

Children, young people and Mobile Phones

This article is separated into 4 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 3

The Research

1. Use of mobile phones by young people; the psychology of phone use; which children have phones? How are phones used? Child safety; the phones; SARs (Specific Absorption Rate); the link between phones and masts; summary; campaigning organisations
2. Official advice across the world; the United Kingdom; America; Australia; Austria; Belarus; Belgium; Canada; European Environment Agency (EEA); Finland; France; Germany; Israel; Italy; Norway and Denmark; Russia; Thailand; technological parents
3. The research; summary; addiction; suicidal ideation and suicide attempts; behaviour; brain effects; brain tumours; acoustic neuromas; parotid (salivary) gland tumours; headaches and migraines; hearing; heart; hippocampus; learning, memory and behaviour changes; eye damage; hospital visiting; kidney; mental health problems; mouth cancer; DNA, cellular and organ damage; reproductive effects (testicular cancer, damaged sperm, reduced fertility); risk perception; sleep; official comments on the implications of the health research; the difficulties with the research
4. References – 144 references

It is not easy to investigate the potential long-term health effects of mobile phones on children, due to the relatively short period that phones have been in use and also to medical ethics restrictions. Britain's official £3.1 million long-term investigation (COSMOS) into the risk of cancer from mobiles specifically excludes young people.

Mobile phone use by children has increased from virtually zero in the mid 1990s to about 90% of ten-year-olds now having and regularly using their own mobile phone. Children as young as five-years of age are now being given simplified mobile phones which are just as powerful radio-frequency transmitters as normal mobiles.

Summary of the concerns over the research findings

In recent years there have been a number of over-views of the research on mobile phones and health. Two of the leading Interphone researchers, Elisabeth Cardis and Segal Sadetzki ([2011](#)) recently published their assessment of the science to date. They say that, while more studies are needed, indications of an increased risk of gliomas, a particularly dangerous form of brain tumour, in high and long-term users from Interphone and other studies, are of concern. *“Even a small risk at the individual level could eventually result in a considerable number of tumours and become an important public-health issue.”*

They conclude that *“until definitive scientific answers are available, the adoption of such precautions, particularly among young people, is advisable. This should include measures such as the use of text messages, and hands-free kits and/or the loudspeaker mode of the phone could substantially reduce exposure to the brain from mobile phones.”*

With regard to the content of phone use van Dijk's results ([2016](#)) show that textese is positively related to children's grammar performance, i.e. the more words children omitted in their text messages, the better their performance on the grammar task, neither did it affect their cognitive abilities.

David Carpenter ([2010](#)), Professor of Environmental Health Sciences and Director of the Institute for Health and the Environment at the University of Albany, New York, concluded: *“That for RF EMFs, standards are set at levels designed to avoid tissue heating, in spite of convincing evidence of adverse biological effects at intensities too low to cause significant heating. The cost of doing nothing will result in an increasing number of people, many of them young, developing cancer.”*

Kevin O'Neill, a consultant neurosurgeon at Charing Cross Hospital in London, says he is seeing more patients than ever and at younger ages.

Lennart Hardell ([2009](#)), a professor in oncology and cancer epidemiology at the University Hospital in Örebro, Sweden, and Cindy Sage (a lawyer) assessed the published evidence and concluded: *“Health endpoints reported to be associated with ELF and/or RF include childhood leukaemia, brain tumours, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, breast cancer, miscarriage and some cardiovascular effects. Since the use of mobile phones is now associated with an increased risk for brain tumours after 10 years, a new biologically based guideline is warranted.”* He has shown that regular use, more than about an hour a day, of any mobile or cordless phone before the age of 20 raises the risk of brain cancer fivefold.

In an overview of the effects of mobile phone radiation on the child's body, Khorseva ([2011a](#)) concludes *“It has been shown that the children's organism is more sensitive to this kind of exposure than the adult one.”* Dr Elisabeth Cardis, head of radiation research in

Barcelona, says that the composition of children's brain tissue is more conductive and their cells are dividing more quickly, so damage gets quickly replicated. Dr Joe Wiart, a specialist on the biological effects of EMFs, showed that children absorb about twice as much radiation as adults.

Redmayne (2013) found in her study of adolescent phone usage that the number and duration of cellphone and cordless phone calls were associated with increased risk of headaches – more than 6 cellphone calls over 10 minutes weekly or more than 15 minutes cordless use daily. Schoeni (2016) found a change in memory performance over one year was negatively associated with cumulative duration of mobile phone and cordless phone use. Texting and extended use of wireless phones was related to having a painful 'texting' thumb. Using a wired mobile phone headset was associated with tinnitus, while wireless headsets were associated with headache, feeling down/depressed, and waking in the night. Several cordless phone frequencies bands were related to tinnitus, feeling down/depressed and sleepiness at school. Being woken at night by a cellphone was strongly related to tiredness at school.

