

Wireless technologies and young people



A resource for schools

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Introduction

Recent years have seen a vast proliferation of wireless communication devices universally available, without a similar increase in advice about the implications for health and safety, especially for children and young people.

Discussing the potential dangers associated with use of the internet and other forms of electronic media can enable young people to use information technologies more safely. In the same way, an awareness of the non-ionising radiation emitted by wireless communication technologies and its absorption by and potential interaction with the body can help young people to make informed choices about how they use digital devices.

Mobile and smart phones, cordless phones, Wi-Fi-enabled technologies and their base stations contain transmitters which emit modulated radio frequency signals in the microwave band of the electromagnetic spectrum.

The majority of young people today do not follow the health and safety advice from the UK Department of Health, UK Chief Medical Officers or NHS Choices about the use of mobile phones. Awareness by schools, young people and families of current guidance, scientific evidence and international advice can play an important role in protecting the health and well-being of children and teenagers.

This document serves to alert adults to the potential dangers associated with wireless technologies and could usefully be discussed by Staff, Parent Teacher Associations, and Governors. The information could then be cascaded to the children or young people themselves. Schools may agree to implement '**Suggestions for best practice in educational settings**' or pass this information to Senior Managers, Staff and Governors, as they revise school policies for health, safety and information technology.

Available electronically at

<http://wifiinschools.org.uk/resources/wireless+technologies+and+young+people+Oct2011.pdf>

Wifiinschools.org.uk offers free information about the safety of wireless technologies. It does not sell any products and has no monetary or other conflicts of interest on this issue.

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1. Current mobile phone guidance for young people

UK Department of Health

http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_124899.pdf

... the UK Chief Medical Officers (CMOs) advise that children and young people under 16 should be encouraged to use mobile phones for essential purposes only, and to keep calls short (February 2011).

In 2006 the Department of Health advised:

http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4123981.pdf

The UK CMOs recommend that if parents want to avoid their children being subject to any possible risk ..., the way to do so is to exercise their choice not to let their children use mobile phones.

NHS Choices

<http://www.nhs.uk/Conditions/Mobile-phone-safety/Pages/Recommendations.aspx>

Children are thought to be at higher risk of health implications from the use of mobile phones. This is because their skulls and cells are still growing and tend to absorb radiation more easily.

It is recommended that children use mobile phones only if absolutely necessary.

You can lower exposure to radio waves in the following ways.

- *Only make short calls on your mobile phone, and do not use it more than necessary.*
- *Children should only use mobile phones if absolutely necessary.*
- **Find out the specific absorption rate (SAR) of a mobile phone before you buy it. This is how much radio wave energy is absorbed into the body from the mobile phone. SAR can vary between different types of phones. Mobile phone retailers have a responsibility to make this information available to you before you buy.*
- *Keep your mobile phone away from your body when it is in standby mode.*
- *Only use your phone when the reception is strong - this is often indicated by bars of energy on your phone screen. Weak reception causes the phone to use more energy to communicate with the base station.*
- *Use a mobile phone that has an external antenna. This keeps the radio waves as far away from your head as possible.*

NHS Choices advise people to keep their mobile phones away from their bodies when in standby mode. This advice would apply to young people who sleep with phones switched on or in standby mode under their pillows or next to their bed throughout the night.

*SAR values can be misleading, as exposures vary with the efficiency of the phone and strength of the reception¹. A low SAR does not mean that the phone is safe.

Health Protection Agency

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/MobilePhones/info_HealthAdvice/

... given the uncertainties in the science, some precaution is warranted particularly regarding the use of handsets held against the head. This is especially relevant to the use of handsets by children and the Agency recommends that excessive use by children should be discouraged.

