



ELECTRO-MAGNETIC FIELDS FROM MOBILE PHONES: RECENT DEVELOPMENTS

LLOYD'S EMERGING RISKS TEAM REPORT

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EMERGING RISKS TEAM

The Emerging Risks team is part of the Performance Management Directorate at Lloyd's. We define an emerging risk as an issue that is perceived to be potentially significant, but which may not be fully understood or allowed for in insurance terms and conditions, pricing, reserving or capital setting. Our objective is to ensure that the Lloyd's market is aware of potentially significant emerging risks so that it can decide on an appropriate response to them. The Lloyd's Emerging Risks team maintains a database of emerging risks that is updated regularly through conversations with the Lloyd's emerging risks Special Interests Group, which consists of experts within the Lloyd's market put together with help from the Lloyd's Market Association. The team also maintains contact with the academic community, the wider business community and government. Contact with academics is often facilitated through the Lighthill Risk Network, an organisation that is run as not-for-profit funded by AonBenfield, Catlin, Guy Carpenter and Lloyd's.

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EXECUTIVE SUMMARY

This paper considers whether exposure to electromagnetic fields (EMF) from mobile phone use can cause health problems and the impact this could have on the insurance industry. The main conclusions of the report are:

1 THE WORLD HEALTH ORGANISATION RECOMMENDS A PRECAUTIONARY

APPROACH. Despite the view of the WHO and the European Union that there is at present no conclusive evidence of adverse effects caused by EMF they believe the slow emergence of health impacts means that governmental bodies should impose exposure limits as recommended by the International Commission for Non-Ionising Radiation Protection. They also recommend longer term studies with people exposed for over ten years and with those exposed to higher levels.

2 THE MAJORITY OF EPIDEMIOLOGICAL STUDIES SHOW NO INCREASED RISK OF BRAIN CANCER.

Most new scientific research studies into the health effects of EMF focuses on the possible increased risk of brain cancer. Although the majority find no increased risk they conclude that the long latency periods (time between exposure and the appearance of the disease) of some cancers mean that more long-term studies are needed before any risk can be ruled out. Two studies have shown an increased risk of certain types of brain cancer but there are problems associated with the methodology of these studies. Neither in vivo (experiments on laboratory animals) nor in vitro (experiments on cell cultures) studies provide evidence that exposure to EMF can cause an increase in cancer risk.

3 NO CONCLUSIVE EVIDENCE OF OTHER MEDICAL ISSUES HAS YET BEEN

DEMONSTRATED. Other potential health issues resulting from exposure to EMF include self-reported symptoms such as headaches and dizziness, nervous system effects and impacts on reproduction and development. So far there is no conclusive evidence to support the theory that EMF causes any of these problems.

4. MORE RESEARCH NEEDS TO BE CONDUCTED ON HOW EXPOSURE AFFECTS

CHILDREN. It is very difficult to make conclusions about the affects on children from studies on adults. There is some evidence showing that due to physiological differences children are actually subject to exposures higher than the recommended limits. Further research is needed to rule out risks in this area.

5 LEGAL CASES TO DATE FAVOUR THE MOBILE PHONE INDUSTRY.

In *Newman v Motorola* (2002) the judge rejected the plaintiffs' expert witness' evidence that EMF causes brain cancer on the grounds that it was generally not widely accepted by the scientific community, and that there were flaws with recall bias in the studies. In *Murray v Motorola* (2009) the judge ruled that plaintiffs are not able to claim for damage caused by mobile phones which conform to US legislation. However, the case is proceeding alleging the defendants have fixed the results of their exposure tests and have suppressed information.

6 EMF CASES COULD BE MORE COMPLEX THAN ASBESTOS CLAIMS.

Similar issues would occur such as the definition of an actionable injury, policy triggers and apportioning liability. The latter would be even more difficult than asbestos cases since in 70% to 80%¹ of cases mesothelioma is caused by exposure to asbestos, whereas brain cancer arises in many more cases where there has been no exposure to EMF.

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1. INTRODUCTION

Mobile phone use has increased rapidly worldwide since the early 1990s. In June 2009 there were more than 4.3 billion mobile phone connections around the world². Mobile phones emit radio and microwave frequency electromagnetic fields (EMF), and there are many concerns about possible health effects of such EMF exposure.

There has been wide coverage of this issue in the press as well as a large body of scientific research into the issue. Unfortunately, due to the potential long term impacts of EMF exposure on health, there are so far no definitive conclusions as to whether EMF is harmful or not.

To judge any potential impact of EMF on the insurance industry we should look at both the available scientific research and the implications that a conclusive link between EMF and disease could have to applicable policies.

This document looks first at current views on EMF as stated by international bodies such as the World Health Organisation and the European Union, and then goes on to examine recent scientific research into the field. It finally considers the implications for the insurance industry by scrutinising current legal cases on EMF and any comparisons which can be drawn with asbestos.

2. CURRENT INTERGOVERNMENTAL POSITION

The position of the WHO and the EU is that at present there is no conclusive evidence that EMF exposure under the current legislative levels causes adverse effects on health. More research is needed on long-term studies with people exposed for over ten years. They therefore recommend a precautionary approach to the use of this technology and that governmental bodies impose exposure limits as recommended by the International Commission for Non-Ionising Radiation Protection (ICNIRP).

2.1 WHO

The WHO document 'What effects do mobile phones have on people's health?' published in November 2006 states that "the evidence available does not provide a clear pattern to support an association between exposure to radio frequency (RF) and microwave radiation from mobile phones and direct effects on health."³ However it cautions that lack of available evidence of detrimental effects on health should not be interpreted as evidence of absence of such effects and recommends a precautionary approach to the use of this communication technology until more scientific evidence becomes available. The WHO intend to update its position on EMF and health effects in 2010, after publication of the Interphone study (see section 3.2.1.1).

2.2 EU

The Scientific Committee on Newly Identified and Emerging Health Risks (SCNIEHR) updated its position on the *Health Effects of Exposure to EMF* in 2009⁴. It concludes that mobile phone use for less than ten years is not associated with cancer incidence, though further studies are required to identify whether longer term human exposure might pose some cancer risk. It therefore also recommends a precautionary approach in line with the WHO. In 2008 the EU parliament passed a resolution on the mid-term review of the European Environment and Health Action Plan 2004-2010 which means it must update its position on the health risk associated with EMF and review exposure limits⁵. The parliament is due to respond in 2010.

