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Mobile Phones

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Contents

1. Background

Mobile phones have revolutionised communications throughout the world. Texting has resulted in a new language barely understood by the pre-mobile phone generation. It is hard to imagine the modern business and younger social world without the mobile phone. Unfortunately, research from across the globe is showing that long-term usage of mobile phones can be damaging to your health. It is associated with brain tumours, memory and concentration problems and rat experiments have found signs of early onset dementia (similar to Alzheimer's - Salford 2003). Mobile phone use without a hands-free kit in a car has been banned in the UK, because of the increased risk of having an accident (Due to the distraction caused by using the phone). The UK Department of Health has also issued advice stating that people should attempt to keep their calls as short as possible, and that children and young people under the age of 16 should only use their phones in emergencies, based on the current uncertainties in the existing scientific literature.

Your phone communicates at full power when it is connecting to a number. Hold your phone away from your body when you have finished dialling until the person answers. If you are texting, hold it away from you until the text is sent. The parts of the body which are most vulnerable to microwave radiation are the eyes, the breasts and testicles. Other parts of the body which are sensitive are

internal soft tissue organs such kidneys, liver, ovaries, etc. Your phone should be kept away from these parts of the body. When your phone is on standby, it communicates (at full power) with the nearest base station regularly to ensure it has the best signal possible. This could be once every 30 minutes if you are staionary in a good signal area. If you are in a poor signal area, it may transmit as often as every 30 seconds as it attempts to get a better signal. If you are on the move, it will transmit frequently.

Mobile phones are suspected to initiate Electrical Hypersensitivity (ES), which can be a very debilitating condition. If you feel you *need* to use a mobile phone, please read reducing your exposure on reducing your microwave exposure from your current phone and what to look for when you buy a new one.

2. Mobile / Cordless Phones and Brain Cancer

There has been repeated coverage in the last few years that mobile phones will increase your chances of getting both malignant and benign forms of brain tumours. There has been vehement criticism of this coverage, claiming that there is no scientific evidence to support such an association, and that reporting a link is inappropriate at best, irresponsible scaremongering at worst.

In actual fact, there is now a large amount of epidemiological literature assessing the risk of mobile phone usage and brain cancer. In reality we would not expect studies to have found a link at this point in time, as the latency period (time between exposure to cause and diagnosis of cancer) of most brain tumours is between 15 and 25 years, and mobile phones have only been in widespread usage for about 10 years.

Despite this, a number of papers are now showing since of a significantly increased risk of brain cancer incidence from long term usage (over 10 years) have now been published:

Lennart Hardell and Swedish Research

Oncologist Lennart Hardell and his colleagues has been researching this association for about 10 years and has published numerous papers covering their findings. Starting with preliminary work at the turn of the century where they found a statistically significant 1.4-fold increase in risk for brain tumours (not sub-categorised) on the same side of the head as the mobile phone was used[Hardell 1999, Hardell 2000].

In 2002, looking at 1617 patients histopathologically diagnosed with brain tumours, they found that use of analogue mobile phones was associated with a significant 30% increase in risk for brain tumours (overall). This increased to 80% when only looking at patients who had used their phone for over 10 years, and further to 150% (2.5 times as likely to develop a brain tumour) when side of the head was taken into account. For acoustic neuromas, the increase in risk was 250% [Hardell 2002]. This was followed in 2003 by a separate analysis that found that Astrocytomas also had a significantly increased risk of 80%[Hardell Feb 2003], and a subsequent paper finding a 3.5-fold risk of Acoustic Neuroma from mobile phone use (CI 1.77-6.76)[Hardell Mar 2003]

