

Mobile Phones

The Mobile Phones set of articles is separated into 9 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 6 Other health effects

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Other health effects

General

As long ago as [1998](#), Hocking reported that 40 mobile phone users from diverse occupations described unpleasant sensations such as a burning feeling or a dull ache mainly occurring in the temporal, occipital or auricular areas. The symptoms often began minutes after beginning a call, but could come on later during the day. The symptoms usually ceased within an hour after the call, but could last until evening. There were several reports suggestive of intra-cranial effects. Three respondents reported local symptoms associated with wearing their mobile phone on their belts.

According to data which has been collected in a rather non-systematic way, phone users in the UK, Australia, Poland, Sweden, the USA, Turkey and Saudi Arabia ([Al-Khlaiwi 2004](#), [Balikci 2005](#)) complain of dizzy spells, fatigue, headaches, loss of concentration and memory, skin irritation, tingling or burning, twitching, eye 'tics', buzzing in their head at night, brain tumours and other brain damage, damage to the immune system, confusion & cancer. Headaches often appear first and / or skin effects. Then concentration and short-term memory tend to deteriorate. It usually starts by affecting learning or remembering NEW facts, similar to early signs of dementia.

A Ph.D study by Dirk Adang at the Catholic University of Louvain in Belgium found long term (equalling 60 years more or less in human terms) effects in rats exposed to pulsed radiation, such as that from mobile phones, WiFi, etc. He found significantly higher levels of white blood cells, indicating potential damage to the immune system, the mortality rate was twice as high as that in the control group, and a significant loss of memory among the survivors. The cause of death of 16 of the 17 radiated rats were different kinds of tumours. These results occurred at a radiation level considered 'safe' by official authorities.

Results from an industry backed study of 11,000 mobile phone users in Scandinavia by Dr Kjell Hansson Mild of the National Institute of Working Life in Umeå, Sweden (1998), identified links with phone use and headaches, fatigue, skin irritation, dizziness and concentration lapses. The longer the phone was used, the greater the likelihood of experiencing these side effects. Sandström ([2001](#)) found a statistically significant association between calling time/number of calls per day and the prevalence of warmth behind/around or on the ear, headaches and fatigue.

In a study by Oftedal ([2000](#)), thirty-one percent of the respondents in Norway and 13% of those in Sweden had experienced at least one symptom in connection with mobile phone use. Next to the sensations of warmth on the ear and behind/around the ear, burning sensations in the facial skin and headaches were most commonly reported. Most symptoms usually began during or within half an hour after the call and lasted for up to 2 hours. Relatively few had consulted a physician or been on sick leave because of the symptoms, but about 45% among those with a mobile phone attributed symptom had taken steps to reduce the symptom.

In a study of students at a French engineering school ([Santini 2002](#)), the results showed that mobile phone users more often complained of discomfort, warmth, and pricking on the ear while using the phone as a function of calling duration and number of calls per day. Users of phones operating on 1800 MHz complained significantly more often of concentration difficulties than users of 900 MHz mobile phone. The combined use of mobile phones and video display terminals significantly increased concentration difficulties. Female mobile phone users had significantly more sleep disturbances than male users.

In a study in Korea (K Kim [2014](#)) women had a higher percentage of risk from using a mobile phone than men, especially those who considered themselves better informed. They believed that the seriousness of the risk to future generations was high.

900 MHz mobile phone radiation produced biochemical changes and oxidative stress in rat brain, liver, lung, testis heart and renal tissue (Esmekaya [2011](#), Luo [2014](#), Ragy [2015](#), Kerimoğlu [2016](#)). Caffeic acid phenethyl ester (CAPE) may offer some protection (Ozguner [2005](#), Koyu [2009](#)).

Students and employees at Alexandria University were asked about their mobile phone use and health (Salama & Abou El Naga [2004](#)). About 43% suffered from headaches, 38% from earache, 32% from fatigue, 30% had sleep disturbance, 29% concentration difficulty and 19% face burning sensation. For headache both call duration and frequency of calls/day were the significant predicting factors for its occurrence. For earache, in addition to call duration, the longer period of owning the mobile phone were significant predictors. Fatigue was significantly affected by both call duration and age of the user, while burning sensation was only affected by frequency of calls/day.

In a study by Stalin ([2016](#)) the health problems that were found to be positively associated with mobile phone usage were headache, earache, neck pain, tinnitus, painful fingers, morning tiredness, fatigue, eye symptoms, sleep disturbance and restlessness. Hypertension was more uncommon among mobile phone users compared to non-users.

Kücer & Pamukçu ([2014](#)) found a significant increase in headache, hearing loss and joint and bone pain was observed in people who reported a daily mobile phone use of more than 16 minutes compared to participants with daily mobile phone use of less than 16 minutes.