International Guidance

- **The World Health Organisation**, International Agency for Research on Cancer - classified radio frequency radiation as a possible human carcinogen (Class 2B, 2011)².
- **The Council of Europe** - recommended that the use of mobile phones by pupils on school premises be strictly regulated³.
- **France** - The French Government advises children to limit their use of wireless phones⁴. The use of mobile phones by pupils in schools and colleges has been banned⁵. Advertising of mobile phones to young people under the age of 14 has been banned⁵. France is to introduce a warning on mobile phones that overuse may damage health⁶.
- **Russia** - The Ministry of Health advises people under the age of 18 (and pregnant women) not to use mobile phones at all⁷.
- **Israel** - The Israeli Ministry of Health has called for children's use of mobile phones to be limited⁸. The Israeli Government's Environment and Health Committee has recommended that schools establish special areas for mobile phone use and limit it elsewhere (similar to smoking). They also recommend that teachers only use mobile phones in staff rooms and allocated areas, and that corded phones are available in school offices for pupils to use⁹.
- **India** - The Indian Ministry of Telecommunication has recommended that children under the age of 16 should be discouraged from using mobile phones¹⁰.
- **Finland** - The Radiation and Nuclear Safety Authority recommend restricting the use of mobile phones by children¹¹.
- **Others** – Politicians and medical organisations from many other countries have also recommended restricting the use of mobile phones by children.
- **European Environment Agency** - The Director said in 2009 that the evidence for potential risks is strong enough to justify steps to reduce people's exposure to radio frequency electromagnetic fields and that the current exposure limits needed to be reconsidered¹².
- **International Commission for Electromagnetic Safety** - *We strongly advise limited use of cell phones, and other similar devices, by young children and teenagers, and we call upon governments to apply the Precautionary Principle as an interim measure while more biologically relevant standards are developed*¹³.

Mobile phone manual instructions

Many mobile phone manuals now contain recommendations about keeping mobile phones away from the body^{14,15}. For example, users are advised to keep the Motorola V195¹⁶ and Blackberry torch 2.5cm¹⁷ away from the body when they are transmitting and the iPhone at least 1.5cm away¹⁸. The Blackberry Torch should be kept away from the abdomen of pregnant women and lower abdomen of teenagers¹⁷. The HTC Droid Eris¹⁹ recommends that no part of the human body be allowed to come too close to the antenna during operation of the equipment. These distances are required in order to comply with the current ICNIRP exposure guidelines²⁰ for radio frequency radiation. (N.B. The existing guidelines are no longer considered protective by the European Environment Agency¹², European Parliament²¹ or the International Commission for Electromagnetic Safety¹³. Thus it is possible that much greater distances may be needed between the user and the mobile phone for safe use).

Concerns have been raised by leading international scientists about the guidance for mobile phone use by young people from the Welsh Assembly Government: <http://wifiinschools.org.uk/resources/Welsh+mobile+phone+leaflets.pdf>.

2. Discussing the safety of mobile communication technologies with young people

The majority of teenagers and many younger children now possess a mobile phone. Use can range from keeping them switched off except for emergency use, to using them for several hours a day and sleeping close to them when switched on throughout the night. The advice from NHS Choices and the Chief Medical Officers (page 3) is that young people should only use a mobile phone if absolutely necessary or use one for essential purposes only.

The safety of wireless communication technologies remains controversial. Some scientists, health professionals and advisory bodies are calling for health and safety warnings on microwave-emitting devices and advise limited use. Others are saying that there is not yet consistent evidence of harm. There is certainly evidence of adverse effects on health or biological damage (e.g. research studies, page 11). But it may take many more years of research and epidemiological studies before there is agreement about the risks, or a full understanding of the conditions necessary for damage to occur.

Discussing the safety of mobile phones with young people allows them to adopt safer practices now and to make informed decisions for themselves. Precautionary actions now may prevent illness in the future.