By 2005, with the Interphone project fully underway, brain tumour risk from mobile phone usage was generally sub-categorised into acoustic neuromas, meningiomas and gliomas. Hardell produced a paper in 2005 analysing the increase in risk for acoustic neuromas and meningiomas. With a very good response rate (85%) he found that, for a mobile phone usage of greater than 10 years, the odds ratio for meningiomas was 2.1 (CI 1.1-4.3) and for acoustic neuromas this was split further into digital mobile phones (2.0 - CI 1.05-3.8) and analogue mobile phones (4.2 - CI 1.8-10)[Hardell 2005]. By this stage his results were consistantly pointing towards a possible doubling in risk, and this for mobile phone users who had not used their phone for as long as the typical latency period for the tumours! Hardell also published one of the only papers to date looking at risk of non-hodgkin's lymphoma, finding a 6-fold increase for over 10 years of use. He did highlight however that there were very few cases and that the results should be interpreted with a fair degree of caution[Hardell Sept 2005].

In February 2006 Hardell published a paper using more recent diagnoses (patients diagnosed between 2000 and 2003), and found that the increase in risk was steadily strengthening in magnitude and statistical significance as the length of phone usage was increasing. For malignant tumours he found that the OR for analogue phone use was 2.6 (CI 1.5-4.3), for digital phone use was 1.9 (CI 1.3-2.7),

and for cordless phone use was 2.1 (CI 1.4-3.0). Looking at patients who had used their phones for 10 years or more this increased to 3.5 (CI 2.0-6.4), 3.6 (CI 1.7-7.5) and 2.9 (CI 1.6-5.2) respectively[Hardell Feb 2006]. This work was followed up in October 2006 looking specifically at acoustic neuromas (a benign form of brain tumour), astrocytomas and non-hodgkin's lymphomas. He found acoustic neuromas and the higher grades of astrocytoma (Grades III and IV) to have significant increases from all forms of mobile and cordless phone usages (around 50% increase in risk in each case), which increased further for those who had used their phone greater than 10 years. However, he found no increase for lower grade astrocytomas (Grade I and II), and no increase for non-hodgkin's lymphomas in contrast to his paper from the previous year[Hardell Oct 2006].

Hardell's published a meta-analysis in September 2007 of the existing literature to date (2 cohort studies and 16 case-control studies). His findings were a 140% increase in risk for benign acoustic neuromas (CI 1.1-5.3) and a 100% increase in risk for malignant gliomas (CI 1.2-3.4), with further increased risks when looking at ipsilateral exposure[Hardell Sept 2007]. His summary so far on all the work (including work from othor researchers) is that "Results from present studies on use of mobile phones for > or =10 years give a consistent pattern of increased risk for acoustic neuroma and glioma. The risk is highest for ipsilateral exposure.

Flaws, Recall Bias and Selection Bias

As he is one of the only researchers consisently finding an effect, he has received a lot of criticism for the expected quality (or lack of) his work. The primary criticism that has been directed at his work is that of recall bias (failure of the mobile phone users to correctly remember the amount of usage and the side of the head). However (and primarily for the Interphone study), this has been addressed by Vrijheid in a study that found that heavy users generally overestimated their use and light users generally underestimated their use[Vrijheid 2006]. As the high risk category is the heavy users, an overestimation of use would imply the risk is actually attributed to lower usage, which will lead to an underestimation of risk. Vrijheid also found a small element of inaccuracy of users recalling which side of the head their phone used which may contribute to an slight overestimation of risk in the highest user category[Vrijheid 2008]. The other Interphone study to look at recall bias found that users were more accurate at recalling phone usage in terms of number of calls made than total phone usage, but without comment as to how this was likely to effect the reported risk[Samkange-Zeeb 2004]. One of the Interphone papers looked at selection bias, and found that approximately 10% less cases responded than controls (70% and 80% response rates respectively)[Lahkola 2005]. If this difference is real, it would lead to an overestimation in risk, but it is only based on one of the Interphone studies and Lloyd Morgan's pooled analysis found only 60% of controls responded on average (See the section on flaws of the Interphone Project below) - if so, this would instead lead to an underestimation in risk.

