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Toxic Systemic Hazards of Radiofrequency Radiation Emitted By Smartphone: A National Survey in Great Cairo Governorate

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Abstract

Background: The widespread global use of smartphones attracts the attention of both the public and media interests on their safety especially being used mostly by children and youth for many hours per day with proximity to body organs. The current study was designed to assess the potential health hazards of whole-body exposures to smartphones and to study the factors predispose to the occurrence of these negative impacts in order to suggest solutions to reduce them. A total of 770 Egyptian volunteers participated in the survey. Participants should have used their smartphone for 4 years at least. 54.5% of the participants were females and 45.5% were males. The age range of volunteers was 15-64 years with a mean of 21.2±7.11.

Results: Volunteers in the present study suffered from multiple complaints simultaneously. 51.9% of them suffered from a headache. Eye fatigue or strain was encountered in 57.5% of volunteers. Ear pain was the commonest ear complaint (19.9%). Depression occurred in 45.3% of participants, 44.3% had body weight changes. Sleep disturbance, social problems, and musculoskeletal disorders also were reported. Statistically significant associations were detected between the appearance of certain complaints upon smartphone use and the gender of the user or the daily time of use, while no association was found regarding the age of users.

Conclusion: the overuse of smartphones is hazardous for users as a strong association between daily use time and certain health problems was found especially in females

Keywords: Smartphone; Non-ionizing radiation; Radiofrequency radiation; Electromagnetic radiation; Health problems

Abbrevations: RF-EMR: Radiofrequency Electromagnetic Radiation; SAR: Specific Absorption Rate; ADHS: Attention Deficit Hyperactive Syndrome; BBB: Blood Brain Barrier; EEG: Electro Encephalo Gram; REM: Rapid Eye Movement

Background

The radiofrequency electromagnetic radiation (RF-EMR) ranged from 3kHz to 300GHz was emitted from many household sources as microwave ovens, televisions (especially plasma screens), refrigerators, washing machines, vacuum cleaners, cordless phone, cardiac pacemakers, Wi-Fi access points, routers, and mobile phones or Bluetooth devices [1].

The non-ionizing type of electromagnetic radiation doesn't cause ionization of molecules, but it produces cell damage either by electrical, chemical or thermodynamic mechanism. For mobile phones, the specific absorption rate (SAR) limits are adjusted to avoid this thermal effect resulting from increasing body temperature as phones are held or used close to human body mostly the head [2].

Smartphones are not merely mobile phones but also powerful portable computers providing real-time information, digital cameras, e- mail services, internet browsing, and game playing with social media facilities [3].

The smartphone manufacture is a fast growing industry with global marketing. The increase in their access and affordability resulting in an increase in number of people contacted and exposed to RF-EMR emitted from them especially young people [1].

For 2017, the estimated number of smartphone users in Egypt is 23.6 million and reached almost 28 million by 2019. The number of smartphone users worldwide raised to around 2.71 billion by 2019. The rising incidence of chronic illnesses with

unspecific symptoms, work disability, absenteeism is posing an open research question about the global pandemic health threats. Moreover, prescription of antidepressant in young adolescence and psychotropic drugs for attention deficit hyperactive syndrome (ADHS) treatment in children are on the rise. All these deserve attention by all members of health care community to put new exposures as to RF-EMF into consideration as a causal or even a contributing factor [4].

The current study was designed to evaluate, investigate the potential health effects of whole-body exposures to smartphones that could result from their excess use and to study the factors predispose to occurrence of these negative impacts in order to suggest solutions or recommend precautions to reduce them.

Subjects & Methods

Participants

This study was conducted in Egypt during the year 2018 on smartphone users of different ages. A total of 770 volunteers participated in the survey. Inclusion criteria: participants should have used their smartphone for 4 years at least. Consents were obtained from all participants and the study protocol was approved by the ethical committee of Alexandria Faculty of Medicine.

Questionnaire

Research instrument was a self-administered questionnaire. A set of questions used for fulfillment of research purpose. Survey targeted smartphone users to obtain demographic data about smartphone user's gender and age, then manner of their usage (the commonly used functions, the activities done while using smartphones and the daily time use). In addition to obtaining information about different health hazards that follow the use of these types of phones to know the extent of the impact of smartphones on human health. Questionnaire was translated to Arabic version and both were used (**Appendix 1**).

Statistical Analysis

Analysis of data analysis was performed using SPSS 20 version. Chi-square test was used to measure the p-value. The p-value <0.05 was considered as statistically significant.

Reliability: Reliability is used to mean the extent to which the research tool provides consistent outcomes if the questions is repeatedly performed. To assess reliability approaches used are test-retest, internal consistency methods, and alternative forms.