Cerutti (2016) highlighted the potential impact of excessive internet and mobile use, which ranges from different types of headache to other somatic symptoms.

Güler (2016) found oxidative DNA damage increased in the brains of the group of rabbits exposed to 1800 MHz radiofrequency radiation in the womb and for a month after birth.

The research findings

Addiction

The addictive properties of mobile phones seem to be based on two hypotheses. There is a social addiction in young people, who do not wish to feel separate from their peer group, there is also a potential chemical addiction first identified by Professor Henry Lai, of the University of Washington in Seattle.

Dong (2012) suggests that Internet Addiction Disorder (IAD) is rapidly becoming a prevalent mental health concern in many countries around the world. Access to the internet is one of the features of mobile phone technology which is increasing especially in young people. fMRI scans showed significant differences in brain activity from those considered to have IAD, compared with those who didn't.

According to Pedrero Pérez (2012), the estimated prevalence of mobile phone abuse or addiction ranges from 0-38%, depending on the scale used and the characteristics of the population studied. Surprisingly, self-attribution of mobile phone addiction exceeds the prevalence estimated in the studies themselves. The personality trait most consistently associated with addiction is low self-esteem, though extraversion is associated with more intense use. Women with low self-esteem are the most vulnerable group, and the most commonly associated psychopathological symptom was depression.

Suicidal ideation and suicide attempts

Cellular phone use (CPU) has markedly changed the everyday lives of adolescents. Issues about how cellular phone use relates to adolescent mental health, such as suicidal ideation and attempts, are important because of the high rate of cellular phone usage among children in that age group. The rates of suicidal ideation were 23.50% and 11.76% in adolescents with problematic CPU and without problematic CPU, respectively (PW Wang 2014). The rates of suicidal attempts

in both groups were 13.70% and 5.45%, respectively. This study highlights the association between problematic CPU and suicidal ideation as well as attempts. It also indicates that good family function may have a more significant role on reducing the risks of suicidal ideation and attempts in adolescents with problematic CPU than in those without problematic CPU.

Behaviour

Exposure to mobile phones prenatally and to a lesser extent postnatally has been associated with behavioural difficulties such as emotional and hyperactivity problems around the age of school entry (Divan [2008](#)). Later studies (Divan [2012](#), Sudan [2016](#)) showed positive associations between mobile phone use and behavioural and emotional problems in young children. Behavioural problems were most often found in children who had both prenatal and postnatal exposure to mobile phones. Guxens ([2013](#)) found that children exposed to prenatal phone use (both mobile and cordless phones) were about twice as likely to be reported by their teachers as having overall behaviour problems at age 5. Aldad ([2012](#)) found that mice prenatally exposed to cell phone exposure were hyperactive and had reduced memory capacity in comparison with unexposed mice. The head author, Dr Hugh Taylor concluded that it would be 'sensible' for pregnant women to limit exposure of their unborn child to all wireless devices, as simply using them could lead to future behavioural disorders.

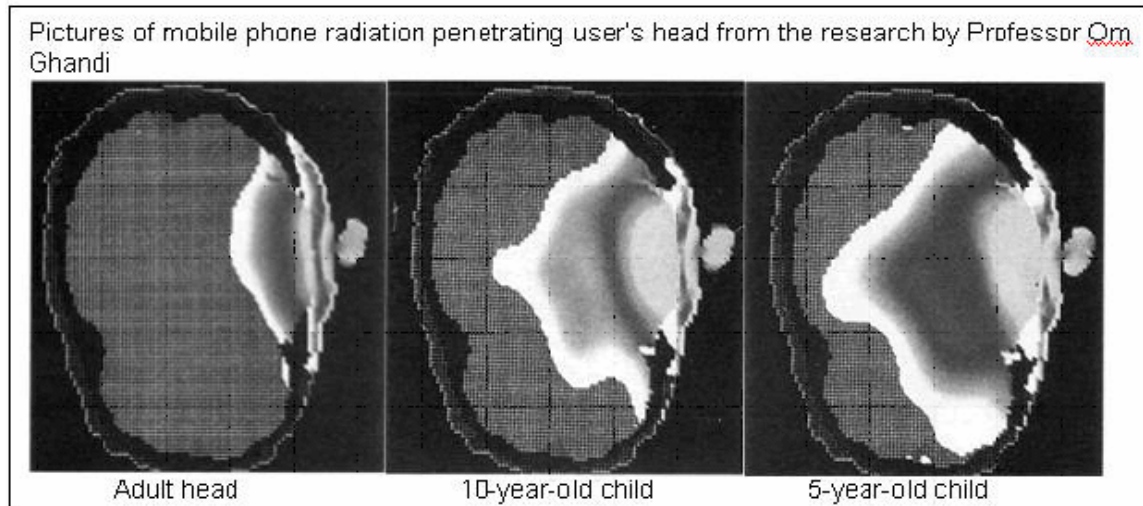
7% of children and 5% of adolescents using mobile phones showed behavioural problems. The higher the exposure, the higher the risk of problems (Thomas [2010](#)).

