Evidence that EMF/EMR causes Leukaemia/Lymphoma in Adults and Children

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Abstract:

Both local ELF fields and far-fields of RF/MW radiation expose the whole human body and induce electric currents that flow through the body seeking "earth". The electric current induces the formation of magnetic fields, creating the combined electromagnetic field. The induced electric currents primarily flow through the strong conduction high water organs, circulation system and bone marrow. They also flow through the electrical conduction fibres of the Central Nervous System. The oscillating electromagnetic signals damage the DNA in the exposed cells the current is flowing through, generating cell death and mutations that primarily lead to Leukaemia and Lymphoma. This explains why Leukaemia rates in Children and Adults have progressively risen over the 20th Century as more and more homes were provided with electric power. This produced living environments involving chronic low-level ELF field exposures in homes, along streets and in all building environments with electric power supplies. The unique ubiquitous exposure situation produced by this development provides a sole and confirmed source of the vast majority of the elevated cancer rates, including most of the Leukaemia/Lymphoma rates. Since both residences and work places involve chronic EM field exposures, the epidemiological studies of both are appropriately considered and the issue of no non-exposed control group needs to be dealt with. Appropriate exposure assessment is vital for determining dose-response relationships. The results of over 40 residential studies and 100 occupational studies give strong, extensive and robust evidence that ELF and RF/MW (EMR) radiation is proven to cause Leukaemia and Lymphoma in children and adults, including over 40 dose-response relationships.

Introduction

The earliest residential epidemiological studies by themselves were of a nature and quality that indicated a causal link between household chronic mean electromagnetic fields and childhood and adult cancer, Wertheimer and Leeper (1, 2). They were confirmed by an independent follow-up study Savitz et al (3). When the growing evidence in the subsequent 20 years was summarized, Milham (4) reviewed about 40 residential studies and 100 occupational studies and found that the showed nearly 500 separate risk ratios. For every lowered Risk Ratio there are about six Risk Ratios that are elevated. Milham records that a number of these studies show dose-responses between magnetic field and cancer incidence. Over 40 studies are cited here. The current evidence cited here provides dose-response relationships between EMF/EMR exposure elevated in over 20 childhood and over 20 adult cancer studies. This is definitely causal.

Milham also notes the obvious but rarely recognised fact that there are no unexposed groups available. This effect is termed here the Ubiquitous Genotoxic Carcinogen Effect (UGCE), resulting in grossly lowered Risk Ratios and major under-estimates of the levels of the effects in more recent studies than the very older studies. This review will

summarize the available evidence and propose and apply methods to more appropriately interpret the results in the face of the UGCE and the Healthy Worker Effect (HWE). The review also accepts that there are established biological mechanisms for these effects including EMR induced melatonin reduction, calcium ion efflux and genotoxic DNA damage, each shown by a large body of multiple independent studies, Cherry (5).

Leukaemia/Lymphoma Description:

Leukaemia is a progressive malignant disease of the blood forming organs, characterised by the distorted proliferation and development of leukocytes and their precursors in the blood and bone marrow. It is classified according to degree of cell differentiation as *acute* or *chronic* (terms no longer referring to the duration of disease) and according to the predominant type of cell involved as *lymphocytic* (ALL, CLL) or *myelogenous* (AML, CML) Dorland (6).

Lymphoma involves any neoplastic disorder of the lymphoid tissue. The term *lymphoma* is often used to denote *malignant lymphoma*. Hodgkin's Disease is a form of malignant lymphoma, characterized by painless progressive enlargement of the lymph nodes, spleen and general lymphoid tissue. Non-Hodgkin's Lymphoma (NHL) is a heterogeneous group of malignant lymphomas, the only common feature being the absence of giant Reed-Sternberg cells characteristic of Hodgkin's Disease. They arise from lymphoid components of the immune system.

Methods

This review will make carefully consideration of the exposure situations for both the exposed and control/reference (lower exposure) groups. Epidemiological results will be initially taken on face value, recognising the local knowledge of the authors. Then their choice of cases and controls and their consideration of the exposure relationships will be assessed and corrections made where they appear to be justified. This is part of the Open Minded Approach (OMA) in contrast to the Preconceived Dismissive Approach (PDA).

The epidemiological level of evidence assessment method used here is guided by Hill (7). Sir Austin Bradford Hill sets out his professional career experience in the area of assessing epidemiological relationships with Association moving to Causation. Each of his individual factors, factors that he carefully called "view points", can be assessed as showing a causal relationship separately or together with other view points. Sir Austin was clearly coming from the precautionary public health protection approach with is dismissal of reliance of statistical significance and his rejection of the pressure he was under to produce a "*Sine qua non*" or a set of hard-and-fast rules of evidence. He gives an example of a group of card-room workers in a spinning mill. They were chronically exposed to dust and consistently showed elevated respiratory illness. While the relationships were strong, none were statistically significant, because of the small group sizes, but it was assessed as causal. Sir Austin's approach sets the principles of the OMA.

Sir Austin considered epidemiological evidence, showing strength of association, consistency, temporality, specificity, analogy, coherence, biological plausibility and dose-response relationship, along with experimentation. Some are appropriate while others are inappropriate in given circumstances. For example, it is inappropriate to rely of specificity

when the disease agent exposes and damages many organs. Biological plausibility has a limited contribution in many circumstances because it is limited by present biological or biophysical knowledge. On the other hand, if a substance is genotoxic, then it does cause mutations and cancer. This is so well established that it is in the Dorland's medical dictionary (6). Across the EMR spectrum there are many independent studies showing chromosome aberrations, micronuclei formation, DNA strands breakage (5), hence EMR causes cancer.