The following resources, or extracts from them, may be useful for discussing the safety of mobile phones with young people:

- NHS Choices and UK Department of Health guidance (page 3); Mobile phone manual instructions about the **minimum** distance necessary between the mobile phone and the body (page 4).
- 'Save the Male' poster from the Radiation Research Trust. Males are advised not to keep their mobile phone in their pocket
http://www.radiationresearch.org/images/RRT_articles/save_males.pdf.
- 'Discussing mobile phone safety with young people', Starkey 2011, British Journal of School Nursing 6(9): 435-438. http://www.school-nursing.co.uk/cgi-bin/go.pl/library/article.html?uid=87718;article=BJSN_6_9_434_438
- Four videos aimed at teenagers, produced by the International Commission for Electromagnetic Safety: http://www.icems.eu/public_education.htm.
- Interview with Dr Devra Davis on CBC TV, September 2010: http://www.youtube.com/watch?v=F4bp7Zi_8pk.
- The book '**Disconnect**' by Dr Devra Davis¹⁴, former Director of the Centre for Environmental Oncology of the University of Pittsburgh Cancer Institute, published September 2010 <http://www.disconnectbook.com/>.
- Award winning documentary film '**Full Signal**'²² by Director Talal Jabari, 2010 <http://www.FullSignalMovie.com>.
- Extracts from some research papers (page 11).
- Frequently asked questions (page 12).

3. Suggestions for best practice in educational settings

Wireless technologies are convenient and are used in many schools. But there is increasing scientific evidence that their use could damage health and some countries are recommending restrictions. Below are suggestions for best practice in educational settings, based on current scientific knowledge and a precautionary approach.

Mobile phones

In school

Given the advice from the UK Department of Health, Chief Medical Officers, the recommendations of the Council of Europe³ (Resolution 1815) and the potential risks identified in scientific studies (e.g. section 4, page 11), we recommend that mobile or smart phones are not used by pupils whilst at school or on educational visits. If pupils keep mobile phones in their possession during the day, they should be switched off and not left in standby mode (as they are still transmitting in standby).

The school could designate areas for staff to use their mobile phones, away from the pupils. The Environment and Health Committee of the Israeli Parliament have also recommended designated areas in schools for staff to use their mobile phones⁹. Mobile phones have been associated with an increased risk of some cancers after long-term use²³⁻²⁷, as well as damage to other body systems²⁸⁻³⁰. Thus the example set by the school is important, as well providing safe working environments for pupils and staff.

Educational visits

Mobile phones are useful in emergencies and have clear benefits for educational visits. Here phones could be stored away from the body (e.g. in a bag) and used in speaker phone mode. Where members of staff are concerned about mobile phone use, particularly for pregnant women, the school could respect their wish not to use a mobile phone.

Passive irradiation and mobile phone etiquette

Some damaging effects of mobile phones have been detected at low electromagnetic field strengths. For example, Panagopoulos *et al* (2010)³¹ reported damage to DNA (genetic material in cells) from up to 90 cm away from a mobile phone in use. Salford *et al.* have found damage to cells in the brain at exposures found nearly two metres away from a mobile phone in use³². Staff could be advised to keep a distance of at least two metres between the phone and other people. The Vienna Doctor's Chamber (Medical Association) recommend a distance of several metres from other people whilst speaking on a mobile phone³³.

Texting

Texting is considered safer than speaking on a mobile phone (held close to the head) as it uses less power and is held further away from the body when in use. However, the phone is still in contact with the body when held in the hand and it is advisable to hold it away from the chest or abdomen (especially for pregnant women). Hadjem *et al.* (2010)³⁴ found that 9 or 15 year old heads absorb approximately twice as much radiation into their brains as adults do when texting (phone held 10cm away from the head). The authors attributed the difference to the front of the head being thinner in children than adults. For a 15 year old, texting with the phone 10cm in front of the head exposed the head to approximately ten

times less radiation than when speaking on a phone positioned close to the cheek. People often hold mobile phones very close to their chests or abdomens whilst texting, and may be unaware that their bodies will be absorbing some of the radiation. Moving the phone away from the body reduces the amount absorbed. Abramson and colleagues found that young people who texted a lot made more mistakes in cognitive tasks (2009, 2010)^{35,36}. Whilst the authors didn't attribute the mistakes to the radiation, cognitive deficits have been described following exposure to a mobile phone or similar electromagnetic fields³⁷⁻⁴², even at very low powers⁴². Studies are also finding changes in brain development after exposure to mobile phones^{43,44}. The British Medical Association has warned that texting may damage kidneys or reproductive organs⁴⁵. The Vienna Doctor's Chamber have drawn up a list of mobile phone guidelines which include: *A mobile phone in the trouser pocket and also the sending of SMS (text) messages under the school desk can influence fertility and should be completely avoided*³³. They also advise against playing games on mobile phones as this can expose the user to the radiation for prolonged periods of time. In October 2010 it was reported that the average American teenager sends more than 3000 texts per month (about 100 a day)⁴⁶. With very little research into the biological effects of sending text messages, a precautionary approach would favour young people limiting their use, and landline telephones and wired computers being recommended and preferred.

