Review Article

Investigation of the Adverse Health Effects of Cell Phone Radiation and Propose Solutions to Minimize Them: A Systematic Review

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Abstract

Today, mobile phones are one of the most common devices emitting electromagnetic radiation and are available to more than seven billion people in different age groups around the world. The effects of electromagnetic radiation on biological systems have been studied for several years. In this systematic review to find relevant articles, international databases such as Google Scholar, PubMed, Scopus, Science Direct, Web of Science, and Cochrane were used since 2007–2022 by selecting appropriate keywords. The result revealed that exposure to cell phone radiation can lead to disturb in the metabolic activity of the cerebellum by increasing the migration of granulosa cells, decrease the water around the fetus in pregnant women, decrease in the number of blood plates, increasing levels of ALT and AST that they are the key biomarkers of liver damage, decrease of phagocytosis and induced apoptosis of neutrophils, changes at the level of glucose and even at the microscopic level of pancreas this may be a predisposing factor for diabetes, increment in tissue temperature in all depth of the brain tissue, EMF increase the volume, weight, and atresia follicles of the ovaries of the children, also it can cause oxidative stress, DNA fragmentation, etc. Mobile phone radiation is harmful and depends on its intensity, frequency, wave type, and exposure duration. It can cause different biological effects in humans. Due to the uncertainty of the results and mechanism of the effect of these waves, research in this field is still ongoing.

Keywords: Health, human, mobile phone, radiation

Introduction

Modern technology has introduced an instrument called as cell phones for the benefit of human beings. It is now widely used by people all over the world. The emergence and evolution of mobile phones is one of the fastest in the history of innovation.[1] Currently, the number of cell phone users worldwide is estimated to be almost 7 billion.[2]

Despite the numerous studies that have been published over a decade, it still remains uncertain that their use of cell phones may lead to serious debilitating problems in the miscellaneous body structures while placing the cell phones or during their use.[1] The aim of this review is to investigate the adverse effects of mobile phone radiation on human health.

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Materials and Methods

International databases (Google Scholar, PubMed, Scopus, Science Direct, Web of Science, and Cochrane) were searched since 2007–2022. Our search strategy was: "cell phone" OR "mobile phone" AND radiation OR waves AND adverse [Mesh] AND effect.

Inclusion criteria: all reviews and original studies in this field. Exclusion criteria: impossibility of accessing the full text of articles, repetitive studies, insufficient data, and

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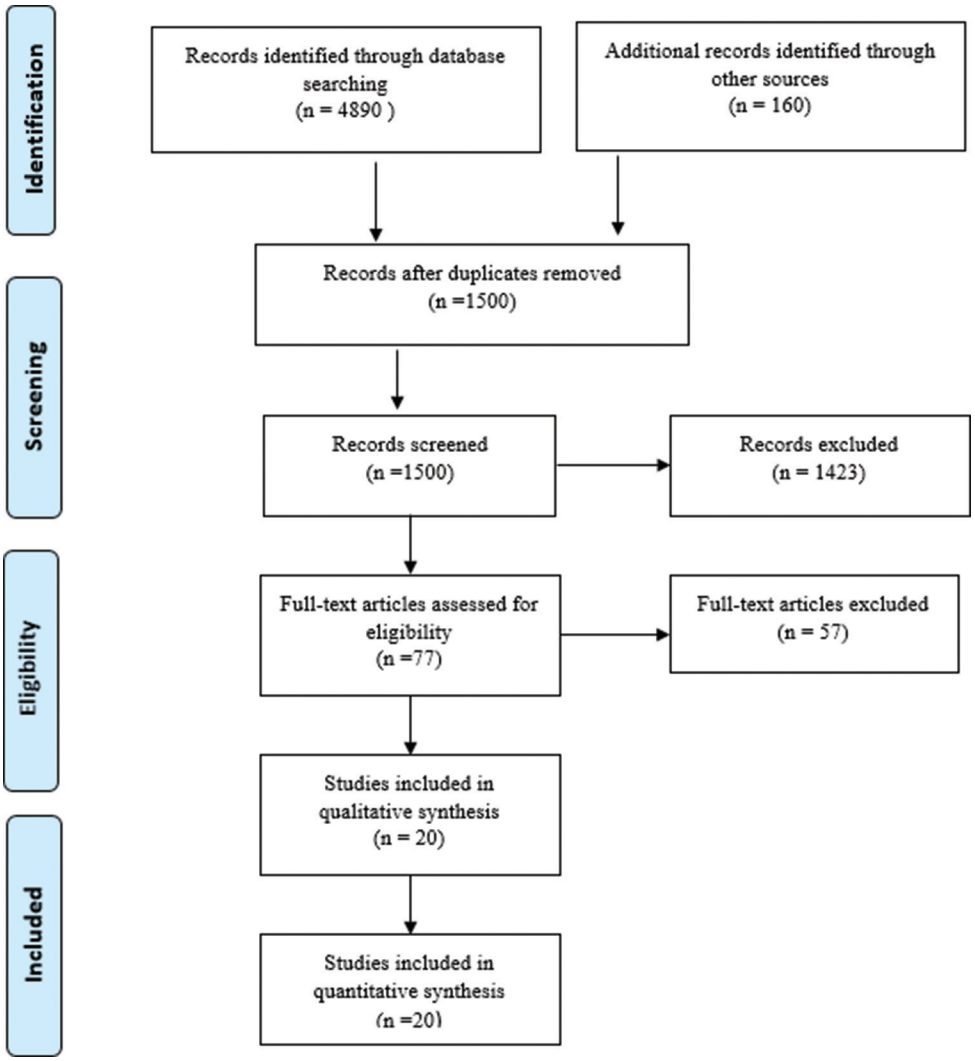