Test-Retest Reliability: Was a measure of reliability obtained by administering the same test twice over a period to a group of individuals. The scores from Time 1 and Time 2 can then be correlated in order to evaluate the test for stability over time.

Pilot study: The pilot study was carried out on ten percent of the total sample to test the clarity and applicability of the study tool as well as the estimation of the time needed to fill the questionnaire. No modifications were done. Subjects involved in the pilot were included in the main study.

Cronbach's alpha: In the present study the Cronbach's Alpha for the questionnaire was 0.87. Most professionals use a Cronbach's alpha value of 0.6 or higher as a requirement for combining several items into a new reliable variable. For this study, we also set the alpha at 0.6 as a minimum for creating new variables that represent a construct.

Results

This study was conducted in Egypt on smartphone users for different genders and ages. A total of 770 volunteers participated in the survey. 54.5% of the participants were females (n=420) and the remaining 45.5% were males (n=350). The age range of volunteers was 15-64 years with a mean of 21.2±7.11. There was no statistically significant difference between males and females regarding the age (Table 1). The age group ranged from 15 to 24 years accounted for nearly 90% of all participants (89.7%).

Table 1: Distribution of the studied volunteers according to demographic data (age and gender).

	Frequency	%
1) Age		
15-24	691	89.7
25-34	42	5.5
35-44	16	2.1
45-54	14	1.8
55-64	7	0.9
2) Gender		
Male	350	45.5
Female	420	54.5

Figure 1 showed the commonly used function of smartphone according to the daily duration of use in this survey, it was found that camera using accounted for 85.1% of the short period usage (less than 1 hour duration) followed by gaming (76.9%) and then calling (67.7%), while social media had the highest percentage (53.9%) among all smartphone functions in cases of prolonged period of daily usage (more than three hours duration) followed by browsing net (40.4%).

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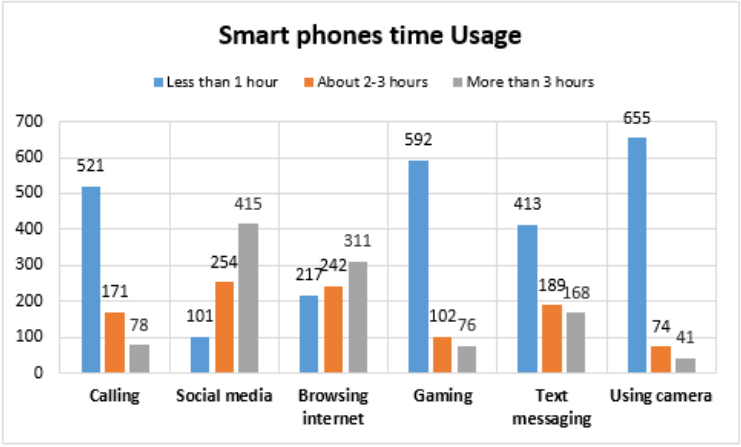

Figure 1: Bar chart showing the distribution of different functions of smartphones according to the daily usage duration by the studied participants.

Most participants (96.8%; n=746) indulged in at least one activity during using smartphones. Watching T.V. represented the most commonly performed activity while using smartphones and accounted for 85.2% of all performed activities. 77.8% of subjects used their phones during walking. More than 50% of participants used their smartphone while eating or drinking. However, 21.6% using a smartphone while driving and 13.8% of all participants faced RTA while using their phones (Figure 2).

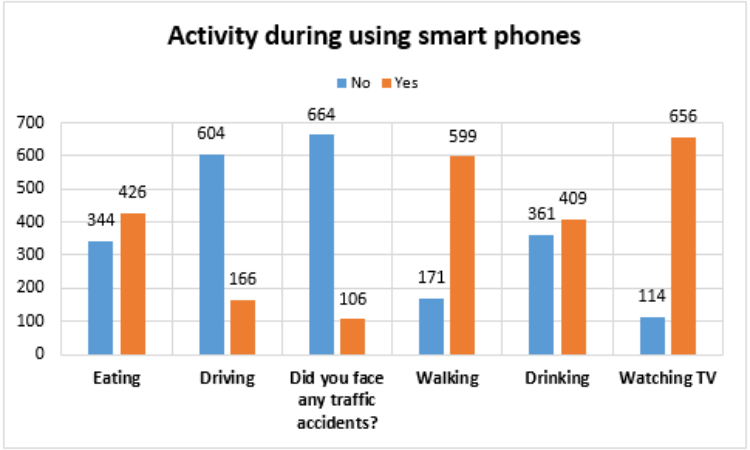

Figure 2: Bar chart showing different types of activities performed while using smartphones by the studied participants.