Allergies

Dr. John Holt, President of the Australian Radiographers' Association, found that mast cells were unable to turn off histamine production (an allergic reaction) in the presence of mobile phone frequencies of 800 to 900 MHz, and conventional anti-histamines and steroids did not work. This was confirmed by Johansson in 1998. The Department of Allergy in Kyoto, Japan, found that microwave radiation increased the sensitivity to some allergy-induced skin wheal responses (Kimata [2002](#)), specifically in people suffering from eczema. The effect lasted between 2 and 4 hours. The 11 specialist allergy clinics in the UK are not able to cope with the increased demand for their services. RF radiation is probably adding to the burden of environmental pollution that is pushing many people's biological systems over the edge towards idiopathic reactions to common allergens.

Mobile phone dermatitis is a recently recognised condition due to either nickel or chromate allergy. It has most often been reported in young adults and less commonly in adolescents (Berk [2011](#)).

Simon ([2012](#)) found that exposure to 900 MHz frequency induces a transient alteration of epidermal homeostasis, which may alter the protective capacity of the skin against external factors.

Babies

Cases of sudden unexpected postnatal collapse (SUPC) were recorded in a study of Swedish neonates (Pejovic [2013](#)); some of which occurred during smart cellular phone use by the mother.

Bacteria

22% of the bacteria on people's fingers were also present on their phones, though men's phones were significantly different from their fingers, while women's were not (Meadow [2014](#)).

Bladder

Intensive use of mobile phones has a negative impact on bladder tissue (Koca [2014](#)). The authors suggested that minimum use of mobile phones reduces the problems of diseases in which inflammation is a factor.

Bone growth

A study by Atay ([2009](#)) suggested that in order to obtain more favourable outcomes to iliac bone grafts, it may be important to establish mobile phone use, as this may affect bone density depending on the side of the body where it is carried. Saraví ([2011](#)) found a correlation between estimated cumulative hours carrying a mobile phone on the right hip and differences in the bone mineral density of the bones on the two sides.

Newborn rats exposed pre-natally to mild daily phone exposure showed ossification of cranial bones and thoracic cage ribs; older littermates showed normal bone growth, suggesting that the effect was transitory (Fragopoulou [2009](#)). Bone and muscle tissue development was negatively affected due to prenatal exposure to 1800 MHz radiofrequency electromagnetic field (Erkut [2016](#)).

Bone healing

EMF at 900 MHz of frequency emitted from cellular phones was found to have a significantly negative effect on bone fracture healing (Aslan 2013).

Brain changes

Mobile phones were found to cause oxidative damage in the brain of chronically exposed animals. Melatonin was found to significantly prevent oxidative damage in the brain (Sokolovic [2008](#), Nirwane [2016](#)).

Yilmaz ([2014](#)) found that electro-magnetic waves emitted by the mobile phones may have an effect on apoptosis in brain tissue.

Exposure to LTE EMF changed the electroencephalogram in the frontal and temporal brain regions (L Yang [2017](#)).

1800 MHz RF-EMF exposure was found to impair neurite outgrowth of embryonic neural stem cells. The authors suggested that more attention should be given to the potential adverse effects of RF-EMF exposure on brain development (Chen [2014](#)).

S Xu ([2006](#)) found that 2.4 W/kg GSM 1800-MHz microwaves may reduce excitatory synaptic activity and the number of excitatory synapses in cultured rat hippocampal neurons. Mugunthan ([2016](#)) found that long term exposure to 900-1800 MHz frequency radiations emitted from 2G mobile phone could cause significantly reduced neuron density and decreased nuclear diameter in the hippocampus neurons of mice. Hussein ([2016](#)) reported that in a study degenerative changes were observed in the hippocampus pyramidal cells, dark cells and cerebellar Purkinje cells with vascular congestion. In addition a significant DNA fragmentation and over expression

of cyclooxygenase-2 apoptotic gene was detected. Those results suggested that, direct chronic exposure to mobile phone caused severe biochemical and histopathological changes in the brain.

Dasdag (2015) found that 900 MHz RF radiation can alter some of the miRNAs, which, in turn, may lead to adverse effects. miRNAs play a paramount role in growth, differentiation, proliferation and cell death by suppressing one or more target genes. A previous study (Dasdag 2012) found 900 MHz radiation emitted from mobile/cellular phones could be an agent to alter some biomolecules such as protein.

In a study by Mausset-Bonnefont (2004) a 15-min exposure to 900-MHz pulsed microwaves induced a strong glial reaction in the rat brain. This effect, which suggests neuronal damage, was particularly pronounced in the striatum (the part of the brain that helps coordinate motivation with body movement). There were also significant and immediate effects on GABA(A) receptors and dopamine transporters.

Eliyahu (2006) found that exposure of the left side of the brain slows down the left-hand reaction time. This effect was apparent in three of four tasks, and it was highly significant in the spatial item recognition task, though the exposure time exceeded the common exposure time of mobile phone users. Keetley (2006) found simple and choice reaction times showed strong evidence of impairment as a result of exposure to 900 MHz emissions indicating that the more basic functions were adversely affected by exposure.