The two strongest viewpoints are the strength of association and the dose-response relationship. Sir Austin expresses the desirability of seeking a biological gradient in relation to ranked exposure. He concludes that "The clear dose-response curve admits of a simple explanation and obviously puts the case (causation hypothesis) in a clearer light", (7). Therefore a single dose-response relationship can be taken as causal, especially if it is consistent enough (taking into account the sample size) and if confounders have been dealt with appropriately. The weakness of an individual study might raise uncertainties that can be overcome by considering other independent but consistent results from other studies showing consistently elevated disease rates, significantly elevated disease rates or a dose-response trend.

Some studies involve All Cancer (1,2). Since All Cancer for children (<20 years), according to the SEER analysis, is 36.3% of Leukaemia, 24.1% of Lymphoma and 26% of Brain/CNS Cancer, the Leukaemia/Lymphoma cancers are 60.4% of All Cancer. When Brain CNS cancer is included then it covers about 86% of All Cancer. For Adult cancer the proportion for these three are smaller because of the growth of cancer in many other sites. Despite this, All Cancer will still show relationships with Leukaemia/Lymphoma.

Exposure Assessment:

When an AC (Alternating Current) electric connection is provided, the wires have a voltage and oscillating electric fields. When the current flows to provide the electrical energy then the magnetic field is added to the electric field, forming an electromagnetic oscillating field (50/60Hz). All homes have low level ELF fields throughout rooms, with higher local fields near some appliances, especially electric motors such as in vacuum cleaners, hair driers, sewing machines, drills, lathes, washing machines and clothes driers. All offices, shops, schools, hospitals, factories, and all other buildings with electric power supply connections have ELF fields, including 50% of readings being greater than 2mG roads. In electric trams the median was 10.3mG, Lindgren et al. (8). Cars have ELF fields from equipment and from the rotating steel belted radial tyres Milham, Hatfield and Tell (9). This creates the ubiquitous ELF exposure situation.

The relative personal mean magnetic field strengths for children living or going to school near high voltage power lines were measured in Norway (10). Inside 30m from a 300kV power line the fields rose from 5 to 12mG. Living near the power line (60m) produced 2 to 20mG, averaging 4mG. The home 175m from the power line ranged from 0.3-0.8mG, averaging 0.6mG. At the school near the power line the child's fields ranged from 5 to 90mG, averaging 15mG. The school away from the power line (300m) produced personal fields in the range 0.1-2mG averaging 0.2mG. This illustrated the influence and range of internal and external magnetic field sources.

Because of the EMR reduced melatonin mechanism (5), with melatonin being high at night, the greatest impact on cancer risk is probably the mean bedroom exposure. For

some children the proximity to power lines will dominate this magnetic field exposure. Other children will live further away from power lines but sleep in higher fields because of the configuration of the household wiring. For example, the child's bed is on the outside wall of the house, near to where the power cable enters the house or is joined to the power switch and fuse board, with fields in the range 4 to 12mG.

The initial global ubiquitous exposure to RF/MW fields was produced by short-wave radio and telecommunication and weather satellite signals. RF/MW fields are produced by many more sources than is commonly known, including high voltage power lines Vignati and Giuliani (11). Many modern appliances at home and work also produce RF/MW radiation fields, including microwave ovens, computers, TVs and Play Stations, cordless and mobile phones Mild (12) and Kraune et al. (13). Urban and rural areas have detectable and usable RF/MW signals from many Radio and TV stations, Tell and Mantiply (14), Mantiply et al. (15), and cell phone base stations Bernardi et al. (16).

Some occupations are identified as having above average exposures. They include "electrical and electronic occupations", radio and radar operators that include military, police officers and fire fighters, heavy computer users (17), welders (18,19) and many industrial situations where workers spend long period near operating electric motors. Some office situations are worse than others because of proximity to transformers and power cables. All occupations using mobile phones or two-way radios, including police officers, security guards, commercial truck operators, and airport staff. Commercial and military pilots are exposed to a mixture of ELF and RF/MW fields from power supplies, visual displays, radios and radars (20, 21). Radar, radio and TV equipment and antenna repairmen are frequently exposed to higher than average RF/MW radiation.

Biological Mechanisms for Leukaemia

The primary biophysical mechanism for Leukaemia/Lymphoma is the induced internal voltage gradients within the body from external ELF fields or from the absorption of body tissue penetrating RF/MW radiation. Both sources, but the second much more strongly, produce oscillation electric currents flowing through the body towards the nearest electrical "earth". "Nearest" means the lowest electrical resistance path. The induced current therefore flows primarily through denser ion currents, in the brain and CNS, and through substances with more water, including blood and bone marrow. Enhanced rates of DNA damage are caused by these electromagnetic fields, in all body organs, but at higher rates in the higher conductors. Thus Brain/CNS Cancer and Leukaemia/ Lymphoma are the most frequently associated cancers with EMR exposures, each in over 100 published epidemiological studies. The fields passing though the brain also pass through the pineal gland and reduce the output of melatonin (5). Melatonin is a highly potent natural antioxidant. It penetrates cell membranes and scavenges oxygen free radicals that damage DNA in the cell nucleus. Melatonin is also a supporter of a healthy immune system (22). Thus there are multiple ways in which reduced melatonin contributes to enhanced cancer rates.

Epidemiological Results:

The biological mechanism for EMF/EMR exposure includes genotoxic DNA damage. Therefore it is known that EMF/EMR fields cause cancer with no safe threshold level. Hence even at very low average residential field exposures there will be enhanced rates of cancer. The challenge was to identify a gradient of chronic average residential

exposures and to ensure that there were no associated confounding factors. The higher exposures are more easily identified in some “electrical occupations” but the lack of identification and use of a non-exposed reference group, especially in cohort studies, is a problem. Military activities often involve RF/MW exposures and in the Polish Military they have a strict occupational hygiene regime to record the individual RF/MW exposure events, Szmigielski (23). The Polish control group is all other military personnel, all of whom are regularly exposed to low level fields at work and at home. This underestimates the rate rise compared with a “No Exposure” group.

