Childhood cancer and EMFs

The most common form of childhood cancer globally is **leukaemia** (generally between 25% and 30% of childhood cancers). **Brain tumours** are usually the second most common type of cancer (23% to 25%), and l**ymphomas** are third. There is quite a lot of variation between countries, or even different areas of one country, possibly due to inadequate, or different, data recording, particular ethnic mixes, or different environmental conditions, with the incidence rate increasing over time for most types of cancer and in most countries (Glazer 1999, Gurney 1999, Ducore 2004, Coebergh 2006, Kaatsch 2006, Yang 2006, Fajardo-Gutiérrez 2007, Arora 2009, Bodkyn & Lalchandani 2010, Datta 2010, de Camargo 2010, Forsythe 2010, González-Garcia 2010, Kaatsch 2010, Marcos-Gragera 2010, Peris-Bonet 2010, Rosychuk 2010, Alrudainy 2011, Harmon 2011, Missaoui 2011, Perez-Saldivar 2011, Rajalekshmy 2011), though not all countries (Baba 2010). Kaatsch suggested that "*the patterns and magnitude of the increases suggest that other factors, e.g. changes in lifestyle and in exposure to a variety of agents, have contributed to the increase in childhood cancer in the recent decades.*"

As well as differences between countries, there are also age (Juárez-Ocaña 2008), sex, socioeconomic (Pan 2010, de Camargo 2011) and other differences in incidence (Stiller 2006, Mousavi 2010, Wiangnon 2011), though there are also many similarities, especially with regard to leukaemia incidence, age peak and subtype (Fajardo-Gutiérrez 2007, Bernaldez-Rios 2008).

Tumour predisposition in children is rare, accounting for approximately 10% of all cancers in childhood. It is now almost universally agreed that the development of most forms of cancer, with a few exceptions, seems to be largely a multi-factorial process, with several factors being implicated, no one factor being 'necessary' or 'sufficient' to cause cancer in children. The first factor, or event, often prenatal, is regarded as an initiation process, whilst subsequent events are 'promotional'. Promotional factors may not coincide with each other in terms of timing, and the exposures may occur at different stages in a child's life. These factors need to be taken into account as the time-window of exposure for childhood cancer is not known (Urayama 2009).

The incidence of childhood leukaemia has been rising more or less steadily over the last 30 years (Hosny & Elkaffas 2002, Török 2001, 2002, Coleman 2004, Steliarova-Foucher 2004, Kaatsch & Mergenthaler 2008, Hagopian 2010), possibly due to changes in lifestyle or environmental circumstances.

The Observer reported in April 2009, that Kevin O'Neill, a consultant neurosurgeon at Imperial College London said "*In my unit we have seen the number of cases of child brain tumours nearly double in the last year.*"

Excessive exposure to non-ionising radiation has been linked to an increased risk of developing cancer. Environmental agents can also contribute to cancer by increasing the genotoxic potential of other agents, interfering with the DNA repair processes, allowing a cell with DNA damage to survive and stimulating the cell division, resulting in alteration of the normal functions of the cell.

What causes childhood cancer?

There are several factors that are involved in cancer susceptibility and initiation. These can be grouped into broad categories (Sinnett 2007), including:

- Cellular growth and differentiation
- DNA replication and repair

- Metabolism of carcinogens
- Apoptosis (programmed cell death)
- Oxidative stress response
- Failure of immune recognition of transformed cells

Precisely how many sequential co-operating mutations are required to produce overt, clinical cancer is not entirely clear, but the relatively short latency, especially in infancy and childhood suggests that only a few are needed in comparison with most adult carcinomas that are thought to evolve over decades.

The increase in incidence of childhood leukaemia during the 20th century suggests that changes in environmental factors, including lifestyle, are at least partly responsible.

Eden's summary of the aetiology of childhood leukaemia (2010) said "*environmental factors for which some evidence exists include non-ionising electromagnetic radiation and electric fields.*"

Here we look at non-ionising radiation (electromagnetic fields or EMFs) which has been implicated by a significant amount of scientific research in the development of childhood cancer, either as cancer initiator or promoter.