Mobile phone radiation exposure during chick embryogenesis impaired social behaviours after hatching and possibly induced cerebellar retardation (Z Zhou 2016). The authors felt that this indicated potential adverse effects of mobile phone radiation on brain development.

3G mobile phone radiations were found to affect brain function and cause several neurological disorders (Kesari 2014).

Cardiovascular changes

A Polish team led by Andrzejak (2008) found that a mobile phone call could affect heart rate variability when the mobile phone is kept close to the chest (Ahamed 2008), but not when near the head. Alhuseiny (2012) found that the position of the mobile at belt level or close to the chest showed effects on the heart.

Mobile phones can cause interference with an insertable cardiac monitor (or implantable loop recorder, ILR). When they rang in close proximity to an externally applied ILR, they caused bursts of high-frequency signals during electrocardiogram monitoring, without causing permanent device dysfunction or reprogramming. The authors felt that mobile phones are a potential source of electrocardiographic artifacts on ILR recordings (Trigano 2007).

A study by Schlegel (1998) supported the recommendation to maintain a separation distance of at least 6 inches between pacemakers and wireless phones.

Blood pressure increase was found by Braune (1998), though no changes in healthy subjects was found by Barutcu (2011), and a hypertension decrease was found by Suresh (2011).

Not just the user is affected. Foetal and neonatal heart rate and cardiac output was found to be affected by maternal use of mobile phones by pregnant women (Rezk 2008).

Spichtig (2011) found that intermittent exposure to UMTS had small short- and medium-term effects on cerebral blood circulation and heart rate.

Burgess (2016) found that exposure to TETRA had consistent neurophysiological effects on the electroencephalogram, but only during chest exposure, in a pattern suggestive of vagal nerve stimulation. The team also observed changes in heart rate variability during exposure to TETRA.

Chronic Fatigue Syndrome (CFS)

Andrew Goldsworthy, a long-term researcher into the health effects of RF radiation says *“There is a very good chance that CFS is caused largely by the effects of prolonged mobile / DECT phone radiation on the thyroid gland. This can result in hypothyroidism, the most common symptoms of which are fatigue and obesity. The thyroid gland is in the neck, just inches from where you hold the phone and is one of the most likely parts of the body to be damaged.”* He continues *“It may be no coincidence that CFS was once called Yuppie 'flu. Yuppies were among the first to make extensive use of mobile phones.”* He points to the study by Eskander (2012) showing that prolonged exposure to either mobile phone radiation or that of their base stations (6 years) caused a highly significant reduction in the amount of thyroid hormones being produced.

CNS effects

Sub-chronic exposures to a 900 MHz EMF signal for two months could adversely affect the brain, showing signs of a potential gliosis (Ammari 2010). Microglia and astrocytes play important role in maintaining the homeostasis of central nervous system (CNS). Data in a study by Lu (2014) provide novel insights into the potential mechanisms of the reported CNS impacts associated with mobile phone use.

Depression

High mobile phone use was associated with symptoms of depression in both men and women (Thomé 2011).

Diabetes

Meo & Rubeaan (2013) found that exposure to mobile phone radiation caused an increase in fasting blood glucose and serum insulin, potential diabetes precursors.

Ear effects & hearing

A study by Sibella (2009) found that the presence of a cochlear implant inside the cochlea produced negligible variations in the averaged SAR values, both in the head and in the cochlear tissues. Many cochlear implant recipients achieve good objective telephone speech perception performance, indicating that they should be effective telephone users, especially when using mobile phones and among younger implant recipients (Tan 2012).

Panda (2010) concluded *“Long term and intensive mobile phone use may cause inner ear damage”* and Seckin (2014) indicated cellular structural damage in the cochlea caused by radiofrequency radiation exposure during cochlear development. In a study by Colletti (2011), all patients showed a substantial decrease in amplitude and a significant increase in latency of cochlear nerve compound action potentials during the 5 minutes of exposure to mobile phone radiation. These changes lasted for a period of around 5 minutes after exposure. Khullar (2013) found that long term exposure to mobile phones may affect conduction in the peripheral portion of the auditory pathway.

A study by Oktay (2006) showed that a higher degree of hearing loss is associated with long-term exposure to EMFs generated by cellular phones. Chronic usage of a mobile phone showed high frequency hearing loss in the dominant ear (Velayutham 2014). A study by Meo & Al-Drees (2005) reported that about 35% of problems experienced by mobile phone users were related to impaired hearing, ear ache and/or warmth on the ear, and 5% of complaints with decreased and/or blurred vision.

Mobile phone radiation can damage the auditory hair cells present in the inner ear. Once damaged, these cells can never regenerate.

A study by Kayabasoglu (2010) found that exposure to mobile phone radiation for 6 hours a day for 30 consecutive days had no effect on the hearing of newborn or adult rats, at the outer ear, middle ear or cochlear level.

Short-term exposure to mobile phone EMFs did not affect the transmission of sensory stimuli from the cochlea up to the midbrain along the auditory nerve and brainstem auditory pathways in a study by Kwon (2010), neither did 10 minutes exposure affect evoked otoacoustic emissions (Paglialonga 2007).