Table 2 showed that volunteers in the present study suffered from multiple complaints simultaneously. More than half of them (51.9%) suffered from a headache (Figure 3). Eye fatigue, strain, pain or discomfort was encountered in 57.5% of volunteers. In addition, 36.9% of participants had blurred or double vision, while eye itching or burning occurred in 33.4% of them (Figure 4). Ear pain was the commonest ear complaint (19.9%) followed by hearing impairment (19.1%), while tinnitus and ear itching were present in 14.2%, 15.1% of participants respectively (Figure 5).

Table 2: The effect of smartphones on health.

Smart Phones Problems	No		Yes	
	Frequency	%	Frequency	%
1) Headache	370	48.1	400	51.9
2) Vision Problems				
Eye fatigue/ strain/ pain/ discomfort	327	42.5	443	57.5
Blurred/doubled vision	486	63.1	284	36.9

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Eye burn/ itching	513	66.6	257	33.4
3) Ear Problems				
Tinnitus	661	85.8	109	14.2
Hearing impairment	623	80.9	147	19.1
Ear itching	654	84.9	116	15.1
Ear pain	617	80.1	153	19.9
4) Musculo-skeletal Problems				
Tech Neck	324	42.1	446	57.9
Thumb pain	574	74.5	196	25.5
Pain in other fingers	605	78.6	165	21.4
5) Sleep Disturbance				
Insomnia	502	65.2	268	34.8
Decrease sleep quality	443	57.5	327	42.5
Increase time takes to fall asleep	382	49.6	388	50.4
6) Psychological Troubles				
Anxiety	545	70.8	225	29.2
Depression problems	421	54.7	349	45.3
Obsession	563	73.1	207	26.9
7) Social Impact				
Relationships problems	504	65.5	266	34.5
Family problems	488	63.4	282	36.6
8) Weight Changes				
Increase	543	70.5	227	29.5
Decrease	656	85.2	114	14.8

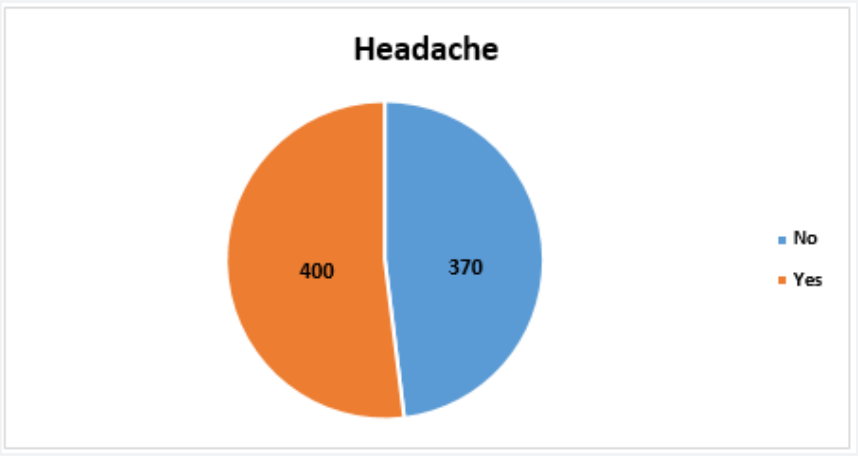

Figure 3: Showing headache frequency among smartphones using participants.

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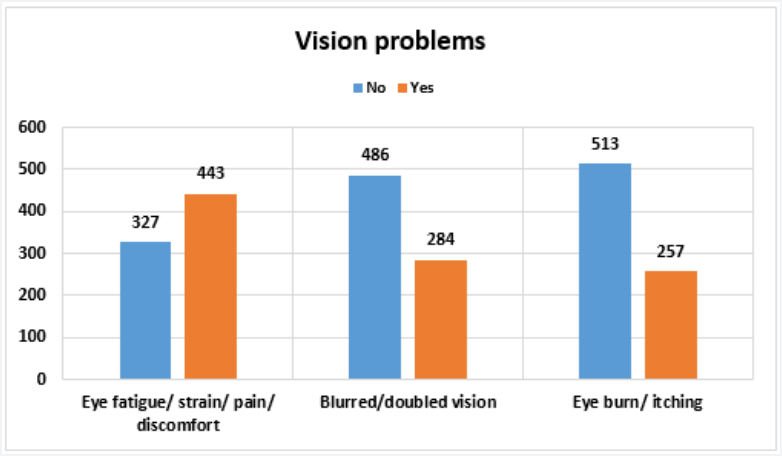

Figure 4: Bar chart showing the distribution of different vision problems among smartphones using participants.