ELF (powerfrequency or PF) magnetic field exposure

Parental occupational exposure to EMFs

In a study of children whose mothers were occupationally exposed to low levels of powerfrequency magnetic fields during pregnancy, Infante-Rivard & Deadman (2003) found a slightly increased risk of developing ALL between 0-9 years. Pearce (2007) found that paternal occupational exposure to EMFs prior to the child's conception resulted in a significant increased risk of acute lymphoblastic leukaemia (ALL) for boys aged less than 6, though the strength of this association is weakened as the research team looked at ionising radiation exposure as well, which has been linked to male susceptibility. Criticisms have been made of studies that rely on estimated field levels, as being unreliable due to the variation in exposure of different jobs, and neither was home exposure assessed.

A small increase in risk of ALL Reid (2011) and a larger one with childhood cancer (Smulevich 1999) with either maternal or paternal exposure any time before the birth, was linked to extremely low frequency electromagnetic fields (ELF EMFs).

Children under 5 had an increased risk of brain tumours if their mothers or fathers were employed as electrical workers (Cordier 2001) or electric power installers (Olshan 1999). Li (2009) suggests a possible association between maternal occupational ELF-EMF exposure shortly before and during pregnancy (including among sewing machine operators), and astroglial tumours in their children.

The evidence is mixed as to whether EMFs directly damage DNA, although indirect effects such as from the bystander effect, may be responsible. It is possible that the way EMF exposure has been measured may be responsible for the mixed results obtained experimentally. Kavet (2011) suggests that contact current could be responsible for the association of childhood leukaemia with magnetic fields.

Though experiments may be contradictory or inconclusive, nevertheless, it is suggested that EMFs could act by:

- Directly increasing the level of harmful **free radicals** within the body
- Affecting **other cellular processes** (including direct, or indirect tumour promotion), some of which may not even have been investigated as yet
- Decreasing the level of the protective hormone **melatonin**
- Acting in a synergistic way with respect to **other pollutants**, making them more harmful

Free radical effects

In body tissue free radicals are dangerous high-energy particles that damage cells and can both cause and accelerate the progression of cancer. Timmel & Henbest (2004) were the first to show that exposure to EMFs can increase the yield of free radicals by more than 60%. The theory was reviewed by Simkó & Mattson (2004), who concluded that EMFs cause a general increase in the levels of free radicals, which could explain the diverse and often inconsistent nature of observed effects of EMFs, free radicals being intermediaries in many processes. DNA damage could arise as a result of persistently elevated free radical concentrations, caused by long-term EMF exposure, or via the radical pair mechanism by which magnetic fields increase the lifetime of free radicals, allowing more DNA damage to occur (Rollwitz 2004, Henshaw 2008).

Effects on other cellular processes

Binhi (2008) suggested that magnetic nanoparticles in the human body may be one of the avenues by which EMFs may be implicated in the development of childhood cancer. Changes in levels of cellular proteins or ions can affect cell function (such as removing unnecessary or damaged cells) and cause cancer cells to develop. Some experiments have shown that EMFs affect these functions, though they have been difficult to reproduce and therefore remain controversial. Calcium ions play a critical role in determining the rate of cell division, and the overall evidence is that magnetic fields induce changes in apoptosis (programmed cell death), according to a review by MT Santini (2005). Changes in B lymphocytes can also change cellular division rates. A series of studies (Uckun 1995, Dibirdik 1998, Kristupaitis 1998) demonstrated EMF effects that made cells more likely to become cancerous. These findings may prove particularly important with regard to B-lineage ALL.