Neuronal degeneration signs, such as increased vacuolization in the cochlear nucleus, pyknotic cell appearance, and oedema were found in a group exposed to electromagnetic fields (Özgür 2015).

30 min exposure to mobile phone RF did not show any immediate effects on vestibulocochlear function (Bamiou 2008). However, long-term and intensive GSM and CDMA mobile phone use may cause damage to cochlea as well as the auditory cortex (Panda 2011).

Alsanosi (2013) found that 60 minutes of close exposure to EMFs emitted by a mobile phone had an immediate effect on hearing threshold levels and it also caused a number of other symptoms.

“The use of mobile phones at short distances from the ear of infants should be avoided” concluded Budak (2009) because of the effect on their hearing. A similar effect was found in adult female rabbits (Budak 2009).

Cox & Luxon (2000), from their clinical practice, in a letter to the editor of the Occupational and Environmental Medicine Journal say *“In our opinion there is good theoretical and clinical evidence to support the hypothesis that some people, perhaps 5% to 8% of mobile phone users, have transient symptoms of vestibular disturbance associated with their use. We think that the hypothesis should be tested experimentally as the number of people affected will increase as use of mobile phones increases.”*

A study carried out by Uloziene (2005) concluded that a 10-minute exposure to EMFs from a mobile phone showed no measurable hearing deterioration in 18-30 year olds and Cinel (2007) found no effect on an auditory order threshold task. However, Singh (2015) found that EMFs from a mobile phone affects the auditory potential.

A short-term exposure (15 and 30 minutes) to 900 MHz RFR from a mobile phone caused a significant increase in DNA single-strand breaks in human hair root cells located around the ear which is used for the phone calls (Cam & Seyhan 2012). It is unclear what implications this may have for future changes, including hair loss.

Mandalà (2014) found no short-term effects of Bluetooth EMFs on the auditory nervous system, whereas direct mobile phone EMF exposure had a significant effect on the cochlear nerve in all subjects.

Emotionality

A study by Narayanan ([2013](#)) looking at the effect of RF exposure on adolescent rats found that it could affect the emotionality of rats without affecting their general locomotion.

Psychological effects may also arise as a result of 'sexting' or the exchange of sexually explicit material via mobile phone which is an increasingly prevalent behaviour, and which female college students react more negatively to, than do males (Dir [2013](#)).

Epilepsy

Acute and relatively prolonged exposure to GSM-EMFs modulates cortical excitability in patients affected by focal epilepsy. These effects were evident only after EMF exposure over the hemisphere contralateral to the epileptic focus. They were characterised by a significant cortical excitability increase in the exposed hemisphere paired with slight excitability decrease in the other one (Tombini [2013](#)).

In a review in the Lancet, Dr Hyland ([2000](#)) explained the perils of mobile phone technology: "*A good example of human vulnerability to a non-thermal, electromagnetic influence is the ability of a light flashing at about 15 Hz to induce seizures in people with photosensitive epilepsy. It is not so much the amount of energy absorbed from the light that provokes the seizure, but rather the information transmitted to the brain by the (coherent) regularity of its flashing, at a frequency that the brain "recognises" because it matches, or is close to a frequency utilised by the brain itself.*"

In October 1999 he reported that epileptic seizures had gone up in schools as a result of youngsters using mobiles. He also suspects that the increase in adolescent female Chronic Fatigue Syndrome (CFS) in Australian schools may be related to the extensive use of mobile phones amongst this age group.

Cinar ([2013](#)) and Kouchaki ([2016](#)) suggested that continued and prolonged contact with mobile phone radiation might increase the risk of seizure attacks and should be limited.

Eye effects

Demirel ([2012](#)) found that with a short period of exposure to 3G emissions, no harmful effects on eye tissue and blood in rats was seen. Balik ([2005](#)) found that long term users of mobile phones had increased incidences of blurring of vision, secretion, inflammation and lacrimation of the eyes.

DNA damage occurred in human lens epithelial cells, dependent on exposure power and duration. Repair mechanisms were also affected (Sun [2006](#)). Wessapan & Phadungsak (2013, 2014) found that the highest SAR values from 900 and 1800 MHz was in the cornea, and the highest temperature at the frequency of 900 MHz was in the anterior chamber while the highest for the frequency of 1800 MHz was in the vitreous.

Akar ([2013](#)) showed that exposure to RF might cause alterations in rat corneas.

RF radiation can cause greater damage to eye tissue when used in conjunction with anti-glaucoma drugs. It has also been found to cause derangement of retinal differentiation in animal experiments (Zareen [2009](#)). RF radiation is known to be associated with the development of cataracts.

Okano ([2010](#)) found no short-term effect on the inhibitory control of saccades (fast, usually conjugate, movements of the eyes) after 30 minutes mobile phone exposure.