Figure 1: PRISMA diagram

irrelevant studies. The path of our study was done according to Figure 1. This article is taken from a research project at Kermanshah University of Medical Sciences (IR.KUMS.REC.1402.228).

Results

After reviewing the articles, 20 articles were selected, which are summarized in Table 1.

Discussion and Conclusion

The daily increase in the number of cell phone users, especially smartphones, has led scientists to study their short-term and long-term adverse effects on human health. This study has revealed most of the effects of cell phone radiation on human health, and it has carefully examined the short-term and long-term effects of radiation on all the organs and systems of the human body.

Electromagnetic radiation (EMF) is found everywhere. More and more wireless communication devices are expected. It seems that there is no way to change this trend among people. There is no way to completely protect ourselves against dangerous radiation, but by taking the measures mentioned and informing people who do not know about them, we can minimize the effects of these deadly radiations. Some of these measures include.[22,23]

- People should use less of it.
- Cell phones with a minimum SAR have to be used.
- Usage of cell phones by children <10 years old should be limited.
- Avoided it to make calls when it has a low signal and a low battery that is why the cell phone will produce more radiation in an effort to rectify it.
- Keep your cell phone away from your body when you are talking to it.
- While communicating, apply speaker mode or hands-free devices such as earphones or Bluetooth, and use more landline phones.
- People who have medical implants should keep their mobile phones at least 30 cm away from their implants.

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Table 1: Summary of articles