The Interphone Project

The Interphone project, initiatied in 2003, is a multi-national initiative aiming to fully examine the association between long term mobile phone usage and increases in risk for all forms of brain cancer. Unfortunately, there are a a number of flaws with the design of the studies in the Interphone project. One of the major flaws is a lack of inclusion in most of the studies of any form of recognition of digital cordless phone users. With the handset similar to a phone and the base unit exposing users all the time whilst they are in the building, this becomes a very large confounder for using "length of phone usage" as a metric of exposure level. There have been a number of other issues on an individual study basis, such as the Danish cohort study towards the end of 2006[Schuz Mar 2006, Schuz Dec 2006] which was hyped as being a "definitive study", containing some 400,000 people in the dataset. Sadly, as we covered in great detail in December 2006, the classification of these subjects was extremely misleading: Firstly, only contract users were considered as those were the only users that it was possible to identify. All "pay as you go" users were classified as "non-mobile phone users" and effectively moved into the control group - this would lead to an underestimation of risk. Originally the authors had 720,000 records, of which 100,000 were removed (quite validly) due to duplication. Out of the remaining 620,000, a further 200,000 were removed because they "couldn't identify the users" as the contracts were corporate and not linked to any specific individual. By the authors' own admission these were likely to be the heaviest phone users in the dataset, so another 33% of the heaviest users they were looking for were moved in to the "non-user" control group, which would also lead to an underestimate the risk. Strangely, the study's findings then highlighted a significant protective effect (7 of the 18 data points had a statistically significant reduction in risk), which disappeared in the highest usage category. One reason for this is the flaws detailed by Lloyd Morgan

below, that would expect a significantly reduced OR in cases when compared to controls. If these are controlled for in the statistical calculations, we end up finding an increase in risk of 30% for the heaviest users, reaching borderline significance!

Lloyd Morgan, an American researcher and electronic engineer (and currently Director of the Central Brain Tumor Registry of the United States), has been writing about the Interphone papers as each one is published, and has explained the major flaws with the Interphone protocol in great detail in his column. The summary of the 6 primary flaws are listed below:

Flaw 1: Selection Bias

The first flaw is called selection bias. It is likely the result of the low percentage of controls that participated in the studies (weighted average of 59%). Think about being randomly selected for a cellphone study. You are told you will be asked to answer a long questionnaire. If you use a cellphone you are more likely to agree to participate than if you do not use a cellphone. If this happens it is called selection bias. Selection bias will result in an underestimation of risk.

Flaw 2: Inclusion of Tumors Outside the Cellphone's Radiation Plume

The second flaw is the inclusion of all brain tumors without regard to their location. Because the cellphone's radiation plume only penetrates a short distance into the head, nearly all of this radiation is absorbed by the temporal lobe, the acoustic nerve, or the parotid gland. Even when cellphone exposure of one side of the head is considered on the side where the cellphone was held, a substantial portion of half the brain is unexposed (the opposite side is completely unexposed). Studies that include brain tumors outside of the cellphone radiation plume contribute to an underestimation of the risk of brain tumors.

Flaw 3: Latency Time and Definition of Regular User

The third flaw is the definition of "regular" cellphone use in relation to a reasonable latency time. "Regular" cellphone use is defined as use of a cellphone on average once per week for at least 6 months. Exposure within 1 year of the diagnosis date is not considered. The result of this definition, combined with the incredibly fast rate of new cellphone users, is to overweight "regular" users with an incredibly large group of short-term users - far too short a time to expect a tumor to be diagnosed.

The latency time for brain tumors is between 15 and 25 years. For the Interphone studies, using weighted averages for cases or controls, we see that 0.61% of cases and 10% of controls have used a cellphone for 10 years or more, and 18% of cases and 21% of controls have used a cellphone for 5 years or more. For a reasonable latency time, it would be unlikely to find any risk of tumors, given the percentage of cases and controls. Yet some of the Interphone studies are already finding a risk. Because such a large percentage of "regular" users have used a cellphone for an unreasonably short latency time the reported results for < 10 years as well as for > 10 years (6.3% of cases) are an underestimation of risk.