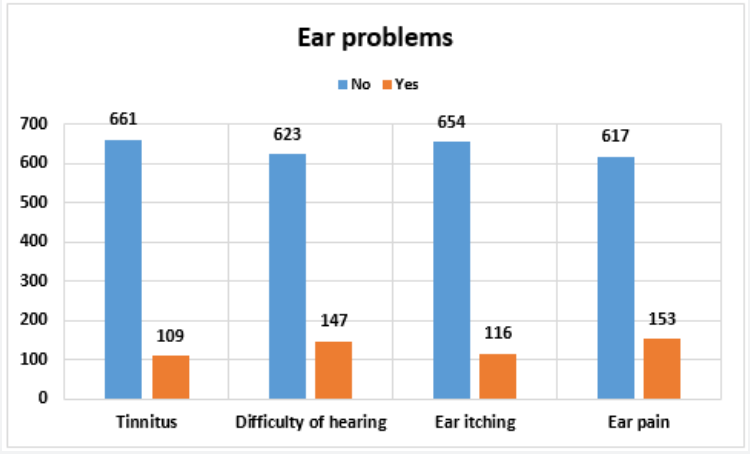

Figure 5: Bar chart showing the distribution of different ear problems among smartphones using participants.

Regarding sleep disturbance, the increase in the time taken to fall asleep occurred in nearly half of volunteers (50.4%) and decreased sleep quality present in 42.5%, while 34.8% suffered from insomnia (Figure 6).

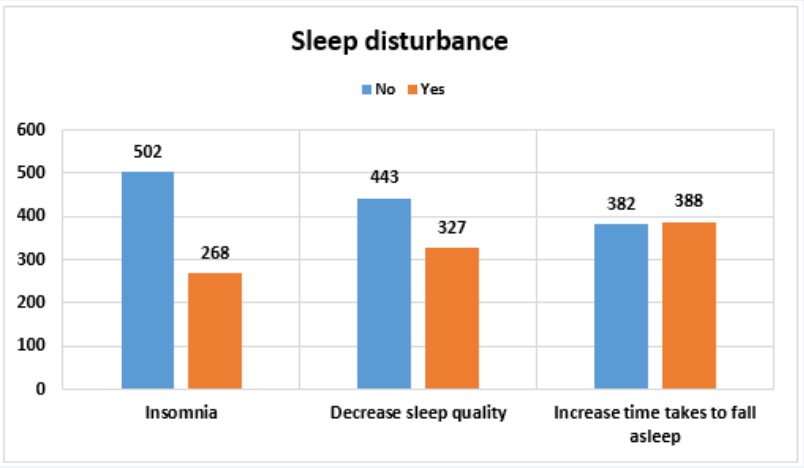

Figure 6: Bar chart showing the distribution of different sleep problems among smartphones using participants.

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The most common psychological trouble represented in the current study was the depression problem which was encountered in 45.3% of participants, followed by the anxiety problem in 29.2% and lastly the obsession neurosis were present in 26.9% of contributing volunteers with consequent social impact in the form of relationships or family problems in 34.5% and 36.6% of volunteers respectively. Moreover, 44.3% had a change in their body weight either increase (29.5%) or decrease (14.8%).

The musculoskeletal system was also involved in the symptomatology associated with chronic smartphone use, in the form of tech neck in 57.9% of volunteers and fingers pain either thumb pain which was represented in 25.5% of participants or another fingers pain in 21.4 %.

The current study revealed that there was a highly statistically significant difference between males and females regarding the occurrence of headache, eye fatigue or strain, depression and tech neck, P-value was 0.000. A statistically significant difference was also found between both genders regarding fingers pain where P-value was 0.034. Furthermore, there was a borderline statistically significant difference between both genders as regard to insomnia where P-value was 0.051, where females had a higher incidence for all these symptoms (Table 3).

Table 3: The effect of smartphones on health according to gender.

Smartphones Problems According to Gender	No		Yes		Chi-square Test	
	Male	Female	Male	Female	Value	P-value
1) Headache	211	159	139	261	38.472	0.000*
2) Vision Problems						
Eye fatigue/ strain/ pain/ discomfort	175	152	175	268	14.901	0.000*
Blurred/doubled vision	233	253	117	167	3.289	0.07
Eye burn/ itching	244	269	106	151	2.757	0.097
3) Ear Problems						
Tinnitus	308	353	42	67	2.454	0.117
Difficulty of hearing	290	333	60	87	1.576	0.209
Ear itching	298	356	52	64	0.022	0.883
Ear pain	288	329	62	91	1.873	0.171
4) Musculo-Skeletal Problems						
Tech Neck	175	149	175	271	16.523	0.000*
Thumb pain	267	307	83	113	1.024	0.312
Pain in other fingers	287	318	63	102	4.48	0.034*
5) Sleep Disturbance						
Insomnia	241	261	109	159	3.793	0.051
Decrease sleep quality	208	235	142	185	0.944	0.331
Increase time takes to fall asleep	168	214	182	206	0.666	0.415
6) Psychological Troubles						
Anxiety	252	293	98	127	0.36	0.548
Depression problems	218	203	132	217	14.997	0.000*
Obsession	262	301	88	119	0.989	0.32
7) Social Impact						
Relationships problems	224	280	126	140	0.6	0.438
Family problems	230	258	120	162	1.511	0.219
8) Weight Changes						
Increase	248	295	102	125	0.035	0.851
Decrease	297	359	53	61	0.058	0.81

P-value < 0.05 is significant * (means that there is a relationship between gender and the effect).

