, a field of 1800-MHz EMF disturbed the rhythm of melatonin secretion in rats [31], and irradiation of 835-MHz EMF (5 h/day) affected striatal neurons in C57BL/6 mice and led to a reduction in the dopamine concentration [32].

However, exposure to cell phone EMF caused histamine, dopamine, adrenaline, and noradrenaline to increase and led to significant decreases in the serotonin and melatonin content of newborn rats' brains [33]. In contradiction to these investigations, Radon *et al.* concluded that 900-MHz EMF had no significant effect on melatonin levels in students [34]. In another experiment, exposure to the 1800-MHz EMF (30 min/day) had no change in the level of melatonin in rat serum [35]. Similarly, the exposure of hamsters to 383, 900, and 1800-MHz EMF (24 h/day) did not result in alternations of the melatonin secretion [36]. The variation of melatonin is associated with various physiological disturbances such as sleep disorders, depression, stress, and cancer. Melatonin accumulates in the brain system at high levels compared to those in the bloodstream [37]. Hence, the pineal gland, melatonin secretion, and circadian system may be affected by EMF at the cell phone-call time.

Our results indicate that a 74% decrease in the chance of having poor-quality sleep was detected among employees who use hands-free for calling time. Although it is known that cell phones should usually be kept away from the brain, it should be borne in mind that this is only an observed relationship and never means that it is certainly causal. With innovative technology in human life, it is impossible to stay away from the EMF. Therefore, particular care must be taken when using a cell phone. In fact, the possible harmful effects of EMF may be reduced by increasing the cell phone distance from the brain, and an alternative way to reduce the negative effects of EMF is the usage of hands-free in call time. Our knowledge about the effects of EMF effects on the human brain is ambient, and there is not enough evidence about the biological mechanism of EMF. Moreover, it is necessary to conduct further research into the effects of EMFs on sleep quality.

Regarding the main objective of the research, the present study was performed on only hospital staff as a relatively homogeneous group. One of the effects of homogeneity is the diminution of some expected associations. For example, shift work was not significant in either the univariate or the multivariate model in our study. This finding can be attributed -to some extent and not completely- to the effect of homogeneity in nominally shift workers and others in terms of sleep quality among hospital staff.

Indeed, a small group (about 5.9%) of the study participants used hands-free, but their quality of sleep was very different from the others so that the observed association was significant even in the multivariate model in terms of adjusted odds ratio (OR=0.26, P=0.016). However, the effect of the low sample size on that group caused a low precision of the estimate, which can be seen in the relatively wide estimated confidence interval (95% CI: 0.08, 0.78).

Poor sleep is associated with many factors and underlying conditions and their interactive effects can complicate the interpretation of the direction and magnitude of the observed associations; it can also be influenced by many unmeasurable environmental factors. Although we tried to consider some probable and measurable influential factors in the design and analysis as much as possible, we can never claim to have considered all of them. Even in the best linear models, there is a possibility that the truth will not be revealed. Therefore, we should be cautious in interpreting the results.

5. Conclusion

The results of this study demonstrated that the sleep quality of hospital staff might be affected by cell phone use. In our study, using hands-free during phone calls was associated with poor quality sleep. Different factors, such as decreased levels of EMF reaching the brain, can be involved in this effect. The use of hands-free for calling time may decrease the chance of having poor quality sleep probably partly through declining the effects of EMF on the brain, while the participants who use hands-free are possibly those who care about their health and, hence, they possibly have a better diet or better lifestyle. Due to the limitations of our study, this finding must be interpreted with caution. Further research can be suggested in this regard.

Acknowledgments

Ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

This work was supported by Semnan University of Medical Sciences (1082). We would like to thank the Kosar and Amir al-Momenin hospital staff (Semnan University of Medical Sciences, Iran) for their cooperation and for making available facilities for this work.

References

1- Akbari V, Hajian A, Mirhashemi MS. "Evaluating of Sleep Quality in Shift-Work Nurses; Iran." *J Sleep Disoreders Ther*; 5:1-4, (2016). DOI: 10.4172/2167-0277.1000225.

2- Shao MF, Chou YC, Yeh MY, Tzeng WC. "Sleep quality and quality of life in female shift-working nurses." *J AdvNurs*; 66: 1565-72, (2010).