In a study by Küçer (2008) a significant increase in blurring of vision was reported by people who had used phones for more than 2 years. Women complained more often of inflammation in the eyes than men.

Dovrat (2005) found clear evidence that microwave radiation had a significant impact on the eye lens, which remained after the exposure ceased.

Gastric effects

RF radiation from a mobile phone induced a stimulatory effect on the motor function recorded at the oesophagus, stomach, jejunum and descending part of the colon (Lazebnik & Lychkova 2013).

Growth

Mobile phone exposure decreased the production of growth hormone by 28% in male volunteers ((Djeridane 2008). The hormone levels returned to normal post-exposure.

Hand and arm effects

Some tendons in the forearm seem to be thicker in subjects who frequently use mobile phone texting. The increase in thickness parallels the number of messages, but it is unknown whether such changes may become problematic later on in life (Akkaya 2015).

Repetitive use of mobile phones for text messaging can lead to the damage of Extensor pollicis longus of the thumb in addition to the tendons of the first compartment of the wrist (Eapen 2014).

Headaches

The following comments are from a discussion site:-

"I constantly get headaches now when I put the iPhone to my ears. I have to use the speaker or the head set. I've had my phone over a year now and the headaches just started."

"I get a headache from using my iPhone. Seems to happen most when I download or watch videos. It also seems to occur when I use my iPhone from a remote location, not in a city. I get the headache after usage and also the next day."

Chia (2000) found more than a 20% reduction in the amount of headaches mobile phone users complained about when they used a hands-free kit.

Chu (2011) found that headaches associated with mobile phone use usually showed stereotyped clinical features including mild intensity, a dull or pressing quality, localisation ipsilateral to the side of mobile phone use, provocation by prolonged mobile phone use and often accompanied by a burning sensation.

Heart

A study by Ozgüner (2005) demonstrated the role of oxidative mechanisms in 900 MHz mobile phone-induced heart tissue damage. Long-term mobile phone use influenced heart rate variability in studies by Yılmaz & Yıldız (2010) and Ekici (2016).

Hormone effects

Pawlak (2014) found in an experiment that T4 and T3 concentrations decreased markedly and CORT levels increased in embryos and in newly hatched chicks exposed to EMF during embryogenesis.

Kidney damage

Rat kidney tissue was damaged by exposure to mobile phone radiation and the damage persisted for some time after the exposure had stopped (Koca 2013). It is important not to carry a phone on standby near the kidneys, especially in people who may be at risk of kidney damage.

The study by Bedir (2015) showed that the RF from mobile phones had harmful effects on the kidney development of prenatal rats. Odacı (2015) found that RF applied during the prenatal period caused pathological changes in kidney tissue in 21-day-old male rats owing to oxidative stress and decreased antioxidant enzyme levels.

Life span

Chronic exposure to a low-intensity GSM-like signal was found to exert negative health effects and shorten survival if RF exposure was applied sufficiently long and the observational period covered the full life span of laboratory rats in a study by Bartsch (2010). Survival varied within certain limits depending on the month of birth, and the authors found an additional modulatory influence on a year-to-year basis which they felt might be related to changing solar activity during the the 11-years' sunspot cycle.

Liver

Kumari (2012) found that exposure to microwaves (2.45 GHz) or to the radiofrequency field of a mobile phone (900 MHz) could lead to oxidative stress in the liver and to increased liver values in rats. Exposure to 900 MHz mobile phone for 4 hours per day for 18 days could induce liver histological changes, which may be partly due to apoptosis and oxidative stress induced in liver tissue by electromagnetic radiation (Ma 2015).

Prenatal exposure to mobile phones caused liver damage (Yilmaz 2016) which persisted into adulthood.

Migraines

The incidence of reported migraines has increased by 70% in the last 10 years though the reason is unknown. It is anticipated that only about 1 in 3 migraines are reported to GPs, people just cope in the majority of cases. There are generally speaking five different sorts of 'migraines' only two of which have the severe headaches usually considered to be the primary symptom. It is believed that 'resonance' migraines are caused as a result of pulsed fields on the brain stem. Transcranial magnetic stimulation was found to induce migraines in people predisposed to visually triggered headaches (Aurora 1999). People whose first cellular telephone subscription was between 1982 and 1995, who were subsequently diagnosed with a CNS disorder had an increased incidence of 10-20% for migraine and vertigo (Schüz 2009).

Mouth

Long-term exposure to mobile phones might have a genotoxic effect on the oral mucosa (Banerjee 2016). Gandhi & Singh (2005) found an increased number of chromosomal changes in cheek cells

and abnormalities in cultured lymphocytes that showed genetic damage from mobile phone use. Yadav & Sharma (2008) found an increase in DNA damage in cheek cells of subjects using a mobile phone on average an hour a day.

Mortazavi (2008) found that microwave radiation emitted from mobile phones significantly released mercury from dental amalgam restoration.

Multiple sclerosis

Harbo Poulsen (2012) found an increased risk in women of multiple sclerosis if they had had a subscription to a mobile phone network for more than 13 years, though the numbers were very small.