The first review will be of studies involving Childhood Cancers, followed by adult residential and occupational exposure related Cancer.

Childhood Leukaemia from Residential Exposures

The first epidemiological studies associating ELF exposures with cancer were Wertheimer and Leeper (1, 2), published in 1979, 1982. Wertheimer and Leeper developed a physically rational chronic mean electromagnetic field exposure regime based on an assessed mean current loading in the wiring systems near each case’s and control’s residence. With electrical power supplies there is diurnal and seasonal variation in the electrical energy requirements. Therefore a mean wiring current assessment provides the best estimate of the chronic mean fields produced by these currents. This has been independently confirmed, Wrensch et al. (24).

After carrying out an exposure survey, Wertheimer and Leeper (1) carefully assessed the Wiring Code Configuration for each case and control, and evaluated potential confounders relating to age, race, economic status and proximity to heavy traffic. The cases and controls were ranked into four levels in relation to the wiring code, Very Low, Low, High and Very High. The percentage of all surveyed homes in these levels was 6.8%, 63.7%, 29% and 0.6%. This illustrates the problem of finding a non-exposed group. The cancer rates were calculated for each exposure group. A significant dose-response trend resulted, p = 0.008, Figure 1.

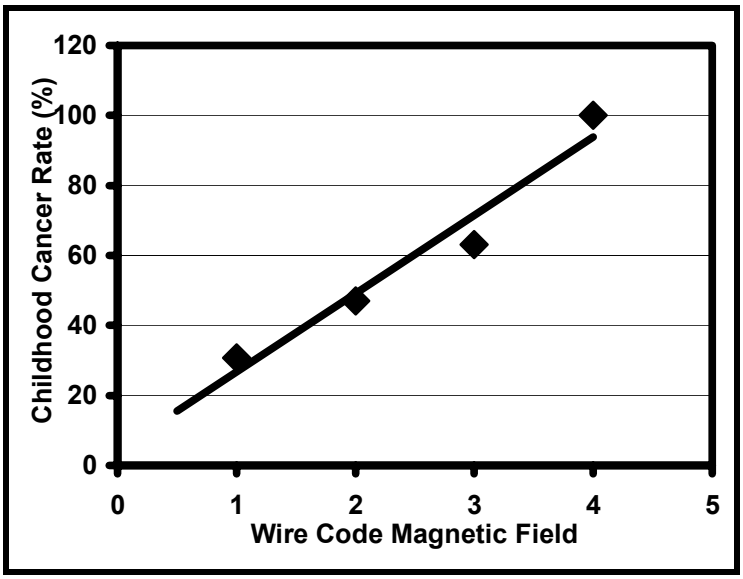

Figure 1: Childhood cancer rates in Denver 1976-79, relative to chronic electromagnetic field exposures assessed using a Wiring Code Configuration, (1). Trend p = 0.008.

The chronic mean magnetic field exposure associated with the Very High Wire Code (VHWC) is about 2 mG. It was observed that the children diagnosed with cancer living in the VHWC fields (n=6), their cancer was 100% associated with the magnetic fields. Even in the Very Low fields, 30.8% of the cancer cases were associated with the magnetic field exposures.

A study in New Zealand involved long-term measurements (hours) of the magnetic fields in the bedrooms and play areas of children with leukaemia. Dockerty et al. (25,26) found that for a cut-off point of 2 mG, after adjusting for pregnancy, income and mothers eduction, the Adjusted Odds Ratio was Adj OR = 12.0 (1.1-137). The middle (1-2mG) group had Adj OR = 1.75 (0.4-7.4), with <1mG being the reference group OR = 1.0. This shows a weak, non-significant trend from a small case number study. When cases were divided into size-based “thirds”, the adjusted bedroom fields showed no association but the highest exposure cut-point was quite low, at 0.55mG. This illustrates the strongly skewed distribution of mean daily personal exposures. For the Dayroom exposures this produced a dose-response with middle third Adj OR = 3.8 (0.5-28.7) and Highest third Adj OR = 5.2 (0.9-30.8). When the readings were combined into a time-weighted average exposure, using the cases with <1mG as the reference group (OR = 1.0), a more uniform dose-response increase in childhood leukaemia incidence was found. For 1mG - <2 mG, Adj OR = 1.5 (0.3-7.2). For $\geq$ 2 mG the Adj OR = 3.5 (0.5-23.7) (26).

A similar project, with long-term mean magnetic field measurements, was carried out in Germany (27). They compared the Childhood Leukaemia rate with a range of mean magnetic field measurements in the child’s bedroom. The 24-hr median, OR = 2.3 (0.8-6.7). For the 24-hr median for children $\leq$4 yrs, OR = 7.1 (1.4-37.2). For the nighttime only medians for all children, OR = 3.8 (1.2-11.9) and for children $\leq$4 yrs, OR = 7.4 (1.4-38.4). This confirms the stronger association with sleeping ELF exposures and leukaemia, most likely because of the magnetic field reducing melatonin. The vulnerability of younger children is also evident, also related to lower immune system competence and lower levels of melatonin in early childhood.

Savitz et al. (3) carried out a replication of Wertheimer and Leeper (1). They used an expanded cancer data-base and developed an alternative Wiring Code approach, using a buried wiring system as the lowest exposure situation, Figure 2.