Row	Study	Country	Article title	Exposure detail	Key results
1	Mittal *et al*. (2022)[3]	India	Ocular effects of mobile phone radiation.	A convenience sample of 200 adults visiting our out-patient's services with 20/20. All participants underwent Schirmer's test, Tear film break-up time, central corneal thickness and central macular thickness measurements for comparison on both the sides.	Radiofrequency may adversely influence ocular surface with quicker evaporation of the tear film, suggestive of subtle increments in ocular surface temperature during usage.
2	Singh *et al*. (2020)[4]	India	Effect of mobile phone radiation on oxidative stress, inflammatory response, and contextual fear memory in Wistar rat.	Exposure was performed on young adult male Wistar rats for 16 weeks continuously (2 h/day) with MP-RF-EMF radiation having frequency, power density, and SAR 1966.1 MHz, 4.0 mW/cm^2, and 0.36 W/kg, respectively.	Induce oxidative stress, inflammatory response, and HPA axis deregulation.
3	Hasan and Islam (2020)[5]	Bangladesh	Biochemical and histopathological effects of mobile phone radiation on the liver of Swiss albino mice.	Male mice were categorized into three groups: control group (A), exposed group for 40 minutes (B) and exposed group for 60 minutes (C). They were exposed to radiation per day for 60 days from 4G (Huawei GR5 2017).	The alanine transaminase (ALT) and aspartate transaminase[6] values were increased in exposed groups that those are key biomarkers of liver damage.
4	Yinhui *et al*. (2019)[7]	China	Effect of cell phone radiation on neutrophil of mice.	Sample: 40, 5–6 week-old male. Group A (control group): Free from exposure. Group B (blank group): Exposed to cell phone with no communication card. Group C (TD-SCDMA group): Exposed to cell phone with Time Division synchronous. CDMA communication card, 1800MHz frequency. Group D (LTE-advanced group): Exposed to cell phone with Long Term Evolution-Advanced communication card, 1900MHz frequency.	It could increase of neutrophil numbers yet with no effect whatever on neutrophils chemotaxis, and the radiation was likely to cause decrease of phagocytosis and induced apoptosis of neutrophils.
5	Elsawy *et al*. (2019)[8]	Egypt	Electrophysiological assessment of the impact of mobile phones. Radiation on cognition in persons with epilepsy.	The Global System for mobile communications signal had a carrier frequency of 900 MHz, and the head-specific absorption rate was 0.636 W/kg.	Alpha power decreased and it was associated with increased bilateral alpha frequency. In persons with epilepsy last seizure and with the therapy regimen changed.
6	Hosseini *et al*. (2019)[9]	Iran	Assessment and prediction of parasites and the use of mobile phones in pregnant mothers on the amount of water in the fetus based on the given algorithms.	After collecting data (by questionnaires) and preprocessing them with The mentioned features on the reduction of the amount of water around the fetus, investigation and appropriate associative rules for extracting predictive prior algorithm became.	If pregnant mothers use mobile phones for more than 6 hours a day, the internet for 4 hours, and the Internet with Wi-Fi on for 8 hours, the water around their fetuses will be low.
7	Gupta *et al*. (2018)[1]	India	Effect of mobile phone radiation on the pancreas of rats.	42 Albino rats, Exposure group (mobile phone of GSM model with a frequency bandwidth of 900 MHz, over 2 watts and SAR value of 0.38 W/Kg).	Changes at the level of glucose and even at the microscopic level of the pancreas may be a predisposing factor for diabetes.
8	Forouharmajd *et al*. (2017)[10]	Iran	Changes in the temperature of different depths of brain tissue in the face of radiofrequency waves.	Cow brain tissue was investigated in a chamber at three tissue depths of 2,22,12 mm and at a distance of 4 cm and 4mm from a mobile phone for 15 minutes, the thermal effect of mobile phone radiation during exposure and after stopping exposure.	Cell phone radiation not only caused an increment in tissue temperature in all depths of brain tissue but also in deeper brain tissue (22mm), the temperature caused by mobile phone radiation was higher.
9	Siqueira, *et al*. (2016)[11]	Brazil	Cell phone use is associated with an inflammatory cytokine profile of parotid gland saliva.	Participants (82 healthy Brazilian individuals) used cell phone for <10 years and 41.5% of participants reported more than 200 min of cell phone use per month.	The exposure of parotid glands to cell phones can alter salivary levels, consistent with a pro-inflammatory microenvironment that may be related to heat production.
10	Shah, *et al*. (2015)[12]	India	Cell phone radiation and genomic damage: *in-vitro* exposure and assessment.	Two sets of experiments were carried out one with 20 dBm and another with 30 dBm at 916 MHz with the exposure time of 1–8 hrs at one hour interval.	Increase in chromosomal damage at higher power level and longer exposure times.

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Table 1: Contd...