2.3 Exposure Limits

Guidance on exposure limits is given by the International Commission for Non-Ionizing Radiation Protection (ICNIRP)⁶, which has been adopted by over 80 countries, and the Institute of Electrical and Electronics Engineers (IEEE) in the US. The rate at which radiation is absorbed by the human body is measured by the Specific Absorption Rate (SAR), and maximum levels are set by many governments, based on the ICNIRP and IEEE recommendations.

In the US, the Federal Communications Committee has set a SAR limit of 1.6 watts per kilogram(W/kg), averaged over a volume of 1 gram of tissue, for the head. In Europe, the limit is 2 W/kg, averaged over a volume of 10 grams of tissue⁷. SAR values are difficult to measure and heavily dependent on the size of the averaging volume and so it is not possible to compare the two standards.

Mobile phones are tested under worst case conditions by the committee - at the highest power level. The emitted power is often considerably lower than the maximum power due to various factors like power control and discontinuous transmission.

Guidelines are drawn up with the intention of protecting against acute effects of high levels of EMF exposure, such as stimulation of nerve and muscle cells due to induced currents and tissue heating. The current potential health issues surround the possibility that health effects could occur at exposure levels below those set in the guidelines when exposure is over a longer term.⁸

3. SCIENTIFIC EVIDENCE OF HEALTH EFFECTS

This section looks at recent research into whether EMF exposure from mobile phones can cause adverse health effects. It first considers whether there is an increased risk of cancer by considering epidemiological, in vivo and in vitro evidence. The majority of epidemiological evidence shows no increased risk of brain cancer with EMF exposure. Two studies have shown an increased risk of certain types of brain cancer on the same side of the head as phone use, which is where the EMF is absorbed, however, it could not be concluded whether this was due to a causal effect or recall bias. Neither in vivo nor in vitro studies provide evidence that exposure to EMF can cause an increase in cancer risk. It then goes on to look at other potential health issues including self-reported symptoms, nervous system effects, reproduction and development and potential effects on children – so far there is no conclusive evidence to support the theory that EMF causes any of these problems. It should be noted, however, that more long-term studies are needed before any risk can be ruled out, particularly on children.

3.1 Background

In the 1980s first generation mobile phones, using analogue technology, only transmitted sound. Digital transmission and the global system for mobile communication started in 1991 and included new developments such as data and image transmissions. Third and fourth generation mobile phones currently on the market offer additional services to the user such as high speed internet access. All mobile phone signals transmitted and received are in the form of waves in the Radio Frequency (RF) and Microwave parts of the spectrum.

Waves

RF wave radiation is non ionizing radiation with wavelengths that range from 3kHz to 300MHz.

Microwaves have wavelengths which range from 300Mhz to 300GHz and are also non ionizing.

Non ionizing radiation means that the radiation does not have enough energy to cause direct damage to DNA, and so is unlikely to cause cancer formation via the mechanism of DNA damage.

Since mobile phones are used close to the head and the radiofrequency is absorbed mainly within a small area of the skull near the handset, most research is into the possibility of mobile phone use increasing the risk of brain cancer, focusing on intracranial tumours⁹.

Other research into health effects of mobile phone use looks at self reported symptoms: nervous system effects; reproduction and development; and effects on children, all of which will be considered briefly below.

3.2 Cancer

There are three lines of investigation into whether exposure to EMF is involved in carcinogenesis:

- Epidemiology (the study of groups of people to see if certain factors affect the health of populations).
- In vivo experiments (on laboratory animals).
- In vitro experiments (on cell cultures).

Epidemiology

Epidemiology is the field where the most research has been carried out. Absorption of EMF from mobile phones is highly localised; therefore the preferred side of the head during mobile phone use becomes an important parameter of the exposure estimation. This means there is particular interest in the comparison of cancer rates in ipsilateral phone use (where the phone was used against the same side of the head to where the tumour occurred) and contralateral phone use (where the phone was used against the opposite side of the head to where the tumour developed). It is also interesting to see if more brain tumours occur in the region of the brain nearest the ear, as this is where most of the EMF will be absorbed.

Most epidemiological studies look at whether there is a greater risk of brain cancer with EMF exposure. Many of these studies refer to odds ratios (OR) and confidence levels (CL). The glossary at the conclusion of this report provides an explanation of these terms.

1. Interphone Study

The Interphone study is a series of multi-national case-control studies (see glossary) coordinated by the International Agency for Research on Cancer, designed to assess whether RF exposure from mobile telephones is associated with cancer risk. There were 13 participating countries, and the studies included 2,708 cases of gliomas and 2,408 cases of meningiomas (both benign and malignant), as well as around 1,000 cases of acoustic neuroma, 600 cases of parotid gland tumours and their respective controls(see glossary)¹⁰. Information on past mobile phone use was collected during face-to-face interviews with regular users of a mobile phone. Regular was defined as having had an average of at least one call per week for a period of more than six months.

The results of the study on gliomas and meningiomas (see glossary) were published on 17 May 2010,^{11 12} Surprisingly, the results showed that people who had been a regular mobile phone user are less at risk of developing brain tumours (Glioma OR 0.81, 95% CL 0.70-0.94, Meningioma OR 0.79, 95% CU 0.68-0.91). This possibly reflects participation bias or other methodological limitations. No elevated risks were seen more than ten years after first phone use, or for all deciles of lifetime number of phone calls and nine deciles of cumulative call time. In the highest decile of recalled cumulative call time (more than or equal to 1,640 hours), an increase in risk was seen (Glioma OR was 1.40, 95% CR 1.03-1.89, Meningioma OR 1.15, 95% CL 0.81-1.62) but there were implausible values of reported use in this group, which prevents conclusions being drawn. Increased risks were seen for gliomas in the temporal lobe (the region of the brain located nearest the ear) compared to other lobes of the brain, but because the CLs around the lobe-specific estimates were wide it is again difficult to draw firm conclusions. ORs for glioma tended to be greater in subjects who reported usual phone use on the same side of the head as their tumour than on the opposite side.