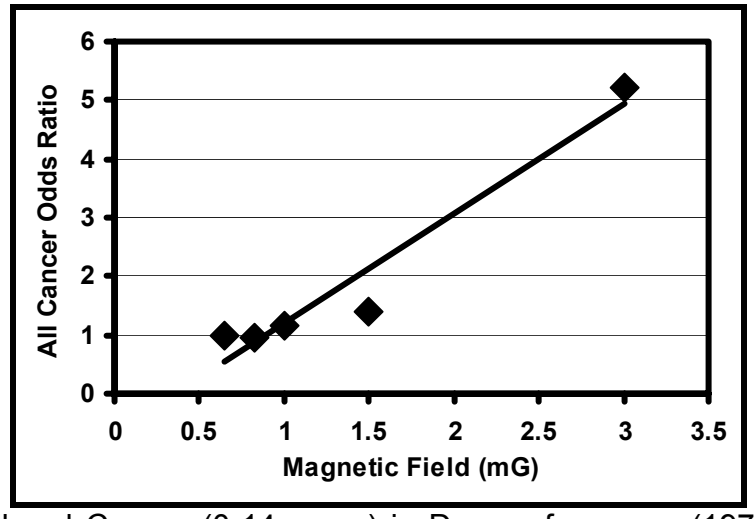

Figure 2: Childhood Cancer (0-14 years) in Denver for cases (1976-1983) and controls (1984-1985), Savitz et al (3). Trend p = 0.01.

The five-level wire code cancer trend associated with fields at the time of diagnosis resulted in a significant trend, p=0.02, with the VHWC Cancer rate OR = 2.20 (0.93-5.21). When the wire code was related to residential exposures 2 years before diagnosis, allowing for a 2 year latency effect, the trend was more significant, p =0.01, Figure 2. The VHWC All Cancer rate was then raised to OR = 5.22 (1.18-23.09). Taken together Wertheimer and Leeper and Savitz et al. provide a classically causal relationship between residential electromagnetic fields and childhood cancer, including leukaemia and lymphoma (7). They are supported and confirmed by New Zealand and German studies cite above and about 20 additional studies cited below.

There is the modern more Preconceived Dismissive Approach (PDA). As the evidence gets significantly stronger the conclusions are significantly weaker, Savitz (28). This occurs despite some of the highest quality and strongest evidence being produced by Professor Savitz's research team. The dismissive approach is putting public health seriously at risk of demonstrated adverse health effects by retaining high allowable public exposure standards of over 1000mG when the childhood cancer rate is significantly elevated, even with daily mean exposures well below 2mG.

The greater strength of evidence available now includes the genotoxic evidence and a very large body of published epidemiological studies showing elevated childhood cancer rates, in many situations they are significantly elevated and in over 20 studies with dose-response trends (1, 3, 25, 26, 29, 31-47). In selecting evidence of dose-response trends a threshold of trend p<0.1 was used because they typically have only 3 to 5 points and often have small case numbers. Many of the studies show significant trends, p<0.05. One example is given from Green et al. (29), Figure 3.

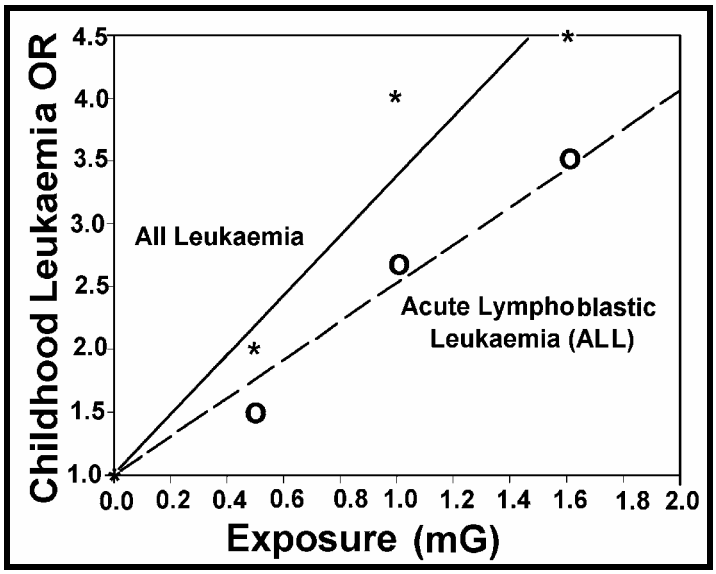

Figure 3: Childhood leukaemia and ALL dose-response relationship in the Canadian Residential related to the measured magnetic fields for the time of diagnosis, Green et al. (29). For the ALL the trend is highly significant, p<0.02 and for all leukaemia, p<0.05.

This definitely shows a causal link between ELF exposures and Childhood Leukaemia. Making adjustments for the Ubiquitous Genotoxic Carcinogen effect, which highlights the No-Exposure Factor, significantly strengthens the causal link. When studies use 1mG or 0.1mG as the reference cut-point they are selecting a group of people whose cancer rate

has been progressively raised by living in these fields all their lives and for several generations. The historical cancer rise relationships have been well investigated.

The predominance of Acute Lymphoblastic Leukaemia (ALL) in early childhood, peaking between 2 and 4 years, has provided the proof of the source of the majority of cancer from its temporal and spatial development pattern over the 20th Century. Sir Richard Doll identified a new carcinogenic phenomenon in 1961, (30). It was associated with a massive progressive rise of Leukaemia in all age groups considered and was characterized by the early childhood peak, 2-4 years, of ALL. This did not exist in 1910 but was well developed in the UK and Wales by 1930 and in the United States by the 1940's.

A great deal of research has tried to identify the cause of this "biomarker" cancer. Milham and Ossiander (31) showed that the only factor that followed the spatial and temporal development of this childhood ALL peak was the introduction of electrical wiring in homes. Every residential Childhood Leukaemia study showing elevated cancer rates confirms this conclusion. In particular, Kraut et al. (32) show significant dose-response increases in childhood Brain Cancer, Leukaemia and Lymphoma in proportion to the level of domestic electrical power supply in Canada. This confirms that the biophysical mechanism is genotoxic and causes a wide range of cancers.