Flaw 4: Children and Young Adult Are Not Included in Interphone Studies

The Interphone Protocol states that cases be between 30 and 59 years of age While a few studies have included cases as young as 20, the non-inclusion of < 20 year olds results in an underestimation of risk. Why? Because children, with their high rate of cell division, are likely to be at a higher risk of tumors than adults. It is generally accepted that teenagers and young adults are the primary users of mobile phones.

Flaw 5: Cellphone's Radiated Power

It is reasonable to expect that risk of a tumor from a cellphone, after a reasonable latency time, would be the cellphone's power multiplied by cumulative time of use. In the early days of cellphone use all cellphones used analog technology. These always radiated a fixed amount of power (~2 Watts). Analog cellphones use has been totally displaced by digital cellphones. Digital cellphones have a feature called Automatic Power Control or APC. At the beginning of a call the cellphone radiates maximum power (~2 Watts) but quickly reduces the power so the radiated power is sufficient to have a reliable link to the cell tower (AKA masks or base stations). The result is that cellphones radiate far less power in urban areas compared to rural areas. This is because cell phone towers are much closer in urban areas compared to rural areas so the cellphone radiates less power in urban areas and more power in rural

areas. When rural and urban cellphones are not reported separately the result is an underestimation of risk.

Flaw 6: Number of Cases Included in a Study

The weighted average time in these 9 studies for a case to be eligible for inclusion in the study was only 2.6 years. When one considers 4 of the 5 previous flaws, it becomes obvious that such a short period of time for eligibility will result in too few cases to resolve these flaws. For example, if tumors were limited only to the exposed region of the brain then there would be far fewer cases; if a reasonably long latency time was included, again there would be far fewer cases; if children had been included there would have been more cases; and, if rural users were to be compared to the far larger number of urban users a much larger number of cases would need to be eligible to participate in the Interphone Study.

In this year's (2008) BEMS (Bioelectromagnetics Society) meeting, Lloyd presented a thorough talk outlining all of these flaws, their implications, and how this affected the statistical data represented in the papers. He summarised that with the flaws shown above one would expect an OR for the cases of approximately 0.8 (i.e. the combined underestimation of risk would lead to approximately 20% less cases in the cases than in the controls), and anything above that should be treated as if it is proportionally above 1.0. Interestingly, this would closely match our original theory as speculated in January 2007 when one of Lahkola's studies[Lahkola 2007] was published, based on crude statistical analysis of suspicious looking figures. Lahkola published a meta-analysis of scandinavian papers in August 2008 that similar found these strongly significant protective effects, with an OR 0.76 (CI 0.65-0.89)[Lahkola 2008]!

It wasn't just Lahkola's work though, a number of the Interphone studies have found statistically significant ***protective*** effects from mobile phone usage[Schuz Mar 2006, Schuz Dec 2006, Christensen 2005, Lonn 2005, Klaeboe 2007], and despite these flaws some have still found statistically significant increase in risk for the heavier group of mobile phone users[Hepworth 2006, Lonn Nov 2004, Schoemaker 2005].

A number of the papers have not shown this unlikely looking protective effect and have still not shown an increase[Christensen 2004, Takebayashi 2006, Takebayashi 2008, Hours 2007], but it is important to remember that with around 5% of the cases having used their phone for 10 years or more we would not expect to see a risk anyway (as the latency period for these tumours tends to be between 15 and 25 years). The fact that any papers are showing a risk is very concerning.