Overall the study concludes no increase in risk of glioma or meningioma was observed with use of mobile phones. Though there are suggestions of increased risk in the top 10% of

cumulative call time, gliomas in the temporal lobe and in subjects who reported ipsilateral phone use biases and errors limit the strength of the conclusions and no causal link can be drawn from the study. The study also concludes that the possible effects of long-term heavy use of mobile phones require further investigation

There have been several issues with regards to the Interphone study design:¹³

- a) Selection bias – refusal to participate is related to lower use of mobile phones in controls, and this could result in a downwards bias in odds ratios for regular mobile phone use.
- b) Potential error in the recall of phone use – errors appeared to be larger for duration of calls than for number of calls, and phone use was underestimated by light users and over estimated by heavy users.
- c) The possible effects of recall errors were evaluated and results suggest that random recall errors can lead to a large underestimation in the risk of brain cancer associated with mobile phone use.

In response to these criticisms the IARC published a paper on the methodology used and recalculated the results before production of the findings outlined above¹⁴. This was one of the reasons publication of results were delayed (they were expected in 2005), and though the IARC have made efforts to correct these issues, there is still criticism of the Interphone study. Methodological limitations could be the reason behind some of the findings, particularly those indicating people using mobile phones are less likely to develop brain cancer.

The report concludes saying that the majority of subjects in this study were not heavy users by today's standards, with a median of two to two and a half hours of reported use per month. Today it is not unusual for young people to use mobile phones for an hour a day or more, though increasing use is tempered by lower emissions from newer technology phones and the increasing use of texting and hands free operations that keep the mobile phone away from the head. As this increase in use in young people was not covered by Interphone, CREAL is co-ordinating a new project, MobiKids¹⁵ to investigate this issue. This project is funded by the EU to investigate the risk of brain tumours from mobile phone use in childhood and adolescence.

Two of the most interesting papers in the Interphone study, which do find raised ORs (see glossary) are discussed below.

2. *Lahkola et al 2007*¹⁶

This paper used the protocol of the Interphone study to look at 1,521 glioma patients and 3,301 controls. The study found no evidence of increased risk of glioma related to regular mobile phone use (OR 0.78, 95% CL 0.68-0.91), nor any significant association with duration of use, years since first use, cumulative numbers of calls or cumulative house use. However, for more than ten years of mobile phone use reported on the side of the head where the tumour was located (ipsilateral use), an increased OR of borderline statistical significance (OR 1.39, 95% CI 1.01, 1.92) was found, whereas similar use on the opposite side of the head (contralateral use) resulted in an OR of 0.98 (95%CL 0.71, 1.37). This result was particularly important as it was the first study where an observed increased OR for ipsilateral use was not compensated by an accordingly decreased OR for contralateral use, as would be expected under a hypothesised real effect. However, assuming causality, it would also be expected that the effect of laterality becomes stronger with increasing exposure. For ipsilateral and contralateral use ORs would be more or less close to 1.0 among short-term or occasional mobile phone users, but would then grow with increasing exposure, and this was not found in this study. The report concludes that it found an indication of increased risk in

relation to reported ipsilateral phone use of more than ten years duration, but that this could be due to either chance, causal effect or information bias. As well as the methodological problems outlined above for the whole Interphone study, this paper discussed the potential uncertainty in reporting the side where the mobile phone is held, which introduces random error and potential bias if the case believes the mobile phone was the cause of the cancer.

3. Schoemaker et al 2005¹⁷

This study also used the shared Interphone protocol to look at 678 cases of acoustic neuroma and 3,553 controls. The study found that the risk of acoustic neuroma in relation to regular mobile phone use in the pooled data set was not raised (OR 0.9, 95% CL 0.7–1.1). There was no association of risk with number of years of use, time since first use, lifetime cumulative hours of use, number of calls, or for analogue or digital phones separately, though as noted above cumulative number of hours of phone use and number of calls are subject to substantial misclassification in recall.

The interesting results of this study were that risk of a tumour on the same side of the head as reported phone use (ipsilateral use) was raised for use of ten years or longer (OR 1.8, 95% CL: 1.1–3.1), though risks were not raised for shorter durations of ipsilateral use, nor for overall ipsilateral use.

Owing to the potential for the reported side of use being influenced by recall bias, the study also analysed the relation of tumour laterality to side of handedness, but this produced results which were compatible with, but not strongly supporting, the results on reported side of use. Again, the study outlines the potential of self reported side of phone use as an extremely biased variable, since hearing loss produced by the tumour could cause the user to change use to the other ear, cases could over-report ipsilateral use because they believe it caused their tumour and tumours might be detected earlier in ipsilateral use as they may notice the hearing loss sooner. These biases can act to increase and decrease the risk, and given the multiple, contrary sources of bias the paper concludes no firm conclusions can be drawn from the analysis of side of use.

4. Findings of the WHO¹⁸

The WHO document 'What effects do mobile phones have on people's health?' published in November 2006 states that although weak and inconclusive, epidemiological evidence does not suggest that there are adverse health effects attributable to long term exposure to radio frequency and microwave frequency from mobile phones. However, it notes that recent studies have reported an increased risk of acoustic neuroma and some brain tumours in people who use an analogue mobile phone for more than ten years.

5. Findings of the SCNIEHR¹⁹

The SCNIEHR Reports 'Health Effects of Exposure to EMF' published in 2007 and 2009 comment on the draft findings of the Interphone study. It mentions the pooled analysis of glioma (Lahkola et al. 2007) which showed no increased relative risk for long-term mobile phone users of ten years or more as well as no increased relative risk estimates for the highest categories of lifetime cumulative number of calls or lifetime cumulative duration of calls. It also discusses the meningioma pooled analysis (Lahkola et al. 2008) where relative risk estimates were slightly decreased, e.g. for mobile phone users of ten years or more (OR=0.91, 95% CL: 0.67-1.25). It comments on two meta-analyses of case-control studies which were not part of the Interphone study, Hardell et al. 2008, Kan et al. 2008. No overall risk for brain tumours were found in the work by Kan et al. (2008), whereas both meta-analyses show an increased risk for brain tumours in long-term users (\geq ten years).

However, it concludes that both studies are of limited use because of inappropriate exclusion criteria and the combination of studies.

The paper discusses the validation studies conducted on the Interphone project, as outlined above, and concludes that it remains an open question whether increased ORs observed for ipsilateral use in many studies are a mixture of true effect and reporting bias or are due to such reporting bias in their entirety.