Cordless Phones

Cordless phones in the workplace

A court in Bresica, Italy, has judged that the brain tumour of an employee from an insurance company was caused by his use of a cordless (DECT) and/or mobile phone in the workplace⁴⁷. The company had to pay court costs and a disability pension. Italian employees are being advised to insist on a written declaration regarding the use of telecommunication equipment, stating that the employer takes all responsibility for medium or long-term consequences of their use.

Tumours

The only research group so far to have studied possible links between head tumours and long term use of cordless phones (as opposed to mobile phones) found increased risks for astrocytoma (cancers of astrocyte cells in the brain, 5 fold increased risk after 10 years) and acoustic neuroma (cancers of the auditory nerve, 2.3 fold increased risk after 10 years) on the same side of the head as cordless phone use²⁴. The risks were similar to those for mobile phones (Hardell and Carlberg, 2009). A major criticism of some investigations into possible links between mobile phone use and cancers is that cordless phone use was not taken into account.

Cordless phone base station

Most cordless phone base stations emit radiation all of the time, even when a call is not being made. Havas *et al.* (2010)⁴⁸ found that some individuals experience increased heart rate (tachycardia) and irregular heartbeats (cardiac arrhythmias) when approximately 60cm away from a cordless phone base station. The study was performed under blind conditions, so the subjects were not aware of when the base station was transmitting.

For safe working environments, we recommend that wired phones are used in school offices, not cordless ones. The Israeli Government Environment and Health Committee have recommended that schools in Israel provide wired phones for pupils to use (2010)⁹.

Wi-Fi

The UK Health Protection Agency state: *People using Wi-Fi, or those in the proximity of Wi-Fi equipment, are exposed to the radio signals it emits and some of the transmitted energy in the signals is absorbed in their bodies*⁴⁹.

Research

Despite Wi-Fi (wireless computer networks or wireless broadband) having been used in some schools for several years, it was only in 2010 that the first study to look at the biological or health effects of a Wi-Fi-enabled device was published. Dr Avendaño and colleagues presented at the meeting of the American Society for Reproductive Medicine that human sperm exposed to a Wi-Fi-enabled laptop for 4 hours had decreased motility and damaged DNA⁵⁰. They suggested that wireless laptops might decrease male fertility (as has been found for mobile phones⁵¹⁻⁵⁵). Damage to DNA from a wireless laptop is of concern, as it raises the possibility that Wi-Fi could, over time, lead to cancers. Studies have also reported damage to DNA following exposure to mobile phones⁵⁶⁻⁶⁰ (for mechanisms – F.A.Q.s 8-9, page 13). Papageorgiou *et al*⁶¹ (2011) used electroencephalogram (EEG) recordings in humans and found that exposure of young men to the electromagnetic fields from a Wi-Fi access point can decrease a measure of attention whilst carrying out a memory task. The exposures were at 1.5m from the Wi-Fi transmitter (0.49V/m field strength) and the study was carried out blind, meaning the individuals did not know when the transmitter was switched on. In young women Wi-Fi electromagnetic fields can alter electrical brain activity, with a decrease in EEG alpha and beta wave energies (<http://wifiinschools.org.uk/resources/wifi+brain+July+2011.pdf>)⁶².