3- Park E, Lee HY, Park CS. "Association between sleep quality and nurse productivity among Korean clinical nurses." *J NursManag*, 26(8): 1051-1058, (2018).

4- Weinberger Z, and Richter ED. "Cellular telephones and effects on the brain: The head as an antenna and brain tissue as a radio receiver.", *Med Hypotheses*; 59(6):703-705, (2002).

5- Aggarwal KK. "Twenty-six Percent Doctors Suffer from Severe Mobile Phone-induced Anxiety: Excessive use of Mobile Phone can be Injurious to your Health.", *Indian Journal of Clinical Practice*, 24(1); 7-9, (2013).

6- Hocking B, and Westerman R. "Neurological abnormalities associated with CDMA exposure." *Occup Med*, 5: 410-13, (2001).

7- Sandstrom M, Wilen J, Oftedal G, Hansson Mild K. "Mobile phone use and subject symptoms.Comparision of symptoms experienced by users of analogue and digital mobile phones.", *Occup Med*; 51: 25-35, (2001).

8- Oftedal G, Wilen J, Sandstrom M, Mild KH. "Symptoms experienced in connection with mobile phone use." *Occup Med*; 50: 237-45, (2000).

9- Yioultsis TV, Kosmanias TI, Kosmidou EP, Zygiridis TT, Kantartzis NV, Xenos TD, Tsiboukis TD. "A comparative study of the biological effects of various mobile phone and wireless LAN antennas." *IEEE Transaction on Magnetic*; 38: 777-80, (2002).

10- Borbely AA, Huber R, Graf T, Fuchs B, Gallmann E, Achermann P. "Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram." *Neurosci let*; 275: 207-10, (1999).

11- Jech R, Sonka K, Ruzicka E, Nebuzelsky A, Jukilickova M, Nevsimalova S. "Electromagnetic field of mobile phones affects visual event related potential in patients with narcolepsy.", *Bioelectromagnetics*; 22: 519-28, (2001).

12- Thomée S, Härenstam A, Hagberg M. "Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults-a prospective cohort study.", *BMCpublic health*; 11: 66, (2011).

13- Mann K, and Roschke J. "Effects of pulsed high-frequency electromagnetic fields on human sleep.", *Neuropsychology*; 33: 41-7, (1996).

14- Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. "The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research.", *Psychiatry Res*;28(2):193-213, (1989).

15- Heidari AR, Ehteshamzadeh P, Marashi M. "The Relationship between insomnia intensity, sleep quality, sleepness and mental health disorder with educational performance in female adolescences of Ahwaz city." *WOMAN AND CULTURE*;1(4):65-76, (2010).

16- Chien PL, Su HF, Hsieh PC, Siao RY, Ling PY, Jou HJ. "Sleep Quality among Female Hospital Staff Nurses." *Sleep Disorders*; (2013). ID: 283490, 1-7. doi.org/10.1155/2013/283490.

17- Liu H, Chen G, Pan Y, Chen Z, Jin W, Sun C, Chen C, Dong X, Chen K, Xu Z. "Occupational electromagnetic field exposures associated with sleep quality: a cross-sectional study." *PloS one*; 9: e110825, (2014).

18- Ma Y, Wei F, Nie G, Zhang L, Qin J, Peng S, Xiong F, Zhang Z, Yang X, Peng X, Wang M, Zou Y. "Relationship between shift work schedule and self-reported sleep quality in Chinese employees." *Chronobiol Int*; 35(2): 9-16, (2018).

19- McDowall K, Murphy E, Anderson K. "The impact of shift work on sleep quality among nurses." *Occup med (Lond)*; 67(8): 621-25, (2017).

20- Wagner P, Röschke J, Mann K, Hiller W, Frank C. "Human sleep under the influence of pulsed radiofrequency electromagnetic fields: a polysomnographic study using standardized conditions." *Bioelectromagnetics*;19: 199-202, (1998).

21- Sahin S, Ozdemir K, Unsal A, Temiz N. "Evaluation of mobile phone addiction level and sleep quality in university students." *Pak J Med Sci*;29(4): 913-918, (2013).

22- Liu R, Zee PC, Chervin RD, Arguelles LM, Birne J, Zhang S, Christoffel KK, Brickman WJ, Zimmerman D, Wang B. "Short sleep duration is associated with insulin resistance independent of adiposity in Chinese adult twins." *Sleep medicine*; 12: 914-9, (2011).