In vivo studies

The SCNIEHR 2009 Paper states that the results of new studies add to the evidence that the RF fields such as those emitted by mobile phones are not carcinogenic in laboratory rodents. Some of the new studies have also used exposure levels up to 4 W/kg which is higher than most previous studies. Thus, these studies provide additional evidence that carcinogenic effects are not likely even at SAR levels that clearly exceed human exposure from mobile phones. Animal studies have not provided evidence that RF fields could induce cancer, enhance the effects of known carcinogens, or accelerate the development of transplanted tumours. However, there remain questions about the adequacy of the experimental models used and scarcity of data at high exposure levels.

The WHO 2006 paper agrees with the SCNIEHR position, and stated that in vivo studies have found very small and reversible physiological changes. Evidence for an increased risk of developing cancer after exposure to RF or microwave fields was extremely weak. However, it cautions that there are difficulties in extrapolating findings from laboratory studies since the whole brain of rodents is exposed to the radiation as opposed to the small part of the brain with human mobile phone use, and thermal effects seen in rodents due to the increase in local temperature of the brain induced by the microwaves are negligible in humans (local increase in brain temperature has been estimated to be up to 0.1° C in humans). As the results of in vivo studies are inconclusive, it therefore concludes that the hypothesis that RF or microwave radiation is harmful and could have unknown or unrecognised effects on health, cannot be rejected.

In vitro studies

The radiation from mobile phones has much lower energy than the energy necessary to break chemical bonds, and it is therefore generally accepted that RF fields do not directly damage DNA and cause cancer by this mechanism. However, it is possible that certain cellular constituents are altered by exposure to EMF, such as free radicals, indirectly affecting DNA²⁰. The WHO 2006 paper²¹ stated that in vitro studies have shown abnormal cell proliferation, changes in cell membranes and movement of ions and substances across membranes, though there are large difficulties interpreting these results. Moreover, a biological mechanism that explains any possible carcinogenic effect from RF or microwave fields has yet to be identified. The EU concurs, stating that in vitro studies regarding genotoxicity fail to provide evidence for an involvement of RF field exposure in DNA damage.

Conclusions on cancer

- Exposure to RF fields is unlikely to cause brain cancer in humans with exposure lasting under ten years²². For exposures over ten years, there are some indications that exposure to EMF can cause increased odds ratios for gliomas²³ and acoustic neuromas²⁴. However, it is not known whether these are causal effects or due to recall bias.

- The conclusion that exposure to RF fields is unlikely to lead to an increase in cancer in humans is consistent with the observation that no visible increases are seen in the age specific incidence rates of tumours of the central nervous system in the Nordic countries over the last decade (Figure 2)²⁵. A noticeable increase in the central nervous system tumour incidence rates from 1970 to the late 1980s, particularly in older men and women, is assumed to be an effect of improved diagnostic methods and appeared long before the widespread use of mobile phones.

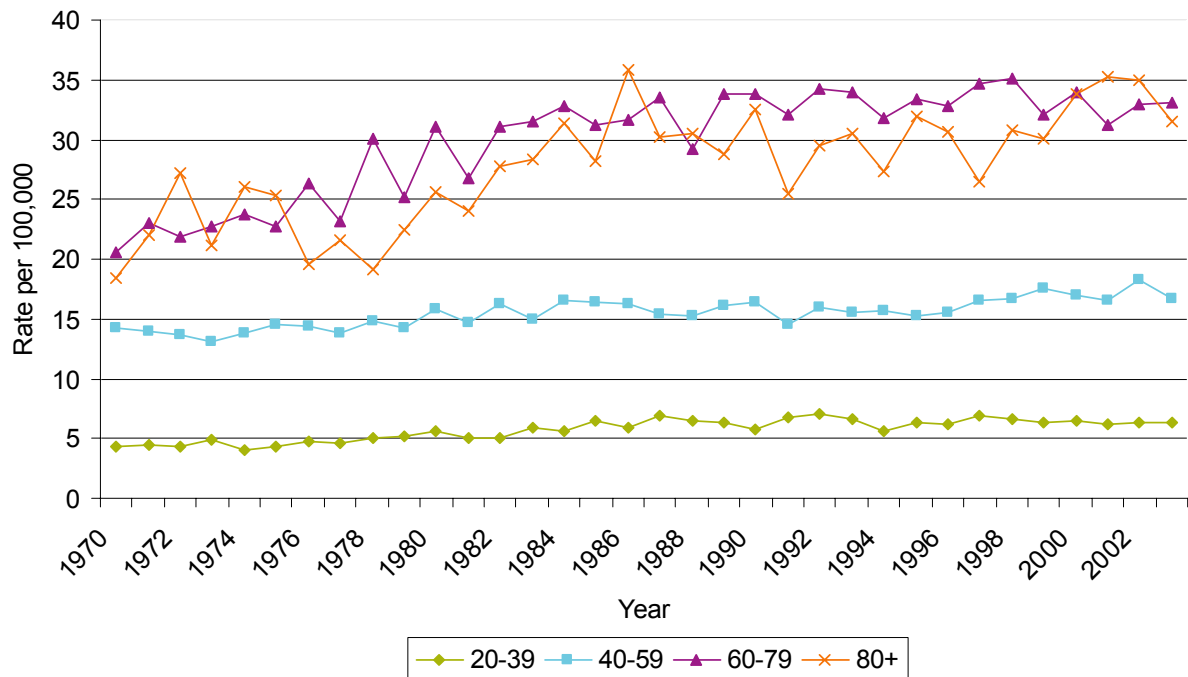


Figure 2: **Incidence of tumours of the central nervous system (CNS)** from 1970 to 2003 among men in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden), by age groups 20-39, 40-59, 60-79 and 80+ years (Engholm et al. 2008)²⁶

- However, due to very long latency times of some cancers (up to thirty years), it is widely agreed that long term studies are required to identify whether longer-term human exposure to mobile phone radiation may pose cancer risk²⁷.
- The recent implementation of digital mobile phone technology means that studies with exposures over ten years are small, and face many challenges as discussed above. The WHO² cautions that “lack of available evidence of detrimental effects on health should not be interpreted as evidence of absence of such effects” and concludes that more long term studies are required before it can be determined whether long-term exposure to EMF does increase cancer rates.