Neuropathic pain

A cell phone carried in a front jean pocket places it directly over the femoral nerve, artery, and vein as they pass under the inguinal ligament. Particularly in thin individuals, this can be very close to the skin and the underlying femoral nerve, which can result in debilitating neuropathic pain (Colip 2013).

Pain perception

Changes in thermal pain threshold with RF EMF exposure were found in a study by Vecsei (2013).

Personality changes

Dr Christine Aschermann, a German psychiatrist makes the following observations, based on her clinical practice.

There has been an increased occurrence of cognitive and psychological disorders as a result of exposure to telecommunications. These include brain malfunctions, brain disturbances, or organic psycho-syndromes, either acute or chronic. *“Initially,” she says “I saw short-term memory disorders, a new very severe form of concentration disorder where people are totally unable to concentrate, amnesic aphasia (difficulty finding words), apraxia (carrying out inappropriate actions). The accompanying irritability and mood swings are considered to be psychological rather than physiological”.*

Personality and character changes may develop gradually some years after incurring these damages to the brain. People may display an absence of flexibility including obstinacy, lack of judgement and diminished self-criticism, fluctuating or distinctly reduced effectiveness, fussiness, frequent inability to control emotions and impulses or insensitivity, together with an intensification of character traits. Subtle mood swings, and the sense of ethical values can be lost.

There have been reports in newspapers about a number of electronics and telecomms employees committing suicide.

Physical activity

Mobile phone use was significantly and negatively related to cardio respiratory fitness in a study by Lepp (2013). It was suggested that mobile phone use encouraged more sedentary behaviours, or the disruption of physical activity which reduced cardiorespiratory fitness.

RF exposure for a month induced oxidative stress in rat brain, but its magnitude was different in different regions studied. RF-induced oxidative stress could be one of the underlying causes for the behavioural deficits seen in rats after RF exposure (Narayanan [2014](#)).

Salivary gland effects

Goldwein & Aframian ([2009](#)) found that the radiation from mobile phones produced elevated salivary rates and oxidative stress (Hamzany [2013](#)) and decreased protein secretion. Significant changes in salivary enzymes (Siqueira [2016](#)) and MDA suggest adverse effect of high use of cell phones on cell health (Shivashankara [2015](#)). Over an hour talking with a cell phone decreased total antioxidant capacity of saliva in comparison with talking less than twenty minutes (Arbabi-Kalati [2014](#)).

The parotid gland of rats showed numerous histopathological changes after exposure to 2100 MHz radiofrequency radiation, both in the short and relatively long terms. Increased exposure duration led to an increase in the histopathological changes (Aydogan [2015](#)).

Skin

Dysaesthesiae of the scalp after mobile phone use have been reported. Hocking & Westerman ([2002](#)) found in a study of one woman reporting dysaesthesiae, that testing before and after exposure showed marked changes in the C-fibre nerves of the affected area compared with the opposite side. Scalp dysaesthesia is characterized by pain or burning sensations on or under the surface of the cranial skin. People who suffer from dysaesthesia can become incapacitated with pain, despite no apparent damage to the skin or other tissue.

Case reports of mobile phone-associated allergic contact dermatitis (ACD) have risen rapidly in number since 2000. Case reports highlight mobile phone ACD in both paediatric and adult populations in many countries. Metal allergens, notably nickel and chromium, were frequently implicated in mobile phone associated ACD. Nickel release from mobile phones appears to be common and has been reported in both cheap and expensive mobile phones, including phones covered under the EU Nickel Directive (Richardson [2014](#)).

Millimeter waves penetrate into the human skin deep enough to affect most skin structures located in the dermis and epidermis (Alekseev [2008](#)). Christ ([2007](#)) found there could be significant heating at the body surface.

Sleep

Changes in electroencephalograph (EEG) brain patterns following exposure to a digital mobile phone signal, were found to influence sleep patterns (Huber [2000](#), [2003](#), Hung [2007](#), Lowden [2010](#)) and memory functioning and other waking activities. Arnetz ([2007](#)) found a prolonged latency to reach the first cycle of deep sleep and the amount of deep sleep was reduced.

In a study by Exelmans & Vane den Bulck ([2016](#)) six out of ten adults took their mobile phone with them to the bedroom. Sending/receiving text messages and/or phone calls after lights out significantly predicted respondents' scores on the PSQI, particularly longer sleep latency, worse sleep efficiency, more sleep disturbance and more daytime dysfunction. Bedtime mobile phone use predicted respondents' later self-reported rise time, higher insomnia score and increased fatigue.

Pulse-modulated RF EMFs were found to alter brain physiology during sleep following mobile phone-type RF exposure (Schmid [2012](#)).

47% of college students reported night-time waking to answer text messages and 40% to answer phone calls. Higher levels of technology use after the onset of sleep predicted poorer sleep quality, and poorer sleep quality predicted symptoms of depression/anxiety (Adams & Kisler [2013](#)).