Hatch et al. (33) found that pregnant mothers who used electric blankets or electric heating pads during their pregnancies had significantly elevated incidence of children with ALL, OR = 1.59 (1.11-2.29), and OR = 1.46 (1.10-1.98), respectively. Hatch et al. also found that the small children's EMF/EMR exposure from the TV produced dose-response increases in ALL with distance from the TV and with hours per day of watching TV. Being less than 6 ft and more than 6 hours, OR = 4.67 (1.64-13.36). For video games connected to the TV for an hour or more a day, OR = 1.87 (1.13-3.10). This finding confirms the early initiation of the cancer in utero during pregnancy, and the advancement of the ALL with EMF/EMR exposures after birth. The RF/MW impacts are quite high with large and significant OR's.

Green et al. (29) independently confirmed these observations. They found a dose-response for All Leukaemia and for ALL for children in Ontario with measured average residential magnetic fields. All Leukaemia rates were doubled from 0.5mG average fields compared with <0.3mG, OR = 2.0 (0.6-6.8). For 1mG it was significantly 4-times higher, OR = 4.0 (1.1-14.4), Figure 3. This confirms that the higher the domestic EMF fields the higher the ALL and All Leukaemia incidence rate.

Feychting and Ahlbom (34) found a trend relationship between Childhood Leukaemia and the measured magnetic field closest to the time of diagnosis. After extensive analysis of the magnetic field data they chose <1mG as the reference group. The 1-1.9mG group has RR = 2.1 (0.6-6.1), n=4; for ≥2mG, RR = 2.7 (1.0-6.3), n=7 and for ≥3mG, RR= 3.8 (1.4-9.3), n=7. By pooling together a Danish and this Swedish study the results were strengthened Feychting et al. (35). Retaining the 1mG reference cut-point, for ≥2mG, RR = 2.0 (1.0-4.1), n=10 and ≥5mG, RR = 5.1 (2.1-12.6), n=8, Trend p <0.0001.

Fajardo-Gutierrez et al. (36) found in Mexico that children living near the high voltage distribution substations had significantly increased Leukaemia rates, OR = 2.63 (1.26-5.36). For children living near power lines, there was OR = 2.5 (0.97-6.67) and near the

lower voltage distribution power lines, OR = 2.12 (0.79-5.85). This is effective as a weak dose-response as the higher fields produce higher childhood leukaemia rates.

Over the 20th Century the 0-5 year old cancer rate (per 100,000 p-yrs) has risen from less than 1 to over 8. For 2-3 year olds Leukaemia has risen from less than 1 to over 10. All other age group leukaemia rates have risen in parallel, along with other cancers and many other health effects. The contribution of household wiring and electromagnetic fields is at least 50% of the cancer rise, (31). Therefore an adjustment factor to reduce the control group rate to deal with this effect, the No-Exposure Factor (NEF) recommended is NEF = 4. For All Childhood Cancer this corresponds to a reference cancer rate of 2 per 100,000 p-yrs. When using a risk assessment approach to identify the acceptable cancer rate of 1 in a million or 1 in 100,000, then the use of the NEF is vital.

If Hatch et al. and Green et al. had used a conservative non-exposure control rate of 2 per 100,000 p-yrs reducing their control group rate (group size) then their results would be significantly stronger. For example from Hatch et al. watching TV >6 hours at closer than 4 feet has an ALL Odds Ratio of OR = 4.39 (1.75-11.04). If adjusted for the NEF this rises to OR = 17.6. From Green et al. All Leukaemia was elevated from ≥1.4 mG exposure to Adj OR = 4.5 (1.3-15.9). Adjusting for the No-Exposure Factor gives an of OR = 18.0. Both of these papers provide multiple dose-response increases in Leukaemia from a range of ELF/RF/MW exposures, confirming the causal link.

Three recent meta- or pooled- analyses have shown that combined data consistently results in significantly elevated childhood Leukaemia from EMF field exposures. Angelillo and Villari (48) found that 6 studies involving wire codes gave overall RR = 1.46 (1.05-2.04), p=0.024, and 4 studies involving 24hr exposures gave overall RR = 1.59 (1.14-2.22), p=0.006. Greenland et al. (34) pooled 8 studies and found that for magnetic fields >3 mG, OR = 1.52 (0.99-2.33), VHCC wire code alone, OR = 1.65 (1.15-2.35) and for Field and Wire Code, OR = 1.58 (1.18-2.28).

Ahlbom et al. (35) pooled 9 studies to detect the dose-response from measured exposure levels 1 to <2 mG, 2 to <4mG and ≥ 4mG. For All Leukaemia this gave RR = 1.08 (0.89-1.31), RR = 1.11 (0.84-1.47) and RR = 2.00 (1.27-3.13). For ALL the equivalent rates are RR = 1.08 (0.88-1.32); RR = 1.12 (0.84-1.51) and RR = 2.08 (1.30-3.33). With the reference group being exposed to <1 mG this is not a no-exposure group. For mean exposures to 0.5mG compared to <0.3mG the Childhood Leukaemia rate is doubled, Green et al. (29). The Adjustment by the NEF=4 makes all of these elevated rates highly significant.

Many of the very early Childhood Leukaemia cases, especially ALL, result from parental exposures to the genotoxic EMR fields. They damage the chromosomes in the sperm or egg and in utero during pregnancy. This was confirmed for ALL by Hatch et al. and is independently confirmed for Childhood Leukaemia from radar exposure by Hicks et al. (49), mothers manufacturing communications material, Olsen et al. (50). Mothers working in high magnetic fields from sewing machines in Spain, have a far higher Childhood ALL rate, OR = 7.0 (1.59-30.79), Infante-Rivard (51).

With the genotoxic and melatonin reduction mechanisms, many multiple independent studies both separately and pooled show dose-response increases of Childhood Leukaemia from residential EMF field exposure. Therefore the link is robustly causal, (7).