3.3 RF and self reported symptoms

The SCNIEHR 2009 report²⁸ concluded that scientific studies have failed to provide support for an effect of RF fields on self-reported symptoms, such as headache, fatigue, dizziness and concentration difficulties or well being, sometimes referred to as electromagnetic hypersensitivity (EHS). Scientific studies have indicated that a placebo effect (an adverse non-specific effect that is caused by expectation or belief that something is harmful) may

play a role in symptom formation. There is no evidence supporting the theory that individuals, including those attributing symptoms to RF exposure, are able to detect RF fields.

3.4 Nervous system effects

The SCNIEHR 2009 report²⁹ states that with the exception of a few findings in otherwise negative studies, there is no evidence that acute or long-term RF exposure at SAR levels relevant for mobile telephony can influence cognitive functions in humans or animals. There is some evidence that RF exposure influences brain activity as seen by electroencephalography (EEG) studies which record electromagnetic activity along the scalp in humans. Human studies also indicate the possibility of effects on sleep and sleep EEG parameters. However, findings are contradictory and there is a need for further studies into mechanisms that can explain possible effects on sleep and EEG. Other studies on functions and aspects of the nervous system, such as cognitive functions, sensory functions, structural stability and cellular responses show no or no consistent effects. There is also no evidence that exposure to RF fields at the levels relevant for mobile telephony have effects on hearing or vision.

3.5 Reproduction and development

The SCNIEHR 2009 reports concludes that the recent studies that addressed RF field effects on prenatal development in animals and the association of maternal mobile phone use with behavioural effects in children show that there are no adverse effects at non-thermal exposure levels.

3.6 Children

There are many concerns about the exposure of children to EMF from mobile phones. The SCNIEHR 2009 report discusses this in detail. Children's nervous systems have completed anatomical development at around two years of age, however, functional development continues up to adulthood, and could possibly be disturbed by RF fields.

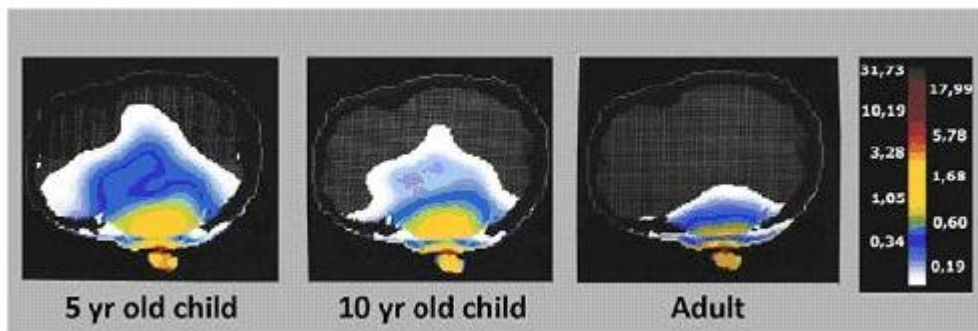


Figure 3: Estimation of the penetration of electromagnetic radiation from a cell phone based on age using computer generated models (scale on right shows the SAR in W/kg)³⁰

There are several differences between exposure to EMFs for children and adults, in that children will have much greater cumulative lifetime exposures and also that dosimetric effects may be different. Part of this is due to children having smaller brains, so more of the brain is exposed to EMF, and part of it is due to greater conductivity of the brain tissue as children's brains contains more water than adult brains.

Several studies (Gabriel 2005, Martens 2005, Schmid and Uberbacher 2005, Peyman et al 2007, Gandhi et al 1996) have indicated children have more conductive brain tissues, which

would lead to higher exposures. However, these were studies on the brains of dead animals and there are difficulties extrapolating this data from animals to children and from dead to living conditions. As shown in figure 3, the study by Gandhi et al (1996) was based on computer generated models.

In another study of a computer generated model of a five year old child it was shown that when the model is exposed to electromagnetic fields at the ICNIPR reference levels of public exposure, the standardised limits were exceeded by 40% (Conil et al. 2008). It is important to realise that this study refers to far-field exposure only, for which the actual exposure levels are orders of magnitude below existing guidelines. Far field exposure can be roughly defined as the recipient of the exposure being more than two wavelengths away from the source of the EMF. This would be from, for example, a transmitter rather than near field exposure which is the recipient being around one wavelength away from the source.

There are many difficulties extrapolating data from adult studies to children, and so it is important that further studies of the exposure of children to EMF should be carried out using a variety of models and exposure conditions. One positive conclusive result with regards to children and EMF exposure is that recent well conducted epidemiological studies provide evidence against an association between RF EMF exposure from broadcast transmitters and the risk of childhood leukaemia.

4. INSURANCE IMPLICATIONS

When considering the potential impact EMF could have on the insurance industry it is of course important to look at what will happen if it is scientifically demonstrated that EMF causes adverse health effects. It is difficult to be certain of any future outcomes so this section looks at where insurance cover is likely to be triggered, the current legal situation with EMF cases and finally considers the issue of asbestos and whether any comparisons can be drawn. If EMF is proved to cause an increased risk of brain cancer it is likely the insurance industry will see claims under product liability policies for bodily injury.

It is informative to look at recent legal cases to assess the current situation and the two following cases will be discussed in more detail below. *Newman v Motorola* (2002) is a very interesting case because the judge rejected the plaintiffs' expert witness' evidence that EMF causes brain cancer on the grounds that it was generally not widely accepted by the scientific community, and that there were flaws with recall bias in the studies.

Murray v Motorola (2009) is another intriguing case because the judge ruled that plaintiffs are not able to claim for damage caused by mobile phones which conform to US legislation. However, the case is proceeding regarding allegations that Motorola et al fixed the results of their exposure tests and have suppressed conclusive information about the health risks EMF poses.

Finally this section will draw comparisons between EMF and asbestos. The issue of asbestos and its implications is widely known throughout the insurance industry, and many comparisons can be drawn with EMF – the initial impression that it was a 'wonder product' coupled with potential very long-term serious health issues not understood at the start of its use. Like asbestos any EMF litigation will probably be long and complex – similar issues could occur such as the definition of an actionable injury, policy triggers and apportioning liability. The last issue will be particularly difficult, since brain cancer occurs without exposure to EMF, whereas mesothelioma usually arises from exposure to asbestos.