Dr Havas, after publishing the paper mentioned above that some people react to cordless phone base stations with cardiac arrhythmias and tachycardia, found that Wi-Fi routers can cause the same effect in some people (2010)⁶³. A group from Wageningen University in the Netherlands have reported that Wi-Fi routers (100milli Watt, typical for Wi-Fi) positioned 50cms from Ash trees for three to six months appeared to lead to damage of portions of the leaves, with the disappearance of the outer cell layer followed by desiccation and death⁶⁴. Many studies find biological damage from microwaves at similar exposures⁶⁵ as those experienced by users of Wi-Fi-enabled technologies^{e.g.66-70,31,32,37,42,48,55,73}.

Health Protection Agency

The Health Protection Agency state: *There is no consistent evidence to date that exposure to radio signals from Wi-Fi and WLANs (wireless local area networks) adversely affects the health of the general population*⁴⁹. We would argue that the inconsistencies reflect the complexities of living systems and a dependence on biological, environmental or electromagnetic conditions⁷¹. It is also possible that schools may have pupils or staff with medical conditions who do not fall under the term ‘general population’. A representative from the Health Protection Agency commented during a course in 2010 (EMF and Health: Guidelines, Regulations and Risk Management) that Wi-Fi might trigger seizures in some people. Studies of animal models of epilepsy have found that modulated microwave signals can induce seizures in susceptible individuals⁷²⁻⁷³, epilepsy patients can respond to mobile phones with different changes in their brain activity⁷⁴, and The Russian National Committee for Non-Ionizing Radiation Protection have warned that mobile communication technologies may increase people’s ‘epileptic readiness’⁷.

International Guidance on Wi-Fi:

- **The Council of Europe** - recommended in 2011 that wired broadband connections should be preferred in schools, to protect children's health³.
- **Germany** - German Government in 2007 said that the use of WLAN in the workplace or home should be avoided, if possible. They have stated that conventional wired connections are preferred⁷⁵.
- **Israel** - The Government's Environment and Health Committee recommended in 2010 that wired connections be preferred over wireless in schools⁹. The Israeli Government has banned the marketing of home Wi-Fi products as a precautionary measure. The Environment Minister said that the health consideration comes before any economic consideration⁷⁶.
- **Austria** - The Public Health Department in Salzburg has advised schools not to use Wi-Fi or cordless phones⁷⁷. The Austrian Medical Association is lobbying against Wi-Fi in schools and recommend wired broadband⁷⁷. The Vienna Doctor's Chamber recommends wired internet connections, as WLAN can lead to high radiation exposure³³.
- **France** - The French Health and Security Agency recommended in 2009 that people reduce their exposure to mobile phones and other wireless devices. *The time for inaction is past* said the Director. *Exposure to children should in particular be limited and Wi-Fi transmitters switched off whenever possible*⁴.
- **International Bioinitiative Report, 2007** - *we recommend that wired alternatives to Wi-Fi be implemented, particularly in schools and libraries so that children are not subjected to elevated RF (radio frequency) levels until more is understood about possible health impacts*⁷⁸.
- **Scientific Panel on Electromagnetic Field Health Risks, 2010** - *The Panel recommends wired internet access in schools, and strongly recommends that schools do not install wireless internet connections that create pervasive and prolonged EMF (electromagnetic field) exposures for children*⁷⁹.

The town of Hérouville St Clair in France has removed Wi-Fi from its schools and public buildings and replaced it with fibre optic connections. The Mayor of the town commented that Wi-Fi is an important tool, but there are some places that it simply shouldn't be – like schools⁶³.

We recommend that schools use wired networks with dedicated computer cabling or fibre optic connections, not wireless ones. Some devices with Wi-Fi capabilities can have the Wi-Fi function turned off so that they are not transmitting (others may need non-wireless alternatives). For schools already with wireless networks, transmitters could in the short-term be switched off in each classroom when not in use. Pupils could be advised not to sit close to Wi-Fi-enabled equipment or to put them on their laps. Schools could monitor pupils and staff for potential adverse health effects, such as abnormally high heart rates, headaches, dizziness, rashes or seizures. As a matter of urgency, research is needed to investigate thoroughly whether children's DNA or cognitive abilities are being damaged by Wi-Fi in the classroom, as predicted by scientific studies.