Chryptochrome (CRY) molecules have been identified in birds and other non-mammalian species, as a sensor of the geomagnetic field involved in navigation. CRY, which is a part of the molecular circadian clock machinery, is a ubiquitous protein likely to be involved in cancer cell growth and DNA repair (Lagroye 2011). The authors concluded *"we now have some clues to test for a better characterization of the interaction between ALL and ELF MFs exposure."*

However, cells are not autonomous units responding to damage as independent entities. Recently, there have been many reports of effects arising in non-irradiated cells as a consequence of inter-cellular communication. These non-targeted effects have been demonstrated in the descendants of irradiated cells (radiation-induced genomic instability) (Lorimore 2008) and in cells that have received signals produced by neighbouring irradiated cells (radiation-induced bystander effects) (Wright 2007, 2008, 2010, Coates 2008, 2008b, Burr 2010), but the expression of such effects is significantly influenced by genetic factors.

Mair (2008) suggested that *"EMF carcinogenesis involves the transport by macrophages of toxins (possibly including free radicals) to sites of infection or tumour localisation. This could increase mutation*

rates at these sites, perhaps promoting malignancy by introducing mutations, or by increasing the DNA instability of small early tumours, thereby engendering a more aggressive phenotype."

Melatonin effects

The hormone melatonin, is thought to protect the body from cancer

- by neutralising free radicals
- by inhibiting the uptake of growth factors by cancer cells
- by increasing the likelihood of cancer cells undergoing apoptosis (cell death), and
- by inhibiting the growth of blood vessels in tumours.

The production of melatonin at night (when the majority of melatonin is produced by the body's pineal gland) has been found to be reduced significantly by light at night and magnetic fields associated with the electricity supply (Henshaw & Reiter 2005, Erren 2005). Lupke (2004, 2006) suggested that EMFs reduced the anti-oxidative protection from melatonin.

Badr (1999) found that melatonin protects cells from genetic damage. Vijayalaxmi (1995, 1996, 1999) found that melatonin helped prevent oxidative damage to the human haemopoietic system and in animal foetuses (Wakatsuki 1999, Okatani 2001). Melatonin levels are particularly high during pregnancy (Nakamura 2001), so any change in these levels may result in some of the *in utero* damage which cause the 'first hit' which ultimately leads to cancer.

Professor Henshaw, Scientific Director of CHILDREN with CANCER UK, said *"Low-frequency magnetic fields can suppress production of melatonin, which, in pregnant women, will deprive the foetal brain of the protective hormone."*

A variety of bone marrow cells have been shown to produce melatonin (Tan 1999, Conti 2000, Carrillo-Vico 2004). Whilst the specific function of melatonin in these cells remains unknown, its suppression could have clear implications for leukaemia initiation and/or progression. A reduction in melatonin in the leukocyte precursor cells would be expected to enhance free radical-mediated DNA damage, thereby increasing the likelihood of these cells becoming carcinogenic.

Melatonin reduces the growth of HL-60 myeloid leukaemia cells *in vitro* (Henshaw 2008).

Light at Night

Evidence suggests that increasing exposure to light at night (LAN) and the consequent disruption of circadian rhythms, especially via reduction in nocturnal pineal melatonin, is a significant factor in the increasing incidence of breast cancer in recent decades in industrialised countries (Blask 2005). Whether LAN features in childhood cancer risk is not known. Electric light exposure at night can disrupt the circadian rhythm and many other physiological processes that are under circadian control. Because of this, Stevens (2012) suggests that ill-timed electric light exposure to pregnant women, to neonates, infants, and small children may increase cancer risk in those children.

Synergistic effects

Airborne pollutant particles are known to have a significant effect on health and a number of studies have reported an association between childhood cancer and exposure to traffic pollution. The strong electric fields associated with high voltage power lines may affect the charge on the

chemicals found in traffic pollution, making them more likely to be absorbed by the body. This effect can be observed up to 7 kilometres downwind of a high voltage powerline (Fews 1999a). The older the cable and the wetter the weather the more charged ions are emitted (Fews 1999b). Very small particles are particularly hazardous because of their ability to penetrate deeply into the lung and pass into the bloodstream (Seaton 1995). These small particles are in the size range where electrical charging can significantly increase lung deposition on inhalation. The report by Draper (2005) found increased risk of leukaemia in children born within 600 metres of National Grid 400 and 275 kilovolt power lines. This distance is clearly too far away to be a direct EMF effect, but could validate the ion polarisation theory.