4.1 Insurance Cover

Should EMF prove to cause brain cancer, or any other adverse health effects, it is likely the main effect on the insurance industry will concern product liability claims for bodily injury. It is therefore interesting to look at recent legal cases where claimants have taken mobile phone manufacturers to court for bodily injury claims and also to look at asbestos and see what comparisons can be drawn between the two issues.

4.2 Legal cases

Newman v Motorola 2002³¹

In this US case Dr Newman claimed that his use of a wireless handheld telephone manufactured by Motorola caused his brain cancer. He filed for \$800m compensation in 2000. The court focused on the issues of general and specific causation – ie can the use of wireless handheld telephones cause brain cancer and did the use of the Motorola phone cause Dr Newman's brain cancer.

The plaintiff's expert witness claimed that EMF exposure causes brain cancer, a theory which relies on maximum exposure occurring at the location where the phone was held and the cancer occurred. Other witnesses gave evidence that in fact the cancer Dr Newman had was 'deeper' in the brain than normal, and that the highest exposure had in fact not been in the location of the tumour

Both sides filed motions to exclude the other's expert testimony. Because no sufficiently reliable and relevant scientific evidence in support of either general or specific causation had been offered by the plaintiffs, the defendants' motion was granted and the plaintiffs' motion

denied because it failed the Daubert principle (a set of guidelines governing the use of expert witness testimony in the US courts).

The reasons the judge gave for not accepting the plaintiff's evidence was that there had been no acceptance of the plaintiffs' theory and technique of demonstrating cancer causation in the scientific community, pointing to problems with recall bias in the studies he put forward as evidence.

The judge also said that overdue emphasis was put on the positive finding for isolated subgroups of tumours, and pointed out that there has been no overall change in the incidence of tumours such as Dr Newton's, despite the increasing use of cell phones. The judge said that reliable epidemiology evidence is essential before any link between animal studies and human cancer causation can be made. The decision was appealed, but upheld by the appeals court.

Although the ruling on this case was several years ago, there has not been a large amount of new scientific evidence since then. The judge's verdict shows that to be liable, there must be relevant and reliable evidence that exposure to EMF causes brain cancer, and this must be generally accepted in the scientific community. It is also worth noting the emphasis on epidemiological evidence above that of in vivo and in vitro.

Murray v Motorola 2009 ³²

In this US case six separate complaints filed in November 2001 or February 2002 suing defendants including Verizon, Vodafone, Nokia and Motorola were amalgamated together. The case was first heard in the Superior Court of the District of Columbia and then heard in the appeal courts in 2009.

The complaints asserted virtually identical causes for action for intentional fraud and misrepresentation, negligent misrepresentation, strict product liability, failure to warn and defective manufacture and design, negligence, gross negligence, breach of express warranty, breach of implied warranty, conspiracy, violations of the Columbia Consumer Protection Act 2000, civil battery and loss of consortium.

The plaintiffs alleged that Motorola et al have long been aware of numerous studies revealing that EMF from mobile phones have both thermal and non thermal effects that are severely harmful to human health. They allege mobile phone companies manipulated the research of the American National Standards Institute before the standards came in, and when SARs were specified in 1996, the Federal Communications Commission (the US regulator for interstate and international communications) allowed mobile phone manufacturers to self-certify their mobile phones within the SAR limits, even though SAR results are easily manipulated.

The complaints continue that SAR values that the defendants report to the FCC are below the real values and actual values exceed the SAR limits established by the FCC. They also allege that though they were aware of numerous solutions that could virtually eliminate the health hazards, the companies did not adopt these nor warn their users of potential risks or methods that could be used to minimise exposure.

Judge Long, in the original case, said that the gist of the plaintiff's complaints is that mobile phones that are sold in compliance with current FCC rules may nevertheless be deemed unreasonably dangerous under state law, so that wireless carriers and equipment manufacturers potentially may be subject to civil liability on that basis.

Judge Long concluded that the complaints are barred by doctrine of conflict pre-emption because, if successful, they would stand as an obstacle to the accomplishment of federal objectives. By urging a jury to find that the defendant's cell phones emit unreasonably dangerous levels of RF radiation, even though the phones' emissions are within the SAR guidelines adopted by the FCC, the plaintiffs are effectively seeking to lower the FCC's current SAR standards.

The FCC explained that the RF limits it uses "provide a proper balance between the need to protect the public and workers from exposure to excessive RF electromagnetic fields and the need to allow communications services to readily address growing marketplace demands".

The Superior Court ruled that all of the claims are barred on the basis of both express and implied federal pre-emption. Although the Appeal court found no express pre-emption, they concluded that federal law does impliedly pre-empt the plaintiff's claims insofar as they seek to hold defendants liable for bodily injuries from cell phones that met the radio frequency radiation standards adopted by the Federal Communication Commission. However, they concluded that insofar as the plaintiffs' allege that they were injured through use of cell phones that only met the FCC standard due to manipulation of the results; the claims are not federally pre-empted. Federal pre-emption also does not apply to the plaintiffs' claims that phones purchased prior to 1996 (when the FCC applied SARs) have caused injury.

This case is interesting because it shows that as long as manufacturers are making phones which comply with the FCC limits they are not liable for bodily harm caused by the exposure. The case about phones which do not meet the FCC standards has been allowed to proceed – it will be interesting to see the verdict because if the manufacturers are found to have been fixing the results of the standards tests, or to have suppressed evidence that EMF does cause harm then they will not only become liable for damages in this case, but many other cases are likely to follow.

Were a similar case to occur in the UK, then it is possible a "state of the art" defence could be used, whereby as long as at the time of manufacture there was no indication that the product would be dangerous, manufacturers are not liable. This defence is an exception to the Consumer Protection Act 1987 which in the main, states that manufacturers are strictly liable for defective products, and claimants do not have to prove negligence. There is much discussion about the "state of the art defence" in British law and its future is uncertain.

4.2 Lessons from Asbestos

Many comparisons can be drawn between EMF and asbestos, and it is useful to look at the history of asbestos and the implications for the insurance industry to see what could happen with mobile phones if they prove to be harmful.

Asbestos was a 'wonder fibre' when it was first discovered, able to withstand high temperatures but remain soft and pliable³³. Its resistance to heat, electrical and chemical damage, as well as sound absorption and tensile strength properties meant it was widely used in the construction industry as fire retardant coatings, pipe insulation, fireproof drywall, flooring and roofing³⁴.