Medical students using mobile for more than 2 hours a day may suffer from sleep deprivation and day sleepiness affecting cognitive and learning abilities (Yogesh [2014](#)). Eyvazlou ([2016](#)) found an association between the excessive use of mobile phones and general health (somatic symptoms, social dysfunction, anxiety, and severe depression) and quality of sleep. Furthermore, quality of sleep has an effect on general health.

Hardell ([2010](#)) found that increasing number of years of use, and cumulative hours of use, of a mobile phone reduced the synthesis of beta-trace protein, a sleep-promoting neurohormone in the brain. He feels that this mechanism may be involved in sleep disturbances reported in people exposed to RF fields. A further study by him, lead author Söderqvist ([2012](#)), found that the younger end of the age group studied (18-30 years) had lower concentrations of β -trace protein with more cumulative hours of mobile phone use.

Stress

Rats exposed to 1800 MHz mobile phone radiation exhibited behaviour symptomatic of stress (De Caires Júnior [2014](#)).

A study by Balakrishnan ([2014](#)) convincingly demonstrated the role of serum HSP and CRP as systemic inflammatory biomarkers for mobile phone-induced radiation.

Tendonitis

The result of a study by Ali ([2014](#)) concluded that almost half of students use their mobile phones for texting more than 50 S.M.S per day and because of their mobile key pads and high speed of texting they experienced pain and weakness over the base of the thumb/wrist.

Tinnitus

Middle ear contractions can be caused by microwave RF, especially pulsed RF from digital mobile phones (personal communication from John Williams). The RF causes a partial depolarisation of neurons, resulting in contractions of the middle ear muscles, with auditory effects like 'clicks' or 'pops' such as those experienced in a plane or tunnel. Such RF can also stimulate the inner ear, causing tinnitus-type symptoms.

Hutter ([2010](#)) concludes "*Mobile phone use should be included in further investigations as a potential risk factor for developing tinnitus.*" The risk was significantly increased for prolonged use, 4 years or more, of a mobile phone.

Other effects

Many, though not all (Koivisto [2001](#)) of the epidemiological studies have shown that burning skin, warmth in the head and ear (Szyjkowska [2005](#)), tingling/tightness, fatigue, headaches (Hillert [2008](#)), dizziness (Cinel [2008](#)), are regularly associated with using a mobile phone, even for a very short call. Monfrecola ([2003](#)) and Miura & Okada ([1991](#) experiments with frogs), found that a mobile phone when it was on, increased blood flow and Monfrecola quantified the effect at the ear at over 130%, and nearly 160% when the phone was receiving a signal.

The combination of slower gait velocity and decrease in attention to the surrounding environment suggests that an individual who is texting while walking could be at a greater risk of injury (Parr [2014](#)). The number of hospital emergency department visits by ambulatory persons injured while being distracted by cell phone use has been increasing (D Smith [2013](#)). The majority of the patients were female (68%) and 40 years of age or younger (54%). The primary mechanism of injury was a fall (72%).

The incidence of both phantom vibration and ringing syndromes significantly increased during medical internships (Y H Lin [2013](#)).

Drug and other interactions

RF / microwave radiation at a frequency of 2450 MHz has been found to alter the behavioural actions of benzodiazepines, such as Valium. Since benzodiazepine receptors are found in most regions of the brain and they can undergo changes after brief perturbation, it is possible that brief exposure to RF from mobile phones can lead to changes in these receptors. Different durations of acute exposure could lead to different biological effects. Benzodiazepines are associated with anxiety-related disorders, and so any interference with this is likely to lead to mood swings.

John Peterson Myers, a Senior Advisor to the United Nations Foundation said in San Francisco Medicine November 2002, that "*low doses are more potent than high doses with regard to some poisons*" (National Toxicology Program 2001). Although he is speaking specifically of chemical exposure, what he says can be translated directly onto what is being said about EMF and RF exposure. Myers suggests that "*one plausible hypothesis is that at low, physiological levels, the contaminant interferes with developmental signalling but does not activate biochemical defences against impacts that would be caused by higher exposures. At somewhat higher levels, these defences are activated and the contaminant is successfully detoxified. At even higher levels, the defence mechanisms are overwhelmed by the toxicant and more traditional toxicological effects are induced*". He continues "*Another important issue raised by emerging science is the powerful interactions that can occur within mixtures of chemicals, even though regulatory toxicology is conducted virtually exclusively on pure single compounds. The issue of mixtures is complicated further by interactions now known to occur between contaminants and infectious agents (bacteria and viruses), leading to large increases in disease risk.*"

Myers states "*Epidemiology cannot be accurate in the light of modern knowledge unless it accurately addresses:-*

- a) *Non-monotonic dose response curves (i.e. biphasic responses), (where low levels of exposure can produce greater biological effects than some higher exposures)*
- b) *Windows of vulnerability during development*
- c) *The ubiquity of mixtures*
- d) *The likelihood that multiple exposures (chemicals or other environmental agents) can induce similar impacts via disruption of developmental processes*
- e) *The same type of exposure can cause different impacts depending on when the exposure occurred*
- f) *Long latencies between exposure and manifestation of impact in a population.*"

He concludes "*The effects of low level, background exposures are likely to be far more widespread than acknowledged, and involve many more health effects than traditionally considered, yet these new mechanisms of toxicity thwart the epidemiological tools now available to establish human harm.*"

Tillmann's ([2010](#)) group of mice treated with ethylnitrosourea (ENU) and also exposed to mobile phone radiation at 4.8 W/m² displayed an enhanced lung tumour rate and an increased incidence of lung carcinomas as compared to the controls treated with ENU only.