Maternal use of a sauna close to conception or in the first trimester, and paternal use in the 3 months before the pregnancy, use of an electric blanket, or any heat source have been linked to an increased risk of medulloblastoma. Heat and magnetic field exposure would both have been involved (Bunin 2006), and both may have contributed.

Mair (2008) also suggested that EMFs could be mutagenic on their own, or could potentiate ionizing radiation mutations.

Brain and CNS tumours

Women who worked in low-frequency magnetic environments when pregnant, such as machinists, hairdressers, nurses and dry cleaners were twice as likely to have babies that developed brain tumours (Li 2009).

In a meta-analysis of 13 studies (Mezei 2008), there was a very slightly elevated risk of brain tumours with exposure to magnetic field levels in the home over 0.2 microtesla (μT), with a greater risk at levels of 0.3 or 0.4 μT. A more recent study not included in the meta-analysis found a positive association between exposure to residential magnetic fields above 0.4 microtesla and the risk of brain tumours (Saito 2010).

Preston-Martin (1996) found no association, but she concluded that the prevalence of high fields in Los Angeles homes was too low even to detect a **moderate** effect. Gurney & van Wijngaarden (1999) concluded that electromagnetic fields (EMFs) played no causal role in brain cancer development, and Kheifets (who has been repeatedly funded by the power industry), in a pooled analysis of 10 studies, found no association (2010).

Leukaemia

There is disagreement as to whether the relationship between EMF exposure and an increased risk of childhood leukaemia is a causal one, or whether there is a coincidental association with some other, as yet undiscovered, factor. However, the relative risk is surprisingly consistent, even though epidemiology is a bit of a blunt instrument to detect causal factors in a multi-factorial illness. Even Public Health England (former HPA-RPD), the International Agency for Research on Cancer (IARC, 2001) and the World Health organisation (WHO) have all agreed that EMFs are a potential carcinogen (Class 2B) and that precaution is warranted.

It is possibly that if magnetic fields are causative, it may be the rotating quality of the fields that is responsible. This is rarely measured.

The California EMF Programme report (Neutra 2002), has been recognised as one of the more definitive documents of recent times. The authors concluded that EMFs increased the risk of childhood leukaemia. The International Agency for research on Cancer (IARC) classified magnetic fields as a "possible human carcinogen", though this was not sufficient to influence public health policy according to Kheifets (2006). The results of one Canadian study by Green

(1999), based on personal measured fields rather than spot measurements found a significant increase in risk of childhood leukaemia at 0.14 microtesla (even lower than most of the published literature, which seems to show a consensus at 0.3 – 0.4 microtesla), though there was no association with living near high voltage powerlines.

An influential report (www.bioinitiative.org) by Hardell & Sage (2008) concluded that in view of the association between electromagnetic fields and childhood leukaemia, a new lower public safety limit for habitable space adjacent to all new or upgraded power lines should be applied. A new lower limit should also be used for existing habitable space for children and/or women who are pregnant.

Kheifets (2011) pointed out some of the difficulties in making sense of the measured levels and childhood leukaemia risk using various statistical tests, and we suggest that it may be as appropriate (if not more so) to take into account peak-level exposure and maternal exposure during pregnancy. Most studies are based on average levels, thus excluding what may be the most important metric, irrespective of analysis procedure.