It was noted from the present work that young volunteers had a higher prevalence of symptoms than others, however there was no statistical significant association between the appearance of symptomatology upon smartphone use and the age of user and the only two symptoms having a borderline statistical significant association with age was eye fatigue or strain and tinnitus where P-value was 0.050 and 0.053 respectively (Table 4).

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Table 4: The effect of smartphones on health according to age.

Smartphones Problems According to Age	No					Yes					Chi-square Test	
	15-24	25-34	35-44	45-54	55-64	15-24	25-34	35-44	45-54	55-64	Value	P-value
1) Headache	323	23	11	9	4	368	19	5	5	3	5.687	0.224
2) Vision Problems												
Eye fatigue/ strain/ pain/ discomfort	296	12	10	4	5	395	30	6	10	2	9.495	0.05
Blurred/doubled vision	441	23	10	7	5	250	19	6	7	2	2.651	0.618
Eye burn/ itching	462	26	9	10	6	229	16	7	4	1	2.505	0.644
3) Ear Problems												
Tinnitus	601	31	14	10	5	90	11	2	4	2	9.361	0.053
Difficulty of hearing	566	32	11	9	5	125	10	5	5	2	5.497	0.24
Ear itching	594	32	12	10	6	97	10	4	4	1	6.314	0.177
Ear pain	553	33	15	11	5	138	9	1	3	2	2.287	0.683
4) Musculo-skeletal Problems												
Tech Neck	282	20	10	7	5	409	22	6	7	2	6.557	0.161
Thumb pain	511	31	13	12	7	180	11	3	2	0	3.83	0.429
Pain in other fingers	536	38	13	11	7	155	4	3	3	0	5.925	0.205
5) Sleep Disturbance												
Insomnia	460	22	8	8	4	231	20	8	6	3	5.843	0.211
Decrease sleep quality	400	19	10	9	5	291	23	6	5	2	3.61	0.461
Increase time takes to fall asleep	344	18	8	8	4	347	24	8	6	3	1.252	0.869
6) Psychological Troubles												
Anxiety	492	24	14	10	5	199	18	2	4	2	6.003	0.199
Depression problems	370	26	10	11	4	321	16	6	3	3	4.88	0.3
Obsession	506	25	15	11	6	185	17	1	3	1	8.195	0.085
7) Social Impact												
Relationships problems	459	22	12	7	4	232	20	4	7	3	5.8	0.215
Family problems	440	26	9	8	5	251	16	7	6	2	0.846	0.932
8) Weight Changes												
Increase	489	30	11	8	5	202	12	5	6	2	1.269	0.867
Decrease	581	40	15	13	7	110	2	1	1	0	6.835	0.145

P-value > 0.05 means that there is no relationship between age and the effect.

There were many statistical significant associations between the appearance of health problems and the average time of smartphone use as eye burning or itching (P-value = 0.019), increased time takes to fall asleep (P-value = 0.036), depression problems (P-value = 0.004), obsession (P-value = 0.001), and increase in the body weight (P-value = 0.020) (Table 5).

Table 5: The effect of smartphones on health according to average time usage.

Smartphones Problems According to Gender	Less than 1 hour		About 2-3 hours		More than 3 hours		Chi-square Test	
	No	Yes	No	Yes	No	Yes	Value	p-value
1) Headache	18	12	105	96	247	292	4.197	0.123
2) Vision Problems								
Eye fatigue/ strain/ pain/ discomfort	15	15	97	104	215	324	9.423	0.085
Blurred/doubled vision	22	8	135	66	329	210	3.759	0.153
Eye burn/ itching	25	5	144	57	344	195	7.946	0.019*
3) Ear Problems								
Tinnitus	26	4	173	28	462	77	0.033	0.984