The EMR Spectrum Principle, based on the frequency dependence of the dielectric constant (52, 53) and induced tissue current (11), predicts and supports the hypothesis the effects that are found for ELF exposures will be stronger at lower mean field and exposure strengths from RF/MW exposure. This is confirmed by multiple studies. Even when standing on their own they give strong evidence. Studies of childhood cancer around radio and TV towers also independently, together and in context, show a causal relationship from the genotoxic and reduced melatonin mechanisms, through significantly elevated cancer rates, Sydney, Australia (54), Hawaii (55) and with dose-response trends in Australia (56), San Francisco (57) and Rome (58).

Adult Exposure and Leukaemia/Lymphoma:

As shown above, the strongest association and evidence of a causal effect is a dose-response relationship. Dose-responses can be derived from job-exposure matrix surveys, personal exposure measurements, years of exposed employment and adjustments for latency and other factors. There are over 20 published epidemiological studies of adult exposure to EMF/EMR showing dose-response trends in All Cancer, Leukaemia and/or Lymphoma (2, 58-79). These studies, along with many others show significantly elevated rates of these cancers too. The causal association is also supported by many showing elevated rates. If they were adjusted for the No-Exposure Factor (NEF =4) then almost all would be significantly elevated.

The first occupational study involving radar exposure and leukaemia was the Korean War Study of Robinette et al. (59). In a 5% job exposure matrix survey, the high exposed personnel had a Mortality Rate of 1.64 compared with MR = 1.06 for assessed zero Hazard Number. In the job groups, the high exposure AT group had a Lymphatic and Hematopoietic cancer rate of 3.055 per 1000 compared with the lower exposed ET group had 1.376 per 1000. This produces the RR = 2.22 (1.03-4.8), p=0.038. Grouping the data into three groups, each containing two occupations, Low (RM+RD), Middle (AE+ET) and Very High (FT+AT) exposures, gives the rates 1.03, 1.24 and 1.67 per 1000, trend p=0.02. For All Cancer the rates are 4.44, 5.04 and 6.54, Trend p = 0.025, Figure 4.

In 1989 Archimbaud et al. (80) stated that it was known that microwaves induce genetic damage in animals and in human lymphocytic cells. They reported that a 46-yr old man who had been typically exposed 5-minutes daily to microwaves. He had major changes to his blood counts, including chromosome alterations and he developed AML.

The military RF/MW exposure linkage with significantly elevated Leukaemia and AML rates, was confirmed by the Polish Military Study, Szmigielski (23). He found highly significant elevation of All Leukaemia, RR = 6.31 (3.12-14.32), p<0.001. For AML, RR = 13.9 (6.7-22.12), p<0.001. In a follow-up study, (60) a prospective dose-response study of All Cancer, associated with daily peak RF/MW exposures in W/m^2 for 2-4 hrs, with mortality rates in brackets: 1-2 (146.9, n=14); 2-6 (135.8, n=9); 6-10 (401.4, n=7) and >10 (427.0, n=6), Trend p = 0.07.

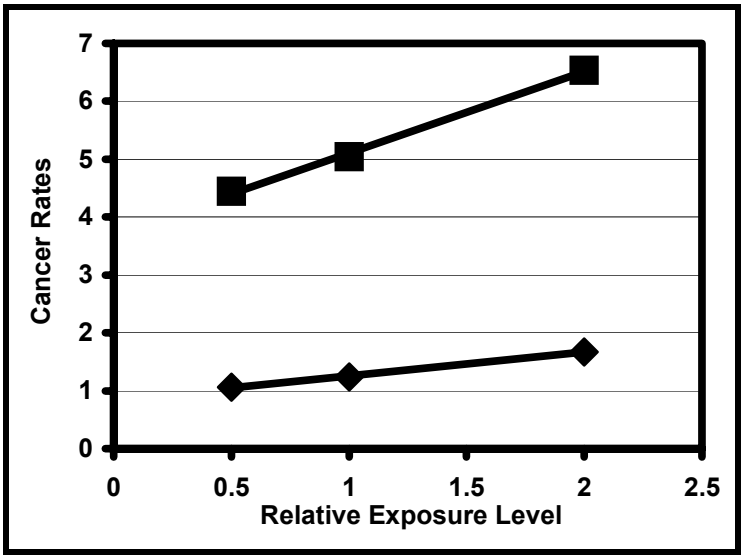

Figure 4: Dose-response of All Cancer (squares) and Leukaemia/Lymphoma (diamonds) in the low(RD+RM), middle (AC+ET) and very high (FT+AT) exposed groups, showing an exposure-based trend, Robinette et al. (59), Trends p<0.025.

The first Adult Cancer residential radar exposure study, Lester and Moore (61), developed the linking hypothesis, based on previous studies, that radar caused cancer. To test the hypothesis they reasoned that having radars on both sides of Wichita, Kansas, then there were homes on ridges exposed to both, others on hillsides were shielded from one, and some, in valleys, were shielded from both. The age, race, sex, and socioeconomically adjusted All Cancer rate resulted in a significant dose-response trend in All Cancer Mortality, p=0.034, Figure 5.

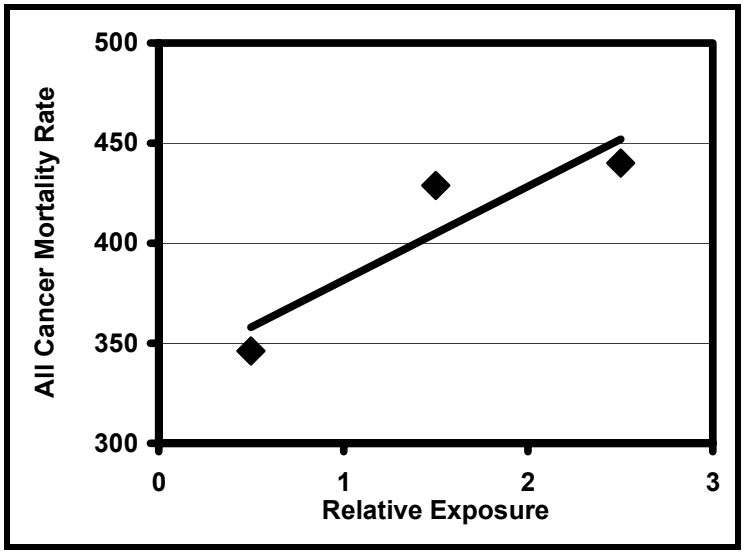

Figure 5: Cancer rates in Wichita, Kansas, for the population who at their residences were (a) not exposed to a radar, (b) exposed to one radar and (c) exposed to two radars, adjusted for age, sex, race and socio-economic status (60), Trend p= 0.034.