Byun ([2013](#)) found that exposure to lead, as measured by blood lead levels, and RF from mobile phone use was associated with increased ADHD symptom risk.

Intensive mobile phone use was found to be part of the same health-related lifestyle as health compromising behaviours, such as smoking, snuffing and alcohol use among 14-16 year-olds (Leena [2005](#)).

Backpackers scored 50% better on a creativity test after spending 4 days in nature disconnected from electronic devices. The authors of the study (Atchley [2012](#)) note that the study was not designed to “*determine if the effects are due to an increased exposure to nature, a decreased exposure to technology or the combined influence of these two factors.*” The researchers cited earlier studies indicating that children today spend only 15 to 25 minutes daily in outdoor play and sports, that nature-based recreation has declined for 30 years, and that the average 8- to 18-year old spends more than 7.5 hours a day using media such as TV, cell phones and computers. Creative thinking and problem solving are believed to arise in the same prefrontal cortex area of the brain that is overtaxed by constant demands on our attention in our technological environment.

Brain effects



Professor Om Gandhi, head of electrical engineering at the University of Utah in Salt Lake City, using life-size models and computer-generated images, found that 5-year-old children absorb 50% more radiation than adults during a call. Scans showed that while radiation spread a short distance from the ear in adults, in the youngest children it spread across most of the brain. *"More radiation can go through since the child's ear is thinner, the telephone is closer to the head and this thinner ear doesn't absorb so much power. Therefore more is able to go past the ear into the head."* Said Professor Om Gandhi, University of Utah, quoted in the Express newspaper, November 2001.

The Specific Absorption Rate, a measure of the radiation absorbed by the head during a phone call, is used to determine the 'safety' of a mobile phone. The lower the SAR, the lower the risk to the user. The plastic model of the head that is used to determine SARs has shortcomings, including the fact that it uses a fluid having the average electrical properties of the head that cannot indicate differential absorption of specific brain tissue, nor absorption in children or smaller adults. The SAR for a 10-year-old is up to 153% higher than that measured by the model. When electrical properties are considered, a child's head absorption can be over two times greater, and absorption of the skull's bone marrow can be ten times greater than adults (Gandhi [2012](#)).

The radiofrequency microwave radiation thus has the potential to be far more disruptive to the biological processes going on in the child's growing and developing brain and nervous system. Motawi ([2014](#)) found that mobile phone radiation affected the relative brain weight of young rats and histopathological examination reinforced the neuronal damage. Dark neuron degenerative changes were found in the brains of rats exposed pre- and postnatally to 900 MHz radiation (Köktürk [2013](#)).

Dr Gandhi's work triggered a backlash from the industry which, he says, has left him without research funding and the subject of mudslinging at industry-dominated meetings. *"I have been marginalised for the last three years because I would not back down from what I was publishing"* he says.

Dr Bill Guy, although not in full agreement with Gandhi's findings, and Dr Gerard Hyland, admit that the radiation will penetrate children's heads more deeply because of their smaller size - with the radiation exposing regions of their brains that are relatively unexposed in adults. Dr Michael Kundi said that a child's skull contains many more stem cells, which can form blood cells, than that of an adult, and the earlier in life a malign transformation occurs, the more likely it will result in a clinical malignancy. Work by scientists at the Jerusalem College of Technology suggest that

the human head, being oval with a short axis on average 16-17 cms in length, will act as an antenna for mobile phone signals. Brain tissue could act as a radio receiver. Dr Camelia Gabriel (MCL and SARtest, UK) points out that children have different electrical properties in their tissues, which change to approximate adult properties as they grow older. She believes further research is needed to understand the implications for health of these differences.

Professor Sianette Kwee, of the University of Aarhus, Denmark, who was part of the European Union's COST 281 project 'Potential health effects from Emerging Wireless Communication systems' reports that "*Our studies showed that there was a significant change in cell growth in human amnion cells after being exposed to EMF fields from both power lines (ELF) and from mobile phones (MW). These biological effects were greatest in young and vigorously growing cells. These results tell us, that e.g. microwave fields from mobile phones can be expected to affect children to a much higher degree than adults.*"

The influential BioInitiative report ([2007](#)) states "*The consequence of prolonged exposures to children, whose nervous systems continue to develop until late adolescence, is unknown at this time. This could have serious implications for later adult health and functioning in society if years of exposure of the young to both ELF and RF result in diminished capacity for thinking, judgement, memory, learning, and control over behaviour.*" As well as evidence for an increased risk of brain tumours, they concluded that it was possible that breast cancer, DNA changes and changes in the blood vessels associated with heart disease were also associated with radiofrequency exposure.