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Difficulty of hearing	27	3	169	32	427	112	3.908	0.142
Ear itching	26	4	174	27	454	85	0.698	0.705
Ear pain	27	3	168	33	422	117	4.482	0.106
4) Musculo-Skeletal Problems								
Tech Neck	16	14	91	110	217	322	3.133	0.209
Thumb pain	27	3	150	51	397	142	4.003	0.135
Pain in other fingers	25	5	156	45	424	115	0.517	0.772
5) Sleep Disturbance								
Insomnia	20	10	141	60	341	198	3.087	0.214
Decrease sleep quality	19	11	127	74	297	242	4.344	0.114
Increase time takes to fall asleep	17	13	114	87	251	288	6.654	0.036*
6) Psychological Troubles								
Anxiety	22	8	148	53	375	164	1.264	0.531
Depression problems	21	9	126	75	274	265	11.257	0.004*
Obsession	22	8	167	34	374	165	13.974	0.001*
7) Social Impact								
Relationships problems	24	6	137	64	343	196	4.245	0.12
Family problems	23	7	132	69	333	206	3.33	0.189
8) Weight Changes								
Increase	24	6	155	46	364	175	7.815	0.020*
Decrease	28	2	173	28	455	84	1.957	0.376

P-value < 0.05 is significant* (means that there is a relationship between average time usage and the effect).

Discussion

On making a call, a sound energy is converted to RF-EMR waves which in turn pass across the atmosphere to the nearest base station then re-travel from the station to receiver's wireless phone which converts the waves into sound energy or voice again [1]. These waves have two components electrical and magnetic charged waves which spread into the surrounding atmosphere. Human body as being made of charged particles so can act as an electro-conductive material resulting in the flow of current though the human body especially through membranes of excitable tissues (nerve and muscle cells). Similarly, magnetic field provokes currents circulating through human body [5].

In the current work, the most frequent age group (89.7%) was that ranged from 15 to 24 years. This agrees with many previous studies which stated that teenagers and people in the early and mid-20s are the major users of smart-phones as they are more susceptible to accept new and higher level of technologies than older generation groups and prefer to read e-books in their education [6,7]. However, children are more vulnerable to RF absorption due to thinner skull, higher conductivity of their brain tissue and their developing nervous system with more serious cumulative effects because of a longer life-time use making them at risk of autism, leukemia and head tumors [4,8].

About 77.8% and 21.6% of subjects used their phones during walking and driving respectively and this reflects a low level of awareness among the participants hence 13.8% of all subjects faced traffic crash (RTA) while using their phones due to distracted walking or driving. The problem aggravates if a head set is worn as it blocks the surrounding sounds of any alarm or notification. Beck et al. [9] stated that using mobile phones during walking or driving raises the risk of RTA like drunken driving, as both hinder the cognitive skills. On contrary, the study of Qasim et al. [10] in Jordan nearly all participants don't use their smartphones while driving.

The higher incidence of symptoms in females than males is in agreement with the study of Kucer et al. [11] and this may be due to frequent use of their smartphones for longer duration daily, moreover females like to use phone so close to their heads for more privacy, moreover some studies have reported that females were highly vulnerable to problematic smartphone use or smartphone addiction than males [12-14].

Volunteers in the present study suffered from multiple complaints simultaneously. Many studies described the mechanisms by which low intensity, non-thermal levels of RF-EMR causing its adverse biological hazards: in particular, their effects on oxidant and antioxidant balance which may explain the

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multisystem affection resulted from EMR exposure [15]. Or their effect on neurotransmitter balance by increasing the calcium ions efflux from the brain altering the neurotransmitter release [16]. Furthermore, EMR alter the cerebral blood flow and the permeability of blood-brain barrier in addition to development of nerve cell damage and genomic alterations [17]. Some individuals have an electromagnetic hypersensitivity (EMH) i.e. develop symptoms even at levels below the safe limits of exposure [18]. This explain the different levels of susceptibility to EMR among exposed individuals [4].

World Health Organization (WHO) revealed many physical symptoms attributed to EMF [19]. Several studies confirmed these results [20-22]. In 2011, WHO's IARC "classified RF radiation (RFR) as a possible human carcinogen (Group 2B) based on experimental evidence of its genotoxicity and carcinogenicity", evidenced by gliomas, neuromas, brain and heart schwannomas.

In the present study, more than half of them (51.9%) suffered from a headache which is higher than the percentage (20%) recorded in Saudi study of Al-Khlaiwi et al. [23]. There was a statistically significant association with gender where female users experienced headache more than male users and this agreed with Kucer et al. [11] where females suffer tension-anxiety and headache more often than males.

The incidence of headache increased with increase the usage time of smartphone although this association is not a statistically significant. Kapdi et al. [1] reported that the head region is the most affected area by mobile phone radiation and the risk increase in case of predominant one-sided usage, high daily exposure.

Maier [24] stated that both headache and sleep disturbances experience by mobile phone users were attributed to exposure to radiofrequency radiation. Hermann et al. [25] revealed that changes occurred in BBB permeability or in EEG activity resulting from smartphone use were the main causes of headache.