More than 25 epidemiological studies around the world have investigated the association between childhood leukaemia and EMF exposure. They have found an increased risk of childhood leukaemia with proximity to high voltage powerlines, substations or high residential magnetic fields (Olsen 1993, Fajardo-Gutierrez 1993, Lin & Lee 1994, Kaatsch 1996, Thériault & Li 1997, Linet 1997, Michaelis 1997, 1998, Dockerty 1998, Li 1998, McBride 1999, UKCCS 1999, Bianchi 2000 Teepen & van Dijck 2012) showing a 2-3 fold increase with residential proximity to powerlines (Feychting & Ahlbom 1993), or even up to 5 times higher (Malagoli 2010, Wünsch-Filho 2011) or more (Sohrabi 2010). Not all studies have found an association (Verkasalo 1993, Tynes & Haldorsen 1997, Kleinerman 2000), and some of these studies used wire codes and calculated fields rather than measured fields from specific sources of EMFs. A study by Lowenthal (2007) found that living within 300 metres of high voltage powerlines within the first 15 years of life tripled the risk of developing a lymphoproliferative or myeloproliferative disorder in later life; and Draper (2005), in the largest single study of childhood cancer and powerlines, reported an increased risk in children whose birth address was within 600 metres of a high voltage power line. The risk was increased 5-fold if it was in the first 5 years of life. This may be due to the air ionisation effect referred to above, which is an electric field effect. Henshaw (2008) who proposed the air ionisation effect, suggested that about 11% of childhood leukaemia cases may be linked to magnetic fields. Swanson (2006) suggests the increased risk could be due to magnetic fields, corona ions, the characteristics of the areas power lines pass through, bias or chance, and Jeffers (2007) adds that population mixing in housing developments which followed the construction of the lines, could also be involved.

Schüz (2001) suggested that night-time levels were of particular importance, though when he made a further analysis of his findings (2007) his conclusions were less clear. Schüz also looked at residential exposure to magnetic fields at 16.7 Hz from the electrified railway system in Germany, and found a moderate but statistically non-significant association with childhood leukaemia (Schüz 2001).

Exposure to various electrical appliances, both during pregnancy and in childhood were looked at by Hatch (1998) who found a link with childhood ALL and maternal use (during pregnancy), or child use, of some household electrical appliances.

A review of 152 articles (Pelissari 2009) suggested that *"an association may exist between exposure to low frequency magnetic fields and acute lymphoblastic leukemia in children, but this association is weak, preventing the observation of consistency in the findings."* The authors concluded that ALL should be the focus of future studies as this seems to be the subtype with the most likely association.

Yang (2008) found genetic markers that showed that those carrying this gene variant were four times more likely to develop childhood leukaemia if they also live within 100 metres of power lines or transformers, compared to those with a fully functioning version of the gene. This groundbreaking piece of research indicates a potential for identifying individual susceptibility. For those already genetically susceptible (children with some congenital syndromes, such as Down syndrome), exposure to magnetic fields seemed to increase the risk of developing leukaemia (Mejia-Aranguré 2007).

Individual studies are often limited because of the relative rarity of childhood leukaemia and the relatively low number of children exposed to high levels of EMFs. Three reports which have pooled the data from individual studies, have found an increase in risk with exposure to magnetic fields of 0.3 – 0.4 microtesla (Ahlbom 2000, Greenland 2000, Wartenberg 2001). This level was confirmed by further studies (Kabuto 2006, Feizi & Arabi 2007).

It seems unlikely that there is a straightforward answer to whether EMFs *cause* cancer. We believe there is increasing evidence that they may play a definite role in affecting the body's ability to cope with pre-cancerous cell damage. There almost certainly will be other factors, such as chemical and other physical exposures (Juutilainen 2006) involved in the final outcome of a diagnosis of leukaemia.

Maslanyj (2010) concluded that taking a precautionary approach with respect to the proximity of powerlines to children was an appropriate one in view of the consistent association with childhood leukaemia in the research. He suggested that low-cost intervention to reduce exposure is timely, accepting that this recommendation was a controversial one as this measure may not fully alleviate the risk, due to other possible interpretations of the data. He did, however, comment that EMF links with Alzheimer's disease may be worth taking into account.