Row	Study	Country	Article title	Exposure detail	Key results
11	Rostamzadeh, *et al*. (2015)[13]	Iran	The effect of mobile phone waves on the migration of hypergranular cells in the cerebellum of newborn rats.	(Nokia 1200b, Type: RH-100, Finland) In conversation mode, SAR=0.81 W/Kg.	Increase migration of granulosa cells, causing anatomical changes and as a result. They prevent its development and these changes can cause disturbances in metabolic activity of the cerebellum.
12	Mahata, *et al*. (2015)[14]	India	Effect of radiofrequency radiation emitted by a mobile phone on the human cardiovascular system.	-	Slight effect on heart rate and blood pressure, effect on cardiac electrical activity and heart rate, blood pressure.
13	Ahmadi Tameh, *et al*. (2014)[15]	Iran	Long-term exposure to cell phone radiation and stress.	Male Wistar rats were randomly divided into control and groups exposed to cell phone radiation for 1, 3, or 6h/day of 5 rats in each group. After 8 weeks, blood samples were obtained using the cardiac puncture method.	Enhances serum cortisol level which may indicate the existence of stress in animals.
14	Ragy *et al*. (2014)[16]	Egypt	Effect of exposure and withdrawal of 900-MHz-electromagnetic waves on brain, kidney, and liver oxidative stress and some biochemical parameters in male rats.	The mobile phone emits 900-MHz EMR on the brain, liver, and kidney of male albino rats. 30 male adult rats, exposure group (exposed to 900-MHz EMR for 1 h/d for 60 d) and withdrawal group (exposed to 900-MHz electromagnetic wave for 1 h/d for 60 d then left for 30d without exposure).	FM might produce impairments in some biochemical changes and oxidative stress in the brain, liver, and renal tissue.
15	Skamrova *et al*. (2013)[6]	Russia	Influence of mobile phone radiation on membrane permeability and chromatin state of human buccal epithelium cells.	Nokia, Samsung, Sony Ericson, Motorola, LG, Siemens, Sony, etc., were selected. As a source of EMR, two mobile phones were selected corresponding to the edges of this distribution with SAR1=0.531 W/kg and SAR2=1.1 W/kg and a frequency of 900 MHz.	The number of heterochromatin granules increased. An increase in exposure time from 1 to 10 minutes resulted in a further increase in RQI.
16	Simon, *et al*. (2013)[17]	France	Exposure to acute electromagnetic radiation of mobile phone exposure range alters transiently skin homeostasis of a model of pigmented reconstructed epidermis.	Mobile phone exposure (GSM basic, 900 MHz, SAR 2 mW g^{-1}, 6 h) on a model of pigmented skin.	Alter epidermal homeostasis which may alter the protective capacity of skin against external factors.
17	Dasdag *et al*. (2012)[18]	Turkey	Effect of 900 MHz radio frequency radiation on beta amyloid protein, protein carbonyl, and malondialdehyde in the brain.	17 Wistar albino rats were exposed to 900 MHz radiofrequency radiation. For the study group (*n*: 10), rats were exposed to the radiation 2 h per day (7 days a week) for 10 months.	Ten months of exposure (2 h per day) of 900 MHz radiation increased protein carbonyl level in healthy rat brain tissue and long-term exposure of 900 MHz exposure may alter some parameters in living systems.
18	Stander, *et al*. (2011)[19]	South Africa	Effects of non-thermal mobile phone radiation on breast adenocarcinoma cells.	Cells were exposed to 2W/kg non-thermal 900-MHz mobile phone radiation.	Increase PS externalization and formation of F-actin stress fibers in MCF-7 cells.
19	Kwon *et al*. (2011)[20]	Finland	GSM mobile phone radiation suppresses brain glucose metabolism.	30 young right-handed male subjects were exposed to a pulse-modulated 902.4 MHz GSM for 33 minutes.	Local suppressive effect of short-term GSM radiation on brain glucose consumption in anterior and posterior parts of right temporal cortex ipsilateral to the radiation source and the present setup rules out changes in skin temperature, acoustic stimulus emanating from the active phone, and changes in the subjects' alertness as potential confounding factors.
20	Terao, *et al*. (2007)[21]	Japan	Effects of 30-minute mobile phone exposure on saccades.	A double blind, counterbalanced crossover design was employed.	Thirty minutes of mobile phone exposure has no significant short-term effect on saccade performances.

- People with epilepsy should keep their cell phones at least 20 cm away from their chest.

Continuous exposure to electromagnetic field radiation is dangerous and can have harmful effects on the human body. These effects depend on the frequency, distance, and duration of exposure. It is always suggested to avoid unnecessary exposure to EM fields whenever possible. Although new technologies make our life so convenient, we should be careful about the more important aspects of their use, that is, their harmful effects, and spread the guidelines for the use of these devices around the world.[22]

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Conflicts of interest

There are no conflicts of interest.

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