Other transmitters

Schools have a choice of wired or wireless connections for printers, security systems, utility monitors, smart meters, white boards, games, audio equipment etc. The choices made have important implications for the electromagnetic environment within the school. Wireless equipment brought in by staff and students and mobile phone base stations (masts) on or near school grounds can also affect the microwave exposures in the school.

Further information about smart meters can be obtained from the document 'Smart Meters – Smarter Practices' commissioned by the Radiation Research Trust

(http://www.radiationresearch.org/index.php?option=com_content&view=article&id=138%3Asmart-meters-smarter-practices-&catid=1%3Anews&Itemid=25).

For a low microwave environment we would recommend a non-wireless policy (covering radio frequency transmitters) and the exposure values recommended by the Public Health Department of Salzburg, Austria. They suggest a maximum of 0.06V/m (volts per metre) outside and 0.02V/m indoors for radio frequency radiation⁸⁰.

4. Extracts from some research studies

To give an idea of some of the research studies published about wireless technologies, the front pages from the papers listed below are available in a single pdf file at <http://wifiinschools.org.uk/resources/extracts.pdf>

Overall health implications: Sage C. and Carpenter D. O. 2009, *Pathophysiology* 16(2-3): 233-246; Blank M. 2009, *Pathophysiology* 16(2-3): 67-69.

Tumours: Khurana V. G. *et al.*, 2009, *Surgical Neurology* 72(3): 205-214; Hardell L. and Carlberg M. 2009, *International Journal of Oncology* 35: 5-17; Sadetzki S. *et al.* 2008, *American Journal of Epidemiology* 167: 457-467; Khurana V. G. *et al.*, 2010, *International Journal of Occupational and Environmental Health* 16: 263-267.

Genetic damage: Ruediger H. W. 2009, *Pathophysiology* 16(2-3): 89-102; Gursatej Gandhi A. 2005, *Indian Journal of Human Genetics* 11(2):99-104; De Iuliis G. N. *et al.*, 2009, *PLoS One* 4:e6446.

Decreased fertility: Agarwal A., *et al.*, 2008, *Fertility and Sterility* 92(4): 1318-1325; Eroglu O. *et al.*, 2006, *Archives of Medical Research* 37: 840-843; Avendaño C. *et al.*, 2010, *American Society for Reproductive Medicine 66th Annual Meeting*: O-249; Gul A., *et al.*, 2009, *Archives Gynecol. Obstet.* 280:729-733.

Cognitive deficits and changes in brain activity: Maier R. *et al.*, 2004, *Acta Neurologica Scandinavica* 110: 46-52; Fragopoulou A.F. *et al.*, 2009, *Pathophysiology* 17(3):179-187; Nittby H. *et al.*, 2008, *Bioelectromagnetics* 29: 219-232; Narayanan S. N. *et al.*, 2009, *Clinics* 64: 231-234; Vecchio F. *et al.*, 2007, *European Journal of Neuroscience* 25: 1908-1913.

Developmental changes: Divan H. A. *et al.*, 2008, *Epidemiology* 19: 523-529; Odaci E. *et al.*, 2008, *Brain Research* 1238: 224-229.

Cardiovascular abnormalities: Havas M. *et al.*, 2010. *European Journal of Oncology Library* Vol. 5: 273-300; Mousavy S. J. *et al.*, 2009, *International Journal of Biological Macromolecules* 44: 278-285.

Changes to the immune system: Johansson O. 2009, *Pathophysiology* 16(2-3): 157-177.

Damage to wildlife: Balmori A. 2009, *Pathophysiology* 16(2-3): 191-199.

For further information about any of the papers or for more examples please e-mail contact@wifiinschools.org.uk

5. Frequently asked questions

1. Which part of the electromagnetic spectrum are we talking about?

Mobile communication technologies emit carrier waves in the microwave region of the electromagnetic spectrum. Microwaves (300MHz-300GHz) are a sub-set of radio frequency radiation and are non-ionizing (do not have enough energy to knock electrons out of orbit and create ions). When information is being transmitted signals are pulsed and modulated, producing lower frequencies as well as the higher frequency carrier waves.