The hypothesis was strongly supported by their first result. They then tested it further and found that US Counties with Air Force Bases (AFBs) (with radars) and cities near AFBs had significantly higher cancer mortality rates, (81,82), confirming the hypothesis.

The first epidemiological study of residential ELF exposure and adult cancer was Wertheimer and Leeper (2). They found a significant dose-response increase of Adult Cancer rate associated with their residential Wiring Configuration Code, Figure 6. They found that the adult cancer latency period was between 4 and 9 years, peaking at 7 years. This results from living in genotoxic fields for many hours per day, initiating and rapidly accelerating the promotion and progression of the Cancer to a detectable disease.

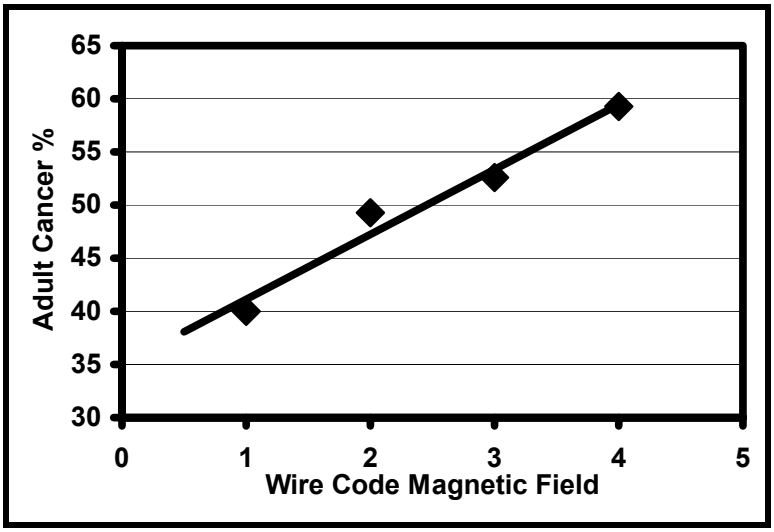

Figure 6: Adult Cancer from Denver showing a significant dose-response trend, p= 0.005, from magnetic field exposures ranked as the Wiring Configuration Code, (2).

Wertheimer and Leeper, after dealing with potential confounders and because of the significant dose-response trend, concluded that the data indicate a causal relationship between magnetic field exposures at the residential levels and Adult Cancer rates. In the lowest exposure group, 40% of the cancer is associated with the magnetic field exposure. At the Very High Current Code the proportion has risen to 60%. This is much lower than the 100% for the Childhood Cancer rate because of the wide range of Cancers associated with cumulative oxidative free radical damage leading to high Cancer rates in old aged populations. The All Cancer elevation and trends include Leukaemia/Lymphoma and Brain Cancer, along with Lung, Skin, Breast, Prostate and Cervical Cancers.

The same year (1982) Wright, Peters and Mack (83) reported highly elevated leukaemia rates in men occupationally exposed to electric and magnetic fields in Los Angeles. The highest rate was for Acute Leukaemia in Power Linemen, PIR = 593.6, $p<0.05$, followed closely by Telephone Linemen, PIR = 567.6 and Motion Picture Projectionists, PIR = 471 and Power Station Operators, PIR = 460.1. In all cases the rates of AML were even higher. Milham (84) also found elevated and significantly elevated Leukaemia in workers in Washington State exposed to electromagnetic fields. The total result for All Leukaemia/Lymphoma was PMR = 124, $p<0.01$, for Lymphosarcoma, PMR = 130, other Lymphomas, PMR = 164, $p<0.01$, Leukaemia, PMR = 136, $p<0.01$ and Acute Leukaemia PMR = 162, $p<0.01$.

A residential study of 114 cases of Acute Non-Lymphocytic Leukaemia (ANLL) in western Washington State 1981-1984, Severson et al. (62), found a dose-response trend from measured magnetic fields, <0.5mG, OR = 1.0, 0.51-1.99mG, OR = 1.16 (0.52-2.56) and ≥2mG, OR = 1.50 (0.48-4.69). When the use of Electric Heating Beds and High Current Configuration were not used, OR = 1.0, or either one was used, OR = 1.8 (0.9-3.6) and

both were used, OR = 3.6 (1.3-9.4) within 3 years of the reference date Wertheimer and Leeper (64). This is a highly significant dose-response trend.

A Great Britain Registrar General's occupational mortality report (85) found that several electrical occupations had elevated Leukaemia rates observed 116, when 92.7 were expected. SMR = 126 (96-156). For electrical and electronic engineers Leukaemia SMR = 202, $p<0.01$ and for AML SMR = 149. For Electricians, Fitters and Plant Operators, for Leukaemia SMR = 120 and for AML SMR = 155, $p<0.05$.

Calle and Savitz (86) report that there is significantly elevated All Leukaemia in Electrical Engineers, PMR = 186, $p<0.05$, and Radio and Telegraph Operators, PMR = 235, $p<0.05$, with the rates being higher for Acute Leukaemia. Flodin et al. (65) find similar results in Swedish Electrical Workers. For AML, RR = 3.8 (1.5-9.5). In Britain Electrical and Electronic workers have elevated rates of Leukaemia Mortality, SMR = 142, government report. Milham (87) found a significant elevation of Leukaemia in a rubric that combined multiple Myeloid Leukaemia and Non-Hodgkin's Lymphoma, SMR = 162 from the RF exposure of amateur radio operators in California and Washington. Garland et al. (86) found that in the US Navy electrician's mate had a significant increase of Leukaemia, RR = 2.4 (1.0-5.0).