Brain tumours

The risk of developing brain tumours is one of the most researched potential health effects (Hardell [2003](#), [2006](#), [2006](#), [2007](#), [2009](#), Interphone Group 2010 (see references), Khurana [2010](#), Kundi [2004](#), [2009](#), Lönn [2004](#), [2005](#), Morgan [2009](#), Myung [2009](#), Sasacci [2010](#), Yakymenko [2010](#)).

Looking at all the data, overall, after ten years use of a mobile phone, there is approximately a doubling in risk of glioma on the same side of the head as that where the handset is usually held. Malignant gliomas are usually fatal within a few years from diagnosis. An increased risk is also seen for long-term regular cordless phone use. Significant increases in both benign and malignant tumours are reported.

In the large, much publicised, Interphone study maximum duration of use among the study participants was about 12 years, and only 5 years had passed since heavier use began. It can take many years before a damaged cell has grown sufficiently to cause symptoms that can be diagnosed as cancer. For most known carcinogens, however, identification of increased risk of solid tumours (particularly brain tumours) has required long follow-up periods of subjects with substantial exposure. For example, while the atomic bombs were dropped on Hiroshima and Nagasaki in August 1945, an excess risk of solid tumours was reported in the survivors only in the 1960s, and no elevation in risk of brain tumours was noted for about the first 50 years.

If the doubling after ten years use is approximately correct, which many scientists now believe it is, then we should expect an much larger in the incidence of brain tumours over the next 30 years.

The concern is that even low levels of mobile phone use are linked to increased risk (Hardell [2009](#)), and this paper revealed that the situation is worse for those who use phones before the age of 20. There has been a 40% increase in brain tumours in Australia in the last 20 years. It has taken over from leukaemia as the biggest child cancer killer.

One worrying finding is the statistically significant association of all benign brain tumours with cordless phone use, showing a doubling in risk after more than 10 years use, at a very low

average use time per day. A greater risk is associated with having used mobile phones for more than 15 years, a finding consistent with other studies showing that observed risks significantly increase after six and ten years of use.

A study of New Zealand adolescents and their use of mobile and cordless phones caused concerns for the author, (Redmayne [2013](#)), that if the results of the Interphone and the Hardell studies were correct, they could already be at increased risk of brain tumours.

The Hardell study has much better data than the Schoemaker paper ([2005](#)) which used virtually the same team as the Hepworth glioma study ([2006](#)) which stated that it couldn't find any relation for under 10 years use but could not say for 10+ years mobile phone use.

Most of the high-grade glioma patients were not included due to being too ill, or having died. This meant that no conclusions could be drawn with respect to EMFs and the cause or proliferation of a glioma.

Professor Michael Kundi of Vienna University says "*Nothing on earth is suspected, let alone known, to induce glioma within a few years,*" and as the duration of phone use in the Schoemaker study is very short and there were only 10 cases, only an effect on tumour development and growth (not cause) could have been observed. He suggested that only ipsilateral tumours (tumours on the same side of the brain as the phone was held) were important, and an increase in risk is exactly what the study found. In a review of 9 studies on mobile phone use, Kundi ([2004](#)) found the risk of developing acoustic neuroma tripled and the risk of uveal neuroma quadrupled. This confirms the report of Lönn ([2004](#)).

Soderqvist ([2011](#)) comments on the CEFALO report, disagreeing with its conclusion and saying that the data contain several indications of increased risk of childhood brain tumours.

A study by Aydin ([2011](#)) concluded that children and adolescents who are regular users of mobile phones are not statistically significantly more likely to have been diagnosed with brain tumors compared with nonusers. Children who started to use mobile phones at least 5 years ago were not at increased risk compared with those who had never regularly used mobile phones. However, this would imply that the risk was not increased. In fact all of the 13 ORs (odds ratios, or measure of risk) included showed an increased risk. It is very unclear as to why the authors did not mention this. One might consider them to be biased for some reason.

Comment from Alasdair Philips, Powerwatch:-

The time-scales are far too short. Ages 7-19 years; 7-11 year olds in this time period are unlikely to have used a mobile phone much and certainly with too short a tumour induction period, so including their data will weaken the study. They don't aggregate the cellphone use and cordless phone use - they analyse them separately which will weaken the statistical power. Brain tumours in children have not been rising in England (and I don't expect it is different in Denmark, Sweden, Norway and Switzerland) over the period 1993-2008, so why should a rise be detected related to cellphone use when there is no rise anyway? That could only be if background brain tumour rates were falling and cellphone use was topping the numbers back up again - most unlikely. Brain tumours take longer than the period allowed for in the study to initiate and develop through to diagnosis (at least ten years).

Acoustic Neuromas

Some of the earliest claims that mobile phones caused tumours were made regarding acoustic neuromas (tumours on the acoustic nerve inside the ear - usually, but not always, benign).

Hardell (2006) suggests that there is a statistically significant increase in brain tumour risk after 5 years of mobile phone use, and there was a dose-response relationship, where the more hours a phone was used resulted in ever increasing risks of developing tumours. For acoustic neuromas they found little evidence of further increases after 10 years use. However for all benign tumours grouped together, the increase with time is significant.