Complexities of study design that may result in finding 'no effects'

A paper by Oftedal ([2007](#)) supposedly cleared mobile phones of causing headaches. However, this is one of the papers that misrepresents the situation as they did not use a mobile phone signal, but surrogate RF exposure, that omitted many of the characteristics typical of a mobile phone signal, including ELF exposure. This confuses the situation with respect to real exposure and subsequent effects when the misleading results are given such a high media profile. Other studies use 'mobile phone-like exposure' in their experiments, such as the one by Johansson looking at atopic dermatitis ([2008](#)) and find no effects. There may, indeed, be no effects, but it also may be that there were no effects because the experimental conditions used, either deliberately or accidentally, produce a type of exposure that may not simulate that from a mobile phone.

Animal, insect and plant experiments and effects

Grigor'ev ([2003](#)) and Batellier ([2008](#)) found that a significantly higher percentage of embryo mortality was observed in chicken eggs exposed to mobile phone radiation compared with an unexposed group.

Interestingly, and hardly unexpectedly, mice have been proven to act and respond differently in trials, depending on their environment and how they were treated. There have been moves to improve the living conditions of animals used in experiments that have led to variations causing problems in interpretation of test results. In an experiment (reported in *New Scientist*, 9th March 2002) looking at mice that carried a gene for Huntington's disease, mice in a cage with 'enriched' living conditions did much better than those in standard cages.

Apart from the obvious questions this provokes with regard to animal experimentation, reliability, and reproducibility, it also makes us wonder about our environment. Is it being 'compromised' by mobile phone masts, etc. and thus is it inevitable that our behaviour will change, even medically, in unpredictable ways?

People who have done research on primates point out that positive results of such research often has no effect or even a reverse effect when applied to humans, despite the genetic similarities.

A scheme to protect endangered wildlife has seriously backfired. The experimental programme required owners of rare species in Queensland to implant electromagnetic chips under animals' skin and to DNA test them so that they could be tracked and identified. Shortly after implementation, however, a number of valuable specimens simply dropped dead.

Kumar ([2011](#)) found that cell phone radiation produced biochemical changes in worker honey bees. Concentrations of carbohydrate, protein and cholesterol all rose significantly (a response to stress), which then declined. The experimenters also observed an increase in agitation and general activity.

Halgamuge ([2017](#)) reviewed 45 peer-reviewed scientific publications describing 169 experimental observations and concluded that about 90% show physiological effect on plants. These included maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants.

Indirect effects

One report (Ramesh [2008](#)) suggested that mobile phones could be responsible for ill-health effects in an indirect manner. Staff at a Barbados hospital rarely cleaned their mobile phones and it was believed that they therefore posed the potential for microbial contamination. A further study (YJ Lee [2013](#)) found that healthcare workers' smartphones were a significant risk factor for

contamination by bacteria with pathogenic potential. This may be an interesting area for hospital authorities to check on in view of the stricter procedures to reduce infections.

Fifty mobile phones were taken from members of the multidisciplinary team working in a surgical unit in a Belfast hospital. 60% of the phones sampled had some form of contaminant isolated from their phone; only 37% admitted to cleaning it regularly (Mark [2014](#)).

People engaged in mobile phone use presented with significant reductions in walking speed; 33% reduction whilst texting, 16% whilst talking. In addition, people who were texting whilst walking demonstrated a 61% increase in lateral deviation and 13% increase in distance travelled. These results (Lamberg & Muratori [2012](#)) suggest that the dual-task of walking whilst using a mobile phone has an effect on cognitive executive function and working memory and influences walking to such a degree that it may compromise safety. A comparison of the 2 mobile phone uses shows that texting has a significantly greater effect on walking than talking. Schabrun (2014) also found that texting or reading on a mobile phone could pose an additional risk to safety for pedestrians navigating obstacles or crossing the road. Studies examining texting while walking suggest this task changes walking to the extent that safety may be compromised. Marone ([2014](#)) found that people texting were affected by the physical, but not the cognitive demand of texting.

Protective effects

Gajski's study ([2009](#)) found that honeybee venom had a radioprotective effect against oxidative DNA damage from 915 MHz radiation.

Red ginseng was also found to be a radioprotective agent, maintaining Ca(2+) homoeostasis and preventing neuronal loss in the brain hippocampal region (Aryal [2011](#)).