2. If exposures are within current ICNIRP safety guidelines then they should be safe, shouldn't they?

The current safety guidelines set by the ICNIRP in 1998²⁰ assume that radio frequency radiation can only cause biological damage via heating of body tissue and are based on acute, short-term exposures. However, the scientific literature contains a large number of publications describing biological damage and adverse health effects below current safety guidelines. The International Commission for Electromagnetic Safety¹³, The European Environment Agency¹², the European Parliament²¹, and the Council of Europe³ consider the current guidelines to be obsolete and that lower values are needed to protect the public. The former Chairman of the UK Health Protection Agency (Sir William Stewart) has also said that there are damaging biological effects below current guidelines⁸¹. The classification of radio frequency radiation as a possible human carcinogen by the World Health Organisation suggests that current guidelines are not protective. However, scientific opinion is divided.

3. Is heating the only way radio frequency/microwave radiation can cause damage?

At high exposures, microwaves heat up body tissues. At lower exposures, below the ICNIRP guideline values, microwaves also alter or damage living things⁸². These low power effects are called non-thermal, as no heating has been detected. Many scientists and doctors now recognise non-thermal effects, as does Russia. Some governments or agencies are yet to admit their existence.

4. Why should we be concerned?

Using a mobile phone for more than 10 years has been linked to an increased risk of developing a head tumour on the same side as phone use in the majority of studies carried out to date^{23-27,83}. Highest tumour risks were found in young people who started under the age of 20²⁴. Increases in tumours are supported by findings of damage to DNA⁵⁶⁻⁶⁰, for which mechanisms of action have been suggested^{84,85}. Our being alive and healthy depends upon our body's electrical signals and movement/interactions between charged atoms or molecules. Perhaps it should not be surprising that modulated microwave electromagnetic fields can alter a wide range of functions in our body^{28-30,78,82}. We may not have all of the answers yet, but there are reasons why discussing safer practices with young people and creating safe environments in educational settings are sensible reactions to current scientific evidence.

5. I heard that there wasn't any evidence of damage to health from mobile phones?

It is incorrect to say that there is no evidence of damage to health from mobile phones. Hundreds of studies have associated mobile phones with adverse health effects or biological damage. However, around a similar number have found no effect on biological processes or aspects of health. People differ in how they interpret there being effects found in some studies and not others. Experimental details are important when considering different results, as electromagnetic fields, cell types or environments may vary. Future research may reveal more about which conditions are necessary for damage to occur.

6. Can't we wait until there is agreement about whether there is harm to health?

Many scientific studies report damaging biological effects and many report no effect. Either an enormous number of studies from many different research groups are wrong, or damage is seen under certain conditions⁷¹ and not others. Belyaev has described some of the conditions upon which effects may depend⁷¹. There will only be conclusive proof of damage to human health when a lot of people have been adversely affected. We will only know for certain whether Wi-Fi in schools can cause cancer, low fertility or cognitive impairments when a lot of young people or staff have been harmed. A precautionary approach, based on scientific evidence, means not installing Wi-Fi in schools, removing Wi-Fi where currently present and using safer alternatives. Waiting for everyone to agree about the risks may damage the people schools work so hard to educate, guide and help.

7. Are children at greater risk than adults?

Children are considered at greater risk from exposure to radiofrequency electromagnetic fields as they absorb more radiation into their brains⁸³, bone marrow⁸⁶ and muscles³⁴, have thinner skulls⁸³ and higher conductivity⁸³. Their bodies and brains are still developing and increased cell division offers more opportunities for DNA damage to be expressed or for adverse developmental effects. Greater increased cancer risks have been described for young people who use mobile phones, than for adults²⁴. For a diagram of increased absorption into children's brains see reference 87.

8. I thought non-ionising radiation didn't have enough energy to directly break molecular bonds and therefore couldn't have biological effects?