23- Lee JE, Jang S-I, ju YJ, Kim W, Lee HJ, Park E-C. "Relationship between Mobile Phone Addiction and the Incidence of Poor and Short Sleep among Korean Adolescents: a Longitudinal Study of the Korean Children & Youth Panel Survey." *J Korean Med Sci*; 32: 1166-1172, (2017). https://doi.org/10.3346/jkms.2017.32.7.1166

24- Abelin T, Altpeter E, Roosli M. "Sleep disturbances in the vicinity of the short-wave broadcast transmitter Schwarzenburg." *Somnologie*; 9 (4): 203-9, (2005).

25- He J-w, Tu Z-h, Xiao L, Su T, Tang Y-x. "Effect of restricting bedtime mobile phone use on sleep, arousal, mood, and working memory: A randomized pilot trial." *PLoS One*;15(2): 1-13, (2002).

26- Forouharmajd F, Ebrahimi H, Pourabdian S. "Mobile phone distance from head and temperature changes of radio frequency waves on brain tissue." *Int J Prev Med*; 9(61): 1-5, (2018).

27- AboulEzz HS, Khadrawy YA, Ahmed NA, Radwan NM, El Bakry MM. "The effect of pulsed electromagnetic radiation from mobile phone on the levels of monoamine neurotransmitters in four different areas of rat brain." *Eur Rev Med Pharmacol Sci*;17:1782-8, (2013).

28- Lewczuk B, Redlarski G, Zak A, ZióBkowska N, Przybylska-Gornowicz B, Krawczuk M. "Influence of Electric, Magnetic, and Electromagnetic Fields on the Circadian System: Current Stage of Knowledge." *Biomed Res Int*; 169459: 1-14, (2014). http://dx.doi.org/10.1155/2014/169459.

29- Burch JB, Reif JS, Noonan CW, Ichinose T, Bachand AM, Koleber TL, Yost MG. "Melatonin metabolite excretion among cellular telephone users." *Int J Radiat Biol*;78(11):1029-1036, (2002).

30- Kesari KK, Kumar S, Behari J. "900-MHz microwave radiation promotes oxidation in rat brain." *ElectromagnBiol Med*;30(4): 219-234, (2011).

31- Qin F, Zhang J, Cao Hm Yi C, Li JX, Nie J, Chen LL, Wang J, Tong J. Effects of 1800-MHz radiofrequency fields on circadian rhythm of plasma melatonin and testosterone in male rats. *J Toxicol Environ Health A*;75(18): 1120-128, (2012).

32- Kim JH, Lee C-H, Kim H-G, Kim HR. "Decreased dopamine in striatum and difficult locomotor recovery from MPTP insult after exposure to radiofrequency electromagnetic fields." *Scientific Reports*;9(1201):1-13, (2019). https://doi.org/10.1038/s41598-018-37874-z.

33- Ismail SA, Ali RFM, Hassan HMM, Abd El-Rahman D. "Effect of Exposure to Electromagnetic Fields (EMFs) on Monoamine Neurotransmitters of Newborn Rats. *Biochem Physiol*; 4:1-17, (2015). doi: 10.4172/2168-9652.1000156.

34- Radon K, Parera D, Rose DM, Jung D, Vollrath L. "No effects of pulsed radio frequency electromagnetic fields on melatonin, cortisol, and selected markers of the immune system in man." *Bioelectromagnetics*;22(4):280-7, (2001).

35- Koyu A., Ozguner F, Cesur G, Gokalp O, Mollaoglu H, Caliskan S, Delibas N. "No effects of 900MHz and 1800MHz electromagnetic field emitted from cellular phone on nocturnal serum melatonin levels in rats." *ToxicolInd Health*; 21(1-2): 27-31, (2005).

36- Lerchl A., Kruger H, Niehaus M, Streckert JR, Bitz AK, Hansen V. "Effects of mobile phone electromagnetic fields at nonthermal SAR values on melatonin and body weight of Djungarian hamsters (Phodopussungorus)." *J Pineal Res*; 44(3): 267-272, (2008).

37- Warille AA, Altun G, Elamin AA, Kaplan AA, Mohamed H, Yurt KK, El Elhaj A. "Skeptical approaches concerning the effect of exposure to electromagnetic fields on brain hormones and enzyme activities." *J Micros Ultrastruct*; 5: 177-184, (2017).