Two Sweden cohort studies proved that sleep disturbance, headache and depression were related to mobile phone use especially if frequent use [26,27]. Similar findings were reported in Saudi Arabia by Al-Khlaiwi et al. [23], in Egypt by Salama et al. [28] and in Poland [29]. However, an England study in 2008 negated any association between physical symptoms and mobile phone use [30]. Even both Stalin et al. [22] and another study done in USA [31] stated that mobile phone is protective against the development of hypertension due to increase in parasympathetic drive with suppression of sympathetic charge.

The vision impairment reported in the present study may be due to non-thermal damage of lens epithelium or cataract caused by the high frequency electromagnetic irradiation emitted from smartphones. This non-thermal effect results from the direct oscillating effect of both electrical and magnetic fields which causes protein unfolding to a much higher degree than conventional heating of protein solutions [32,33]. Excessive exposure to artificial blue light (a visible light of wavelength below 500nm) emitted from smartphones and other digital devices are harmful to the eyes causing macular degeneration. These harmful effects occurred if exposure to blue light is at night because the natural daylight with its red and infrared contents has a regenerative effect balanced out these harmful ones [34,35].

Meo et al. [36] detected also an association between the appearance of vision and hearing complaints and the use of mobile phones. Kapdi et al. [1] reported that workers exposed to high levels of RFR can experience eye irritation and catch cataracts.

A statistically significant association was detected between time of smartphone usage and occurrence of eye burning and itching. Similarly, Qasim et al. [10] reported a strong relation between them.

In the current study, ear pain was the commonest ear complaint (19.9%) followed by hearing impairment (19.1%), while tinnitus and ear itching were present in 14.2%, 15.1% of participants respectively. These findings were in agreement with the study of Nair et al. [37] who stated that people use mobile phones for ≥two hours daily for at least two years had poor scores regarding audiological tests as pure tone audiometry, speech reception threshold and speech discrimination score especially in the dominant mobile phone used ear demonstrating the hazardous effect of mobile phone on the auditory function. Al-Abduljawad [38] and Jadia et al. [39] recorded a significant hearing loss with prolonged use of the mobile phones. Panda et al. [40] stated that excess mobile phone use may damage the cochlear outer hair cells as well as reducing the neural processing in the auditory cortex causing hearing impairment.

The ear is the closest structure to the mobile phone; hence a higher energy deposition occurred in the ears compared to other body structures. Using wireless phones in extended calls exposes the peripheral auditory pathways to a high dose of RF-EMR especially if there is a preferential use in one ear as this might worsen the ipsilateral ear complains [18].

The present study revealed no statistically significant association between gender and occurrence of ear complaints. On contrary, Youssef et al. [41] revealed that Saudi female students were significantly complained of ear diseases in the form of hearing loss, vertigo, and tinnitus more than male students due to affection of auditory nerve up to the risk of occurrence of acoustic neuroma or schwannoma.

It is worth noting in the current study that the occurrence of symptoms decreases with increasing age and this may be attributed to the maturity of old age users and their ability to control themselves. However, presence of borderline statistically significant associations with age regarding the eye fatigue or strain and tinnitus may be indicative of increasing the risk with age if a larger sample size was taken.

There was no statistical association found in the present work between ear complaint and the average time usage while,

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Hutter et al. [42] reported that there was an association between tinnitus occurrence and both excessive daily use of cell phone and prolonged use periods more than 4 years.

Patuzzi et al. [43] reported the occurrence of both headache and ear problems on excess use of cell phone while Qasim et al. [10] detected an alarming combination of different health problems in their studied participants in the form of headaches (65.5%), eye irritation (66.7%) and ear problems (72.5%).

Sleep disturbances reported in the present study were in the form of increased sleep latency period (50.4%), decreased sleep quality (42.5%), and insomnia (34.8%). Depression was the commonest psychological problem encountered (45.3%) followed by anxiety (29.2%) then the obsession neurosis (26.9%). Velizarov et al. [44] stated that electrophysiological changes can occur in nervous system after exposure of the neural tissue to RFR.

Huber et al. [45] and Loughran et al. [46] elicited the adverse effects of EMR emitted by smartphones use at night on sleep EEG and clarified that EMR could alter brain blood flow, cerebral electrical activity and suppress the pineal gland melatonin secretion hence increasing the sleep latency and decreases the sleep depth and duration. This deprivation of optimal sleep causes in turn disturbance in the immune and neuroendocrine systems.