This seems to bear out the work published by Lönn (2004). This study is particularly important because acoustic neuromas are considered to be a signal tumour for other types of malignant and benign brain lesions. These tumours occur in areas with the highest radio frequency radiation exposure during calls.

Han and colleagues (2009) reviewed 11 studies for evidence of an association between acoustic neuromas and mobile phone use. Their meta-analysis found that subjects who used cell phones for at least 10 years had a 2.4-fold greater risk of developing acoustic neuromas on the same side of the head the phone was used.

A recent study by Sato (2011) asked 1589 cases identified throughout Japan to take part. and 787 cases (51%) did participate. A significantly increased risk of acoustic neuroma was identified for mobile phone use for more than 20 min/day on average, with risk ratios of 2.74 at 1 year before diagnosis, and 3.08 at 5 years before diagnosis.

Parotid (Salivary) Gland Tumours

In Israel, Sadetski (2008) found a statistically significant increase, and a positive dose-response trend, between parotid gland tumours on the side of the head where a mobile phone was usually held. More recently a large rise in diagnosed parotid gland tumours has been reported from Israel – the cause is so far unknown. The total number of parotid gland cancers in Israel increased 4-fold from 1970 to 2006 (from 16 to 64 cases per year), whereas other major salivary gland cancers remained stable. The steepest increase occurred after 2001, with an average of 37 cases of parotid gland cancer annually before that date and 61 cases per year subsequently. The distribution of cases by age, sex, or tumour type did not change substantially during this time. Better diagnosis and recording can only account for a small part of this rise.

Headaches and migraines

Mobile phone use was associated with a significantly increased risk of getting headaches, migraines, and also skin itches. Children aged 11-15 who regularly used mobile phones were also considered to have a health status worse than it was a year ago (Chiu 2014). A statistically significant association was found between the time mobile phones were used in talk mode and the number of headaches per month, number of young people experiencing vertigo per month, or number of young people having sleeping problems per month (Mortazavi 2011).

Prenatal and postnatal mobile phone exposures were associated with headaches in children (Sudan 2012).

Hearing

Sudan (2013) observed weak associations between cell phone use and hearing loss at age 7.

Heart effects

Short-term RF EMF exposure of students in a lying position affected the autonomic nervous system with significant increase in parasympathetic nerve activity (Misek 2018).

Hippocampus

The hippocampus is essential to such diverse functions as memory acquisition, integration and spatial manoeuvring. EMF can result in severe damage to both the morphology of the hippocampus and its principal functions during adolescence. Kerimoğlu (2016) indicated that oxidative stress-related morphological damage and pyramidal neuron loss may be observed in the rat hippocampus following exposure to 900-MHz EMF throughout the adolescent period.

Learning, memory and behaviour changes

In 2001, Dr Michael Klieseisen from the Spanish Neuro Diagnostic Research Institute in Marbella, Spain [www.findarticles.com/p/articles/mi_qn4161/is_20011202/ai_n14543438], found that a mobile phone call lasting just 2 minutes can alter the electrical activities and biochemical processes in a child's brain for up to an hour afterwards. This may lead to psychiatric and behavioural problems, or reduce the body's immunity to infection and disease. He says *"We never expected to see this continuing activity in the brain. My advice to all parents is not to allow children to use mobile phones."*

Dr Gerard Hyland, a UK spokesman on mobile phones said, *"Children's brains are affected for long periods even after very short-term use. Their brain wave patterns are abnormal and stay like that for a long period. This could affect their mood and ability to learn in the classroom if they have been using a phone during break time, for instance. We don't know all the answers yet, but the alteration in brain waves could lead to things like a lack of concentration, memory loss, inability to learn and aggressive behaviour."*

A study by Zheng (2014) shows some associations between mobile phone use and inattention in Chinese adolescents. They suggested that decreasing phone usage to less than 60 minutes per day may help adolescents to stay focused and centred.

This change in brain activity may be linked to the reduced ability to learn and remember (Wang 2000). It may not be helpful to our school-age children to impair their ability to learn at the time where they spend most of their time trying to do just this. Progressive learning abilities were found to be decreased in rats exposed to 900 MHz radiofrequency radiation. Memory retention test performed 24 h after the last training revealed minor spatial memory deficit in RF-EMR exposed group. However, RF-EMR exposed rats exhibited poor spatial memory retention when tested 48 h after the final trial. Structural changes found in the hippocampus of RF-EMR exposed rats could be one of the possible reasons for altered cognition (Narayanan 2015). Compromised learning behaviour was also determined in the EMF group rats studied by İkinci (2013). Their results show that the application of a 900 MHz EMF in the prenatal period adversely affected female pups' learning behaviour and also resulted in histopathological changes appearing in the hippocampus. Pyramidal neuron loss and histopathological changes in the cornu ammonis of 8-week-old male rats may be due to the 900-MHz EMF exposure (Şahin 2015). A study by Leung (2011) provided support for an effect of acute 2G and 3G exposure on human cognitive function, especially in adolescents.