Meanwhile, unaccountably, there seems to be mixed opinion as to whether to recommend more precautionary limits to EMF exposure, bearing in mind that precautions are appropriate when there is uncertainty. If a relationship between the two were *proven,* then it would be the time for legislation. Calvente (2010) calls for an urgent reconsideration of exposure limits for both low frequency and static magnetic fields based on a review of experimental and epidemiological research into the link with childhood leukaemia.

The Stakeholder Advisory Group on ELF EMF (SAGE), the official Department of Health working group which was set up to recommend policy about powerlines to government, produced its First Interim Assessment in April 2007. They concluded that banning the building of new homes and schools within 60 metres of power lines is the best available option for reducing deaths from childhood leukaemia and possibly other diseases. The report fell short of recommending this as government policy because of fierce disagreements within the group. It said that such a policy, if implemented by the government would have a dramatic effect on property prices within power line corridors. It put the cost of restricting development at £1bn. Michael Jayne of the Royal Institution of Chartered Surveyors (RICS) called on the Government to take precautionary measures in order to ensure that the health risk is minimised by preventing the building of residential properties within specified distances of power lines.

Other places of EMF exposure

Söderberg (2002) found a slightly elevated risk for AML, but not ALL in children who had been exposed to high magnetic fields from infant incubators.

Changes in magnetic field level above 1.6 microtesla, such as can be found when travelling in electric trains, have been linked with an increased risk of miscarriage (Li 2002). It is possible that

the magnetic fields may also change DNA in ways that may not be destructive enough to result in a miscarriage, but may have health implications.

Ultraviolet light is part of the EMF spectrum. Mahé (2011) found that taking part in outdoor sports increases the risk of developing UV-induced skin lesions in childhood. However, it is also worth remembering that lack of vitamin D, the best source of which is sunlight, is responsible for many health problems, too.

Static fields

Very little has been done to identify whether exposure to static fields may be related to the risk of leukaemia. Bowman (1995) suggested that childhood leukaemia may be related to the combined effects of the earth's static magnetic fields and low levels of ELF magnetic fields resulting in various molecular ion resonances. The earth's static magnetic fields vary from country to country and could be significant in the disparity between study results, if it did, indeed, have a role.

Treatment

It has also been suggested that exposure to EMFs may adversely affect the outcome of treatment for childhood leukaemia.

Effects of EMFs on survival after treatment

Exposure to magnetic fields appeared to decrease the survival time of children in remission from leukaemia, at over 0.3 microtesla (Foliart 2006), or over 0.1 microtesla (Svendsen 2007), though a further study by Foliart (2007) concluded that elevated magnetic field levels were not associated with factors that predicted poor survival.

Neuroblastoma

De Roos (2001) found that paternal exposure to battery-powered forklifts was positively associated with neuroblastoma in the child and there was also a weak association between 0.4 μT paternal, but not maternal, magnetic field exposure and neuroblastoma.

Radio-frequency radiation exposure

Older TV and radio masts transmitted analogue signals. The situation has now changed with the arrival of digital radio and TV and the omnipresent telecommunications (mobile phone) masts. There are also other sources of digital signal transmission (digital cordless phones, WiFi, etc) that are being increasingly situated within houses, schools, offices, leisure facilities, etc. that is increasing the general public's exposure to radiofrequency radiation significantly.

It has been suggested by many scientists that digital signals may well have a greater biological impact on living systems than analogue signals; this possible impact includes not only people, but also animals and plants. If this is so, we would expect to see increasing evidence of health problems associated with exposure, though this may not include an increase in childhood cancer risk.

Navarro (2003) and R Santini (2002, 2003) found evidence of ill-health as a result of living near to mobile phone masts, but they were not specifically looking at cancer incidence. Two studies on adult cancer incidence near masts found significant increases (Wolf & Wolf 2004, Eger 2004) and the Wolf study found a ten-fold increase in female cancer. Neither looked at childhood cancer incidence.