When it emerged in the 1980s that asbestos caused lung diseases claims for bodily injury started being made, and class action suits were brought in the US. Though asbestos primarily affected workers, it was not a workers compensation act or employer liability problem, but a products liability problem.

The impact on the insurance industry in general, and Lloyd's in particular, is well known. The predicted cost of asbestos to the insurance industry is still rising. The UK Asbestos Working Party Update 2009 stated that the undiscounted cost of UK mesothelioma related claims to UK insurance market from 2009-2040 would be over £8bn which is double their estimate of £4bn presented in a 2004 paper³⁵. Long latency periods and increasing life expectancy mean mesothelioma claims are likely to be with us for many years. The comparison here with EMF is obvious – if it is proven to cause cancer, then the injuries may not become clear until many years after the exposure due to similarly long latency periods. The danger with EMF is that, like asbestos, the exposure insurers face is underestimated and could grow exponentially and be with us for many years.

Asbestos claims are complex, and there have been a large number of court cases on the issues, some of which are still ongoing. The three major issues with asbestos are injury, apportioning liability and the trigger of the insurance contract.

Injury

In terms of injury, simply inhaling asbestos fibres is not an injury, let alone an actionable one, as established in *Bolton MBC v Municipal Mutual Insurance Limited* (2006) and *Durham v BAI (run off)* (2009). In fact, people on the street will have a few thousand asbestos fibres in their lungs, whereas people exposed in industry have a few billions of fibres in their lungs³⁶. Pleural plaques, small localised areas of fibrosis found within the pleura of the lung caused by exposure to asbestos fibres which have no symptoms, were compensated for since the 1980s. However in 2007 the House of Lords ruled on the *Rothwell v Chemical & Insulating Co. Ltd (Rothwell)* case that plaintiffs could not claim for pleural plaques as they do not increase susceptibility to other asbestos related diseases, or shorten life expectancy and so do not constitute an actionable injury unless symptomatic³⁷. The situation differs in Scotland, as in 2009 the Damages (Asbestos-Related Conditions) Scotland Act was introduced, which means insurers will have to compensate for pleural plaques in Scotland. In 2010 the Government upheld the previous House of Lords judgement and restated that this is not the case in England and Wales. In addition, it is worth noting that in the UK psychiatric illness due to anxiety about future disease is not actionable because it is not inevitable that exposure to asbestos will lead to mesothelioma. This is not the case in the US. Anxiety about mobile phones causing cancer is therefore not actionable in the UK, though may be in the US.

Liability

The second major problem with asbestos was how to apportion liability, since claimants may have worked in several workplaces and been exposed to asbestos in more than one place.

In *Fairchild v Glenhaven Funeral Services* (2002) the judge ruled that employers were joint and severally liable and that it was sufficient for the claimant to prove that the defendant had materially increased the risk of contracting the disease. However in *Barker v Corus* (2006) the judge ruled that proportionate liability should be applied, with employers severally but not jointly liable. This was immediately followed by the Compensation Act 2006, in which the government decided all parties were jointly and severally liable^a.

This means a person liable in tort for having caused or permitted a negligent exposure to asbestos shall be 100% liable. *Sienkiewicz v Grief* (2009) confirmed this new tort, and that no mesothelioma is required to prove causation. This is where the biggest difference between asbestos and EMF occurs. Although if it is proved that EMF does cause cancer, the

^a This Act applies only to asbestos

problem of apportioning liability due to different cell phones used at different times will be similar to the difficulties witnessed in determining which company was responsible for the injury caused by asbestos. However the situation is more complex with EMF than asbestos. Mesothelioma is, as a rule of thumb³⁸ caused only by asbestos exposure. In contrast, incidences of brain cancer have been known for many years, and incidence varies hugely due to unknown factors.

This can be seen by looking at a map of the US (Figure 3), which shows the huge variation in brain and nervous system cancers in the US by state. Therefore, it will be hard to decide who is responsible for the injury and whether cell phone antenna contribution can be separated from other potential radio-frequency radiation.