Lai (2004) also found an intriguing effect with other environmental EMFs, in that exposure to a specific form of magnetic fields blocked the learning and memory deficits. Abramson (2009) found that in children reporting more mobile phone voice calls, the accuracy of working memory was poorer, reaction time for a simple learning task shorter, associative learning response time shorter and accuracy poorer. Kumlin (2007) and Thomas (2010) found improved learning and memory in rats as a result of mobile phone exposure. The fact that there are changes can be concerning as there are clearly biological implications. Khorseva (2011b) identified the following trends in psychophysiological indicators in children using mobile phones: an increased number

of phonemic perception disorders, abatement of efficiency, reduced indicators for the arbitrary and semantic memory, an increased fatigue.

Children and adolescent reaction to using their phones was tested in a large study using self reported information covering a range of potential effects. A higher intensity of headaches were reported at noon amongst the highest users. At bedtime the highest afternoon users reported a higher intensity of irritation. Children reported a significantly higher intensity of concentration problems (Heinrich [2010](#)).

Microwave radiation has also been linked to mood and behaviour changes, possibly more so in boys. Reports of animal behaviour, in personal emails from New Zealand, indicate that stallions and bulls seem more affected by microwave exposure than mares and cows. As more schools are reporting problem behaviour, which will affect the concentration of students other than the misbehaving youngster(s), we may already be seeing some of the effects.

Grigorev ([2014](#)) found the following changes in children exposed to RF from mobile phones significant tiredness (40%); decreased performance at school and home (51%), concentration difficulties (productivity 14%, accuracy 19%) and memory (accuracy 19%, duration 30%). Also, there was a slowing down of physical response time (56%) and the response to spoken instructions. The author was suggesting that the current regulatory framework is inadequate with regard to children. In a study by Bhatt ([2017](#)), of 26 comparisons of changes in cognitive outcomes, four demonstrated significant associations. The increase in mobile phone usage was associated with changes in response time, and errors in problem solving. The authors found some evidence that change in the use of mobile phones in primary school children was associated with change in cognitive function.

Microwave radiation has shown to break down the blood brain barrier (Schirmacher [2000](#), Bortkiewicz [2001](#), Salford [2003](#)), which is our natural defence against letting poisons into the brain. Alcohol and non-prescribed drugs are poisons to the brain, and mobile phone use may well allow these to enter the brain, possibly giving rise to some of the antisocial behaviour that is seen increasingly, especially in our towns and cities.

Salford's study showed that blood brain barrier damage increased according to the amount of exposure. Just 2 hours of accumulated mobile phone radiation killed a number of nerve cells in the brain. The brain lesions may be indications of a condition similar to early onset dementia. Many hospitals are now reporting the need to set up units for people aged under 50 with dementia, as the current facilities are not adequate to deal with the increased demand. As a result of this experimental result, Norbert Hankin, environmental scientist from the US Environmental Protection Agency, commented *"The concern is that if such effects may occur in young children, then even slight impairment of learning ability over years of education may negatively affect the quality of life that could be achieved by these individuals, when adults."* (Letter to Dr George Carlo, Radiation Protection Project, April 2000).

Eye damage

In [2005](#), Dovrat from the Rappaport Faculty of Medicine at the Israel Institute of Technology, Haifa, found that microwave exposure caused bubbles to form within eye tissue, which did not disappear over time - an indication of the development of cataracts. The research leader, Professor Levi Schächter, said of their findings *"microwaves can cause irreparable damage. Our advice to people with mobile phones is not to use them if they have the option of using a land line until we can conduct more research."* There is already a well-established link between occupational microwave exposure and eye damage. Longer exposure to smartphones can have a

negative impact on eye health in adolescents. The symptoms include vision blurring, redness, visual disturbance, secretion, inflammation, lacrimation and dryness (J Kim 2016).

Hospital visiting

Contamination of mobile phones can pass on infection in neonatal intensive care units (Beckstrom [2013](#)). Bacteria transmitted from mobile phones to hands may not be eliminated using antimicrobial gel.

Kidney effects

Prenatal exposure of rat kidneys to 900 MHz EMF resulted in increased total kidney volume and decreased the numbers of glomeruli (filtering units) (Ulubay [2015](#)).

Mental Health problems

Mobile phone use after lights out may be associated with poor mental health, suicidal feelings, and self-injury in both early and late adolescents (Oshima [2012](#)). Increased duration of mobile phone use has been associated with depression in Japanese adolescents (Ikeda & Nakamura [2014](#)).