Other Research

There have been a number of other epidemiological papers published over the last 10 years looking at mobile phones and brain cancer, but most of these have failed to find an effect. This is unsurprising, as the studies were published a number of years ago and the cases involved had used their phones for less than 5 years - far too short a period to find any risk of brain tumours[Lonn Jan 2004, Cook 2003, Muscat 2002, Johansen 2001, Inskip 2001, Muscat 2000]. More recently Kan performed a meta-analysis on 9 case-control studies, finding no increase of risk overall but a statistically significant increase in risk (OR 1.25) for those who have used their phone for more than 10 years (CI 1.01-1.54)[Kan 2008].

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3. Mobile Phones and Other Tumours

Parotid / Salivary Gland Tumours

An Israeli study this year found a statistically significant association between mobile usage and parotid gland (salivary gland) tumours[Sadetzki 2008]. Whilst the findings show a 60% increase in risk, other research from the previous 5 years failed to find an increase[Lonn 2006, Hardell 2004, Auvinen 2002]. That said, this is another tumour with a long typical latency period (20 years), so any effect would be unexpected and should be treated with concern at this stage. Lloyd Morgan has produced another excellent analysis on why some of the studies may have not found the effect that the Israeli paper found.

Other Tumours

Other tumours that have been assessed but found to have no association with mobile phone usage are central nervous system tumours and arrhythmia-related heart diseases[Johansen 2004], and malignant melanomas of the eye[Johansen 2002].

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4. Mobile Phone Radiation and Fertility

The other issue to have received a large amount of media attention recently is a possible link between mobile phone usage and male infertility. The 5 papers we have on our database found statistically significant effects on fertility from heavy mobile phone usage[Baste 2008, Agarwal 2008, Erogul 2006, Fejes 2005, Grajewski 2000]. Lennart Hardell published a paper in 2007 looking at phone use and testicular cancer, where an association was not found[Hardell April 2007].

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5. Mobile Phone Radiation and EEG or Neurological Effects

Mobile phone usage has expanded enormously over the last 10 years, and teenagers / young adults are now amongst the heaviest users. There have been reports that concentration, behaviour, memory and other cognitive performance have been negatively affected by mobile phones and their base stations. If these are true, extensive mobile phone use could be responsible for behavioural and performance issues in children of school age - A study published in July 2008 found that children exposed prenatally and early postnatally to mobile phones had an 80% increase in behavioural problems (CI 1.45-2.23)[Divan 2008] Other research into prenatal exposure has found that mobile phone exposure has a significant effect on foetal heart rate and cardiac output[Rezk 2008]. The following is a brief summary of the research looking into neurological effects from mobile phone or other pulsed RF electromagnetic field exposure.

Neurological Effects

With two exceptions (a Chinese study that found reaction times decreased from pulsed RF exposure[Cao 2000], and a recent study from Germany finding no effect on cognitive function or sleep[Fritzer 2007]), research has found that exposure to mobile phone or other pulsed RF radiation exposure improved reaction times[Preece 2005, Koivisto Feb 2000], general cognitive performance[Edelstyn 2002], and high intensity memory tasks[Krause Dec 2008, Koivisto June 2008, Krause March 2006]. A Turkish paper from 2006 also found significant temporary hearing loss from mobile phone exposure[Oktay 2006].

The precise implications and cause (if the association is truly causal) is not clear, but it is clear that the pulsed radiofrequency electromagnetic fields produced by mobile phones is having some effect on attention, concentration, memory, reaction times and general cognitive performance.

EEG and rCBF Effects

Sleep, EEG (electroencephalograph) and waking rCBF (regional cerebral blood flow) have been studied in relation to RF exposure for a decade now, and the majority of papers published have found some form of effect. Whilst a Finnish study failed to find any effect on sleep or other cognitive function from pulsed RF exposure[Haarala 2007], most other papers have found significant effects on sleep[Hung 2007, Huber 2005, Huber 2002, Huber 2000, Borbely 1999, Andrzejak 2008]. Interestingly, two of these papers found the effect was only present when the exposure was pulsed (amplitude modulated)[Huber 2005, Huber 2002], and one early paper actually found that sleep quality(measured by the amount of participants' broken sleep) actually improved[Borbely 1999]!