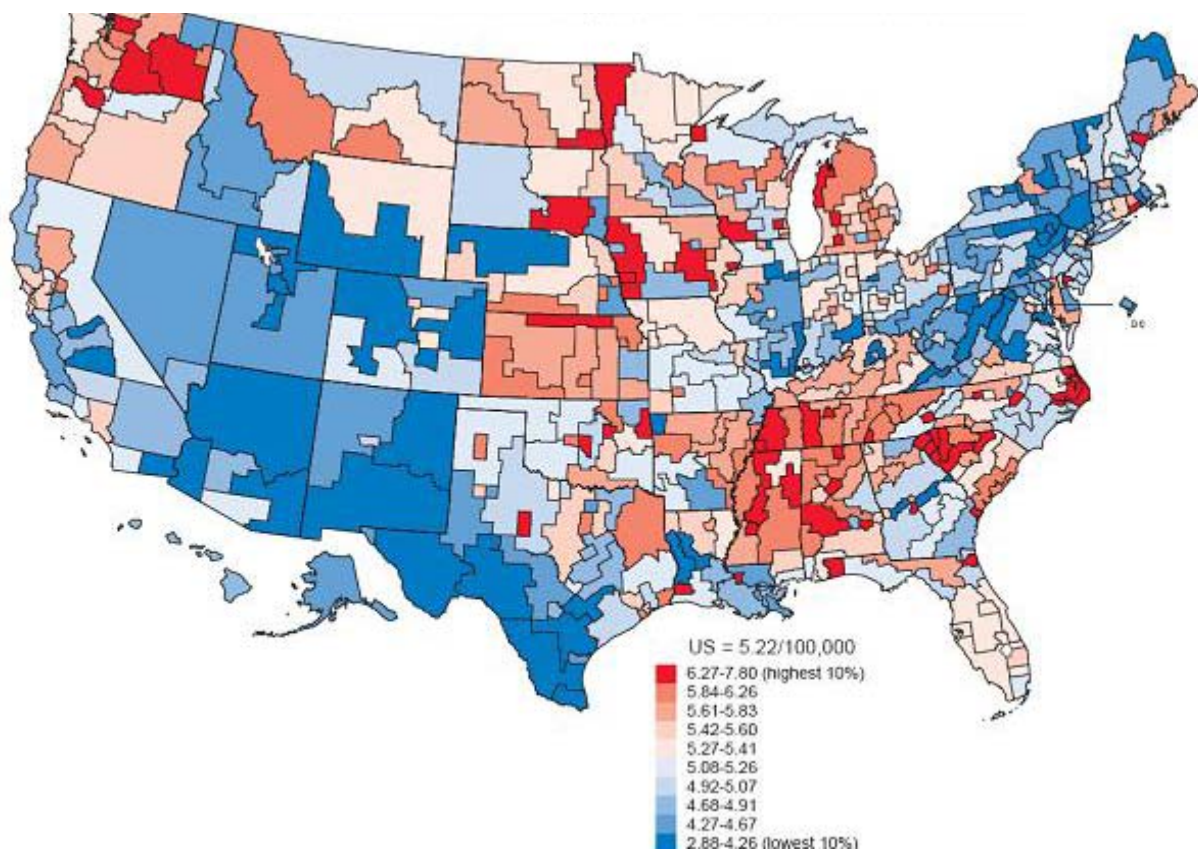


Figure 3: **Cancer Mortality Rates in the US for brain and other nervous system, white males 1970-94**, National Cancer Institute, Cancer Mortality Maps and Graphs³⁹.

Trigger of the insurance contract

Another interesting aspect is deciding when an injury was sustained or caused and accordingly whether an insurance policy will be triggered.

In *Bolton v Municipal Mutual* (2006) it was established that angiogenesis (when the blood supply is established to the tumour), rather than the presence of the first mesothelial cell was the critical turning point. Angeniosis could be up to five years before diagnosis, whereas the first mesotheliomal cell could appear 10-20 years before diagnosis. Product liability policies are usually on a “claims made” basis, meaning the trigger is an injury happening or occurring

during the policy period. The policy is therefore not triggered until an actionable injury occurs ie when the claimant gets cancer, as opposed to when they breathe in asbestos fibres.

Employers' liability policies, on the other hand, are generally not on a "claims made" basis. Before the 1980's they were usually indemnified on injury "sustained" during the policy. In the 1980's this wording was changed to injury "caused" during the policy. There is currently ongoing employers' liability trigger litigation on this issue.

In *Durham v BAI Run off Ltd* (2009) Judge Burton said "sustained" meant "be caused", deciding that injury is sustained and disease is contracted on angiogenesis but that the wording in insurance contracts should be construed to have effect as if there was a causation trigger because that is what everyone would have understood it to mean at the time the contracts were written. There was an appeal on the grounds that this is not in accordance with the ordinary meaning of the word "sustained" and a decision is awaited.

5. CONCLUSIONS

The large bulk of scientific evidence shows that exposure to EMF from mobile phones does not cause cancer, with the exception of exposure over ten years where there are some indications of an increased risk of certain types of brain cancer, namely acoustic neuromas and gliomas. Similarly, other health problems, such as self-reported symptoms do not seem to be caused by EMF. However, the lack of long-term data coupled with the long latency periods of many cancers means that further long-term studies are needed to confirm there is no health risk from long-term low EMF exposure.

With regards to the implication to insurance, as the current scientific evidence stands, it is unlikely that insurers will be liable for compensation for bodily injury on product liability policies. However, as asbestos has shown, new scientific developments coupled with a small number of key legal cases can change the situation very rapidly.

6. NEXT STEPS

Opinion on the issue of whether EMF causes adverse health effects is constantly changing, and therefore to monitor any potential impact EMF could have on the insurance industry it is important to keep up to date with new scientific research as well as legal cases on the subject.

It will also be instructive to review the outcome of *Murray v Motorola*, as this case could prove a turning point in EMF litigation if it is found that manufacturers have suppressed evidence of harmful effects of EMF and are guilty of negligence.

While this paper has looked at the potential health effects caused by EMF exposure during mobile phone use, much higher EMF exposure occurs in industrial situations, such as people working in the electricity generation, transmission and distribution industry⁴⁰, and it may therefore be worthwhile to investigate whether there is more conclusive evidence that EMF exposure in these situations can cause bodily injury.

GLOSSARY

Acoustic neuroma: an acoustic neuroma is a benign tumour that may develop on the hearing and balance nerves near the inner ear. Approximately 3,000 cases are diagnosed each year in the US.

Abestosis: A scarring of the lung tissue from an acid produced by the body's attempts to destroy the asbestos fibres, with a latency period of 10-20 years.

Averaging volume: When analysing the absorption rate, scientists take an area of the brain and average the SAR across that area. The size of this area varies across different countries.

Carcinogenesis: The process by which normal cells are transformed into cancer cells.

Case-control study: Persons who have developed a disease are identified and their past exposure to potential aetiological factors is compared to persons who do not have the disease.

Confidence intervals (CI): Instead of estimating the parameter by a single value, an interval is given that is likely to include the parameter. Thus, confidence intervals are used to indicate the reliability of an estimate. For a 95% confidence interval the smaller the range, the more reliable the result.

Contralateral: On the opposite side.

Dose response: A change in effect on an organism caused by differing levels of exposure (or doses) to a stressor (usually a chemical) after a certain exposure time.

Epidemiology: The study of how often diseases occur in different groups of people and why

Federal pre-emption: Invalidation of state law if it conflicts with federal law. It can be express or implied pre-emption.

Glioma: A cancer of the brain that begins in glial cells (cells that surround and support nerve cells. In the US, the incidence of glioma (the rate of new cases) has been estimated to be 20,000 cases per year⁴¹

Ipsilateral: On the same side.

Loss of consortium: The deprivation of the benefits of a family relationship due to injuries.

Mesothelioma: A cancer of the mesothelial lining of the lungs and the chest cavity, the peritoneum or the pericardium with a latency period of 20-50 years.

Meningioma: A type of slow-growing tumour that forms in the meninges (thin layers of tissue that cover and protect the brain and spinal cord). Most meningiomas are benign and usually occur in adults. In the US, around 6,500 people are diagnosed with this tumour each year.⁴²

Odds ratios: A statistic used to assess the risk of a particular disease if a certain factor is present. It is a relative measure of risk, telling how much more likely it is that someone who is exposed to the factor under study will develop the outcome as compared to someone who is not exposed.

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