Mouth cancer

Every year in the UK, there are 4,300 new cases of mouth cancer diagnosed and 1,700 deaths. In November 2004, John Hamburger, a senior lecturer at Birmingham Dental Hospital, warned of an increase in mouth cancer among teenagers and children in the West Midlands. The British Dental Health Foundation (BDHF) said about 25% of mouth cancer cases in younger people did not involve the most common causes of the illness which are smoking and drinking alcohol to excess. A factor that has simply not been assessed is mobile phone usage, and we know that young people are some of the heaviest phone users. The mouth would be very close to where a regular mobile phone user would be holding their phone. Children wearing braces may be even more at risk, because of the conductive qualities of the metal. The guideline exposures were exceeded in children with metallic implants, up to 100% higher than in the adult head (Joo [2006](#)).

DNA, cellular and organ damage

The Reflex Study, [www.powerwatch.org.uk/news/20041222_reflex.asp], which was supported by the EU at a cost of more than two million Euros, was carried out at various important research centres in Europe. In the course of this study, the so-called mutagenicity (the ability of a substance to cause changes (mutations) in the DNA of cells) of electromagnetic fields was tested. They looked for changes in the genes which are the possible beginning of a cancer. In one part of the study, tests were carried out on human promyelocytes - a preliminary stage of the cells of blood formation. A mutation of such cells can, as a further consequence, lead to leukaemia and similar illnesses of the blood forming system.

The results from these studies can be summarised in one sentence: There is indeed a genotoxic (the ability of a substance to damage DNA) effect on human cell cultures from mobile phone radiation at a strength that is supplied by every GSM mobile phone.

In a study by Sekeroğlu ([2012](#)) much higher and irreversible cytogenotoxic damage was observed in immature rats than in mature rats. The authors recommended that further studies are needed to understand effects of EMF on DNA damage and DNA repair, and to determine safe limits for the environment and for humans, especially for children.

As early as the mid 1990s, Professor Henry Lai and his team at the University of Washington, Seattle published the results of his studies which revealed genetic damage in the DNA of exposed rats. They found that after their laboratory rats were exposed to the low RF radiation for a relatively short period, the DNA strands in the brain were being broken up. He said that DNA breaks do not always lead to cancer, but it can be a factor, as cancer is such a complicated process.

Jerry Phillips (2009) with Lai and Singh published a review paper on electromagnetic fields and DNA damage. They stated: *"Since the majority of cancers are initiated by damage to a cell's genome, studies have been carried out to investigate the effects of electromagnetic fields on DNA and chromosomal structure. Additionally, DNA damage can lead to changes in cellular functions and cell death. Single cell gel electrophoresis, also known as the 'comet assay', has been widely used in EMF research to determine DNA damage, reflected as single-strand breaks, double-strand breaks, and crosslinks. Studies have also been carried out to investigate chromosomal conformational changes and micronucleus formation in cells after exposure to EMF. This review discusses important lessons learned from work in this area."*

Microwave radiation penetrates the body and can affect the cells of soft tissue. It is difficult to know where to carry a mobile phone to avoid radiating vulnerable parts of the body. Eazytrack, makers of mobile phones, provide a free "headset necklace" to carry the 'Owl' phone around the child's neck, which will of course leave it dangling next to their heart, breast buds, and other major organs. We cannot recommend carrying a phone here.

Reproductive effects (testicular cancer, damaged sperm, reduced fertility)

Many young people are using their phones to 'text' their communications. This is cheaper, as the call is charged only when the message is sent, and it keeps the child's head away from the phone. It is important that the phone is held away from the body when the call is connected (which is always at full power). The soft tissue most at risk in boys is the testicles, which are particularly vulnerable to microwaves. Extensive research in many countries now strongly suggests that they may have long-term reproductive problems due to changes in fertility or damaged sperm cells (Aitken 2005, Fejes 2005, Eroglu 2006, Hardell 2007, Wdowiak 2007, Yan 2007, Ye 2007, Agarwal 2008, 2009, Desai 2009, De Iuliis 2009, Mailankot 2009, Meo 2010, Salama 2010, Otitoloju 2010, Falzone 2011).

Risk perception

Female students had higher risk perceptions of both mobile phones and base stations (Hassoy 2013).

Sleep

In a paper presented at SLEEP 2008, the 22nd Annual Meeting of the Associated Professional Sleep Societies (APSS) in Baltimore, Dr Gaby Badre said that teenagers who send more than 5 text messages a day on their mobile phones or make more than 5 calls are ruining their chances of getting a good night's sleep (Van den Bulck 2003). A subsequent study (Van den Bulck 2007) reported that *"mobile phone use after lights out is very prevalent among adolescents. Its use is related to increased levels of tiredness. There is no safe dose and no safe time for using the mobile phone for text messaging or for calling after lights out."* A good night's sleep is a prerequisite for good health, as much of the body's biological repair mechanisms are active at this time. Dr Badre continued *"Addiction to cell phones is becoming common. Youngsters feel a group pressure to remain inter-connected and reachable round the clock. There seems to be a connection between intensive use of cell phones and health compromising behaviour such as smoking, snuffing and use of alcohol."* There are clearly other lifestyle issues which make this finding less straightforward.