Whilst some papers were inclusive or inconsistent[Krause 2007, Papageorgiou 2006], a number of studies have now demonstrated reversible EEG and rCBF alterations from exposure to pusled RF exposure[Aalto 2006, Krause June 2006, D'Costa 2003, Kramarenko 2003]. German research from 2006 found that statistically significant EEG changes could be consistently found, but only in a relatively low proportion of study participants (12 - 30%)[Bachman 2006].

Other Effects

Mobile phones have been negatively associated with subjectively reported symptoms such as headaches, nausea, concentration issues, dizziness, blurred vision and a number of other symptoms that tend to be grouped under the umbrella category Electromagnetic Hypersensitivity. A number of double blind provocation studies have failed to find the association (see our electromagnetic hypersensitivity page for further details), though there are a number of theorised flaws on the methods by which traditional provocation studies are carried out.

Bruce Hocking has published 3 studies at the beginning of this decade looking specifically at finding objective signs on people subjectively suffering from some form of general dysaesthesiae (impairment of any of the senses), finding significant signs of nerve damage in those suffering[Hocking 2001, Hocking 2002, Hocking 2003]. These findings support the possibility, and provide a plausible mechanism, of subjective symptoms that some mobile phone users report to suffer from. The papers are all from only one author, but there are no papers that have attempted to replicate these findings, which now seems long overdue.

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6. Mobile Phone Radiation and DNA Strand Breaks / Cellular Damage

DNA Strand Breaks and Cell Mutation / Death

As early as 1996 researchers have found that radiofrequency EMFs are capable of causing cellular damage, when scientists from Canada found that prolonged (24 hour) exposure to 900 MHz radiation damaged the lungs of live pigs[Singh 1996]. Since then, a number of *in vivo* experiments have found mobile phone or simulated mobile phone radiation exposure can cause cell damage, reactive oxygen species formation (which are the primary cause of DNA strand breaks), and cell death[Oktem 2005, Oral 2006, Ferreira 2006, Panagopoulos 2007, Yan 2008].

It is often claimed that there is insufficient energy in microwave frequency radiation to cause DNA strand breaks (as in the case of, for example, ionising radiation). What is less known is that the primary cause of DNA strand breaks is not high energy radiation, but as a byproduct of ROS (reactive oxygen species) creation. A number of *in vitro* experiments have found an association between RF exposure and ROS production, and then subsequent DNA single and double strand breaks[Nikolova 2005, Friedman 2007, Yao May 2008(1), Yao May 2008(2)], though some papers have failed to replicate this effect[Lantow 2006, Valbonesi 2008].

There have also been a number of other cellular effects found, from cell mutations (such as micronuclei formation and cellular aneuploidy)[D'Ambrosio 2002, Hoyto 2007, Mazor 2008, Schwarz 2008], and even impaired cell repair or cell death[Joubert 2008, Manti 2008].

Heat Shock Protein Type Effects

Heat Shock Proteins are also known as "stress proteins", and are known for increasing their expression when their cells are exposed to elevated stress. It is known that microwave frequency radiation sufficient to heat tissue trigger the increase in heat shock protein response, but research has found effects in both sub-thermal levels of RF exposure, and levels of response beyond those expected from just heating effects for higher levels of exposure[Velizarov 1999, de Pomerai 2003, Czyz 2004, Belyaev 2005, Nylund 2006, George 2008].

Nerve Damage and Signalling Effects

Finally, a number of papers have found effects on nerve damage, calcium pathways, and neurotransmitter expression from exposure to pulsed microwave radiation[Lai 1989, Lai 1994, Donnellan 1997, Leszczynski 2002, Salford 2003, Wang 2004, Wang Mar 2005, Wang Sept 2005, Rao 2008]

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