Microwaves are non-ionizing radiation and are considered not to have enough energy to directly break molecular bonds. However, biological processes do not require bonds to be broken in order for biological effects to occur. Biological systems can react to small changes in the orientation or conformation of molecules, distribution of charge, vibrations, and are sensitive to their own or external electric or magnetic fields⁸⁸⁻⁹¹. One change can trigger cascades of other responses. Damage need not be direct, but could be caused by changes in other chemicals. For example, microwaves may directly increase the number of free radicals⁸⁴ (F.A.Q. 9) and free radicals can damage DNA. Increases in free radicals (or oxidative stress) have been found in studies of microwave-induced DNA damage or decreased male fertility^{84,92,93}. Antioxidants, which neutralise free radicals, can block microwave-induced DNA damage⁹³.

9. I heard there were no known mechanisms by which radio frequency radiation can damage the body?

More research into the mechanisms by which non-ionizing radiation mediates its biological effects is needed. But several possible mechanisms have been suggested. Free radical formation may be increased by changes in the direction of electron spins in pairs of radicals⁸⁴. Our bodies contain a magnetic compound called magnetite, which may respond to electromagnetic fields with changes in the orientation of its crystals⁹⁴. A forced vibration on free ions may alter the opening of cell membrane channels²⁹. There could be a direct interaction with moving electrons in DNA⁸⁵.

10. What is electrohypersensitivity?

We all react to electromagnetic fields and may be affected by low power microwaves without realising it. But some people are particularly sensitive and report adverse reactions, with symptoms ranging from mild to severe. Electrohypersensitivity (EHS, or microwave syndrome) is estimated to affect 1.5-9% of the population. Some studies find clear, measurable effects even when the subjects were not aware of when the radiation was present (e.g. cardiac abnormalities^{48,63}, changes in brain activity: alpha rhythm in parietal-occipital areas⁹⁵). Subjective symptoms such as headaches, nausea and dizziness are more controversial, as many short duration provocation studies have failed to find a clear causal link⁹⁶. But the provocation studies did not test for cumulative effects over time or delayed responses, as found with immune system activation. Inadequate prior screening of whether the subjects really had EHS may have resulted in sensitive people and controls being put into the same groups for analysis. Some children report feeling ill at school, but not during the holidays⁶³ (<http://www.youtube.com/safeschool#p/u/3/KN7VetsCR2l>). It is important for the health and wellbeing of pupils to investigate whether illnesses are linked to the use of wireless technologies at school, and if so to use technologies which are safe for everyone. More people may be affected by EHS, as environmental exposures increase⁹⁷.

11. Alternatives to Wi-Fi – is dLAN OK (using the power distribution system)?

Safe alternatives to Wi-Fi are wired networks using dedicated computer cabling (shielded) or fibre optics. It is also possible to use the power distribution system (dLAN). However, sending information along the power cables increases the high frequency voltage transients or 'noise' ('dirty electricity') riding on the 50Hz signal⁹⁸. Because the power cables are not electrically shielded they radiate electric or magnetic fields, exposing people near the cables and equipment. Voltage transients on power distribution systems have been associated with a cancer cluster in La Quinta Middle School⁹⁸, decreased teacher health and student behaviour in three Minnesota schools⁹⁹, an increase in the number of students requiring inhalers for asthma in one school¹⁰⁰, increased insulin needed for type I diabetics¹⁰⁰. Keeping the transients on the electricity supply at low levels may be important for creating a healthy environment⁹⁸. We do not recommend dLAN.

The safety of a possible future alternative to Wi-Fi, wireless modulated light communication technology¹⁰¹, is unknown at the moment. The effect of the high frequency modulations on brain activity or brain development (including vision) has not yet been reported.

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- 5 LOI n° 2010-788 du 12 juillet 2010 portant engagement national pour l'environnement. Article 183, Art. L. 511-5 - In kindergartens, elementary schools and colleges use during any activity and education in the areas designated by the rules, a student, a mobile phone is prohibited. <http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434&dateTexte=&categorieLien=id>. Article 183, Art. L. 5231-3 – All advertising, regardless of medium, having in direct object of promoting the sale, provision, use or the use of mobile phones by children under fourteen years is prohibited.
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