Moreover, the mental tasks or stress get by overuse of smartphones might influence the sleep quality and structure by reducing rapid eye movement (REM) sleep [47]. This deprivation of REM sleep is an important contributor in depression pathogenesis, and this was elicited by Demirci et al. [13] who found that poor sleep quality was related to depression by regression analysis. This was confirmed in the present study by presence of statistically significant associations between the occurrence of either sleep or psychic problems and the average time of smartphone use as increased sleep latency period (P-value = 0.036), depression problems (P-value = 0.004) and obsession (P-value = 0.001). Similarly, Block [48] and Demirci et al. [13] observed that depression, anxiety, and sleep latency scores were higher in the high smartphone users than in the low smartphone users with presence of positive correlations between the smartphone addiction scale scores and depression or anxiety levels, and some sleep quality scores.

Alhassan et al. [49] detected a strong positive correlation between smartphone overuse and depression. Furthermore, a lot of their study subjects constantly checked their phones for fear of missing conversations with others or experienced a neologism or ringxiety phenomenon, where they falsely imagine that their phone is ringing or vibrating while it is not [1].

Extensive use of smartphones results in a feeling of loneliness, introversion, low self-esteem, anxiety and sleep disturbance which finally leads to unhappy mood, loss of interest and pleasure with disturbed appetite. These can be accounted for depression [50].

Depression was more common in females and this may be attributed to effect of sex steroids on the maturating hypothalamic-pituitary-adrenal axis which might increase female sensitivity to stress, whereas androgens appear to play a protective role in males [51].

The current study revealed the occurrence of negative social impact after smartphone use for four years in the form of relationships or family problems Sarwar et al. [52] stated that the widespread use of smartphones would affect the society, changing the social life and culture with progressive inability to work, and social withdrawal.

In the current work, nearly half of volunteers had a change in their body weight with a higher incidence of being overweight (nearly two times the incidence of having weight loss) Kim et al. [53] reported an association between smartphone overuse and changed lifestyle habits in the form of skipping meals, eating fast or unhealthy food, physical inactivity and hence weight gain. Lajunen et al. [54] stated that overuse of information and communication technology might cause an obesity epidemic among users.

There was a statistically significant association between obesity and the average time of smartphone use (P-value = 0.020). As increasing the period of exposure to both EMR and blue light emitted from smartphones especially at night will disrupt the circadian rhythm suppressing melatonin secretion and this enhances weight gain with its co-morbid disorders.

In addition to the hazards of exposure to EMR, there are muscloskeletal disorders resulting from repetitive motions using one finger in grip control or texting. These appeared in the form of thumb pain in 25.5% of participants and pain in other fingers in 21.4% of studied volunteers. This agree with Berolo et al. [55] who revealed that the right thumb bottom was the commonest complain detected among their studied volunteers. Similarly, İnal et al. [56] stated that smartphones over usage cause a weak pinch strength resulted from the thumb pain.

Chany et al. [57] reported that development of hand pain with the excessive phone use was multifactorial as influenced by both the anthropometry of the user and the phone design which control the style of hand grip. Moreover, using one finger in texting was also resulting in a higher incidence of a finger pain and fatigue [58-60].

Tech neck occurred in 57.9% of volunteers can be a result of looking downwards and dropping the head which in turn influences the natural curve of the cervical spines. Repetitive misalignment made stain on the muscles and development of discomfort, pain and fatigue.

Conclusion

According to the current survey, overuse of smartphones is hazardous for users as there was a strong association between daily use time and certain negative impacts on either physical or psychological wellbeing especially in females.

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Recommendations

It is important to spread awareness among people. Every nation should set safety guidelines for protection against RF-EMR as displaying of radiation level in the pamphlet of mobile phone by the manufacturer, discouraging young people from prolonged use of their mobile phones. Base station should be away from inhabited areas, hospitals and schools.

Precautions to minimize hazards, which may help alleviate health problems:

a. Avoid extended calls by wireless phone and if necessary, placing more distance between the body and the mobile phone.

b. Avoid late night smartphone use for better sleep quality and to avoid blue light.

c. Use the speaker or headset and put the wireless phone away from user's body.

d. Deactivate all non-essential apps, which cause periodic radiation exposure.

e. During sleep, keep smartphones in "airplane mode" or deactivate mobile data, Wi-Fi and Bluetooth and disconnect the power supply to Wi-Fi routers.

f. While sleeping, Avoid magnetic sources in the bed room or in adjacent room as magnetic fields can pass through walls.

g. Select the mobile phone with lower specific absorption rate (SAR) values printed on their batteries or searching for it in their websites.

h. Avoid use the mobile if has a weak signal or when moving at high speed (for each bar lost in the signal strength the smartphone will raise its power by 1000% to endure the connection).

i. Regular assessment for early detection of biological hazards and their progression.

j. Limit the exposure to artificial "blue light" in the evening and if necessary, antioxidants supplementation especially melatonin and blue light screen filters may be helpful by Wearing blue blocker glasses at night.

k. Using anti-radiation shielding technology that can block over 99% of RF radiation.

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