Japanese adolescents using their mobile phones for calling and for sending text messages after lights out have more sleep disturbances (Munezawa [2011](#)).

Excessive use of mobile phone, of computer use during weekdays, and internet facilities were more prevalent in sleep deprived adolescents. Mobile phone is associated with computer practices and with alcohol and tobacco use, which are themselves associated with most risk behaviours. Alcohol use is associated with other substance use, computer use and violent behaviours (Paiva [2016](#)).

In a study of adolescent phone usage overnight by Adachi-Mejia ([2014](#)), more than half took their mobile phone to bed and kept it turned on while sleeping. Almost half used their phone as their alarm. More than one-third texted after going to bed. Two or more times per week, about 1 in 10 were awakened by a text after going to sleep.

Adolescent sleep needs range from 8.5-10.00 hours per night, with older adolescents requiring less sleep than younger adolescents. On average, American adolescents receive between 7.5 and 8.5 hours of sleep per night, with many sleeping fewer than 6.5 hours on school nights. Mobile phone use is emerging as an important factor that interferes with both sleep quality and quantity, particularly as smartphones become more widely available to teens (Adams [2013](#)).

Heinrich ([2010](#)) found children and adolescent phone users most reported chronic fatigue. Zheng ([2015](#)) also found a significant association between mobile phone use and fatigue in children.

Official comments on the implications of the health research

Eric Huber, the Speaker for Environmental Medicine for the Doctor's Chamber for Vienna said *"If medications delivered the same test results as mobile phone radiation one would have to immediately remove them from the market."* He continued *"We must assume that children are more sensitive towards high frequency radiation than adults since the skull bones are thinner and the children's child-like cells show an increased rate of division, in which they are more sensitive to genotoxic effects."*

As a response to this research Dr Michael Clark of the HPA-RPD said *"If future research delivers the same or similar results then public health practices may need to be re-examined."*

The difficulties with the research

Adolescent self-reported laterality is of limited validity according to Inyang ([2010](#)). Epidemiological studies of mobile phone use based on self-reported information may underestimate true associations with health effects.

Dr Jerry Phillips, a well-known cellphone researcher in the USA with dozens of peer-reviewed papers published under his name, said *"There's so much money involved, that the only thing industry sees is the money. They couldn't give a damn about basic science."* Dr Phillips and colleagues found changes in the expression of rat genes exposed to cellphone signals. They did not know what it meant, but they knew it was noteworthy. Dr Mays Swicord, director of electromagnetic research at Motorola, said *"You need to include a statement in here that, even though you see a change in this one gene, that it's of no physiological importance."* Phillips replied *"I can't say that. I don't know whether it is or not."* When the study was published in 1997, it contained a sentence at the end which Phillips says he never wrote. It states that changes he discovered are *"probably of no physiologic consequence."*

Dr Henry Lai of the University of Washington, Seattle, said that among the peer-reviewed, published studies with no direct industry funding, biological effects from cellphone frequencies, such as altered gene expression, DNA breaks and death of animal brain cells, were noted 81 per cent of the time. When corporate money is directly funding the science, effects were noted only 19 per cent of the time.

In 36 studies focused on genetic effects, such as DNA damage, 53 per cent showed some kind of biologic effect that might indicate concern. Of those studies, a vast majority, 79 per cent, were independent. Conversely, studies showing *no effects* had direct industry funding 82 per cent of the time.

When Dr Leif Salford, a neurosurgeon in Sweden, published a study in [2003](#) showing that rat brain neurons were dying from exposure to cellphone radiation, he warned there might be similar effects in humans that over time could lead to degenerative diseases of the brain. His study was written off by the industry as a 'novel' finding that needed to be replicated. "*But the other guys who have tried to do the same thing have not got their papers published*" said Salford. He rated the reality of brain damage as a "*probability rather than a possibility.*"

Teenagers born between 1977 and 1978 show a five- or six-fold increase in nevi (birthmarks which appear later in life, not at birth) compared with a comparable group of teenagers born twenty years earlier. Today, it is not uncommon for 10-year-olds to have nevi on both sides of their face. What concerns Örjan Hallberg, a Swedish specialist in this area of knowledge, is that some of them seem increasingly to develop further and become malignant melanomas (personal communication 2008).

Teenagers who send more than 5 text messages or make more than 5 calls on their mobile phone find it difficult to fall asleep or to stay asleep, according to a study by Badre reported at the 22nd Annual Meeting of the Associated Professional Sleep Societies (APSS) meeting in 2008. It is recommended that adolescents get 9 hours of sleep a night for optimal health. Problems with sleep make the young people more stressed and tired during the day. They reported that they felt pressure to be available to their friends 24 hours a day and they tended to have a more frantic lifestyle than young people who used their phones less.