Brain and CNS tumours

People have expressed concern about the use of mobile phones and brain tumours, but this is a relatively new technology. Children have only just begun to use them extensively and brain & CNS tumours can take some time to develop and be diagnosed. Meanwhile, this uncertainty may influence whether we discourage our young people from exposing themselves to such a potential hazard.

As well as the risk from phones, people have wondered whether the radio-frequency emissions from the mobile phone network of masts and other sources may also result in an increased risk of tumours in children who live nearby.

No link was found between the radiation from AM radio transmitters and the incidence of brain tumours (Ha 2007).

Professor Stefaan van Gool, who is a clinic supervisor at the children's Haematology/oncology department at Louvain University hospital in Belgium and treats children with brain cancer says, *"Cordless baby alarms, toys and phones expose children to daily radiation. Although the intensity is less than a mobile phone, children are more susceptible to the effects. A lot of young people have WiFi at school, so their exposure is continual."* He continues *"There is irrefutable proof of the harmful effects of electromagnetic radiation. It should actually be the responsibility of the operators and the industry to demonstrate that they are not harmful"*

Leukaemia

There have been some studies that have found increases in leukaemia risk as a result of living in proximity to radio or TV transmitters (Maskarinec 1994, Hocking 1996, Dolk 1997a, 1997b, Michelozzi 2002), that mean we cannot be complacent about the effects of RF signals. The study authors concluded that there was a small increased risk in adult and childhood leukaemia for those who lived within 2 kilometres (Ha 2007), but the confidence levels were low due to the small number of cases involved. One study showed no such increase in risk (Merzenich 2008), and Elliott (2010) found no link between childhood cancer and maternal exposure to base stations. Elliott has a tendency to find negative links between the environment and health problems, including the fact that he found no evidence for the reality of Gulf War Syndrome; not everybody concurs with his findings.

Hocking & Gordon (2003) also found an association between living near to TV transmitters and decreased length of survival after leukaemia diagnosis.

Neuroblastoma

De Roos (2001) found that maternal and paternal occupational exposure to a broad grouping of sources that produce radiofrequency radiation was associated with an increased incidence of neuroblastoma in the children.

Skin cancer

Paediatric melanoma is rare, but increasing in incidence. Solar and artificial (sunbed) UV-exposure is the main risk factor for the development of epithelial skin cancer as well as for malignant melanoma. UV exposure in childhood and adolescence is especially important (Greinert & Boniol 2011).

Musselman & Spector (2011) found a link between sunlight exposure and risk of childhood cancer, possibly due to the role of vitamin D as a regulator of cell growth and differentiation. and there was an inverse relationship between NHL risk and sun exposure (Petridou 2007).

The UK has the highest incidence of skin cancers in children and adolescents. In Europe, melanomas are more common in adolescents in the North and West and skin carcinomas in the South and East. Between 1978 and 1997 the annual increase in incidence for adolescent cancers has been 4.1% for melanoma and 2.5% for skin carcinoma (de Vries 2006). The number of children affected was significantly smaller than the number of adolescents. The study authors suggest that the aetiology between childhood and adolescent skin cancers may be different, or it may also be that parental care with respect to skin screening is more influential for children than for adolescents.

Conclusion

At an International Commission for Non-Ionising Radiation Protection (ICNIRP) workshop on risk factors for childhood leukaemia, Anders Ahlbom reviewed the epidemiological data looking at childhood leukaemia and electromagnetic fields. He said "*Generally the exposure measures have been too crude, however this would tend to decrease the estimated association rather than increase it. Significant confounding is most unlikely – there would have to be a very large new factor that has not already been considered. Selection bias is possible, but unlikely to be a large effect given the number of very different pooled studies. It will not be due to chance. The evidence that ELF magnetic fields are a causal factor in the development of childhood leukaemia is stronger than that for passive smoking and lung cancer.*"

We believe that childhood cancer is unlikely to be *caused* by exposure to electromagnetic fields, but there seems sufficient evidence that they may have a promotional effect that we think taking a precautionary stance, minimising exposure, is the best course, whilst further research takes place.