In 1988 Coleman and Beral (89) reviewed 11 studies of electrical workers with Leukaemia and found that the combined rate was RR = 1.18 (1.09-1.29), n=526. None of the cited studies acknowledge the lack of a non-exposed control group.

In England, Coleman et al. (66) found that living within 100m of high voltage power lines raised the Leukaemia rate to RR = 1.45 (0.54-3.88). Within 50m the rate is RR = 2.0 (0.4-9.0). Children <18 yrs also had an elevated rate of Leukaemia, RR = 1.5 (0.7-3.4) within 50 m of a substation. For ALL there was a trend with proximity to power lines, $p=0.1$, peaking at RR = 1.76 within 25m and a trend $p = 0.03$ for the exposure index peaking with an RR = 1.32.

French Electricians (1971-84) had elevated Leukaemia mortality, SMR = 143 (25-450) and incidence, SIR = 125 (22-393), Guberan et al. (90). In a French case-control study, electromagnetic field exposed workers had significantly elevated Acute Leukaemia rates, OR = 4.04 (1.26-12.9), Bastuji-Garin et al. (91).

Electrical workers in New Zealand have elevated leukaemia rate in the age range 20-64 yrs, OR = 1.39 (0.71-2.71) and significantly raised after age 65 yrs, OR = 1.85 (1.03-3.32). In the 20-64yr group Chronic Lymphatic Leukaemia was OR = 3.36 (1.27-8.89). In specific types of work the rates were highly elevated for power station operators, OR = 3.89 (1.00-15.2) and for Radio/TV Repairers, OR = 7.86 (2.2-28.1), Pearce et al. (92).

Reviewing the published studies up to 1990, shows that there is very strong evidence of a causal association between exposure to ELF and RF/MW radiation and elevated rates of Leukaemia/Lymphoma. This is based on many studies with significantly elevated and over 7 with dose-response trends, some of which are very significant, even though the trend case number is often very small. Following the US EPA cancer assessment criteria, the internal staff of the US EPA proposed to declare EMF a Probable Human Carcinogen and RF/MW a Possible Human Carcinogen. Pressure from the White House and the US Air Force led to the decision not to publish the recommendations, Sibbison (93, 94). An EPA administrator ordered deletions from the report, claiming that there were no dose-

response relationships. The evidence presented above includes 7 studies with dose-response relationships for Adults and 3 for Children with Leukaemia and/or All Cancer. In addition there are 6 for Brain Cancer (5), a total of 16 by 1990.

The research published since 1990 strengthens the evidence of a causal relationship. For example, a follow-up New Zealand study, Bethwaite et al. (67), found significant elevation in All leukaemia (ANLL+ALL) and for ANLL and highly significant dose-responses for mean historical magnetic field exposures (trend p = 0.002, Total; p =0.001 ANLL) and for current magnetic field exposures (trend p = 0.001, Total; p = 0.001, ANLL). Odds Ratios were adjusted for age, gender and educational attainment. They investigated potential confounding factors and found none to affect their results. For >10mG mean exposure historical lead to Adj OR = 3.2 (1.2-8.3) for All Leukaemia and Adj OR = 4.2 (1.7-10.9) for ANLL. For current exposure >10mG, Adj OR = 4.0 (1.6-9.8) for All Leukaemia and Adj OR = 5.3 (2.2-13.1). The highest individual occupational rates were for Telephone Line Workers, OR = 6.6 (1.0-43.9) with Welders having OR = 3.1 (1.1-8.5). Over all electrical occupations in New Zealand have significantly higher Leukaemia rates, OR = 1.9 (1.0-3.8). This adds very strong support for a causal link.

Matanoski et al. (68) confirm that Telephone Linemen experience a significant dose-response trend, p=0.05, in Leukaemia, with a latency period of 10 yrs, peaking at a rate of OR = 9.5 for the highest exposure quartile. Dosemeci and Blair (69) studied women working in the telephone industry and found an employment and age period dose-response trend for Leukaemia. The 20-49 yr was the reference group, 50-69yrs, OR = 2.1 (0.3-14.2) and ≥70yrs, OR = 3.5 (0.4-22.4). Non-Hodgkin's Lymphoma was also elevated to OR = 5.0 (0.7-33.9) in the ≥70yrs group and OR = 2.3 (0.8-6.8) for all ages. Women Office workers had elevated NHL, MML and Leukaemia mortality, for NHL in Engineers and Technicians, OR = 3.7 (0.5-26.3) and for NHL in Mechanics and Repairers, OR = 2.0 (0.3-12.4).

Theriault et al. (70) produced one of the largest group studies involving electric utility workers from Ontario, Quebec and France over the period 1970-1989. For All Leukaemia, CLL, ANLL and AML the median and 90%ile groups all showed elevated rates, especially for the 0-20 year latency period and all data together. There were individual rates in the median exposure group over OR=4 for CLL and AML. The trend for All Leukaemia was OR (trend) = 1.45 (0.68-3.08). The highest trend was for ANLL, OR (trend) = 1.68 (0.51-5.51). Using a cut-off level of 2 mG gave OR = 2.36 (1.00-5.58) for ANLL and OR = 2.25 (0.79-6.46) for AML. From the same group, Armstrong et al (71) show a dose-response increase in NHL peaking at OR = 1.8 (0.62-5.25).

Adults living for 15 years within 100m of high voltage powerlines in Sweden have an equally elevated All Leukaemia rate (RR = 1.2) in the 0-50m and the 51-100m groups. Within each group, particular Leukaemia types were significantly raised. Inside 50m for CML, RR = 2.4 (1.0-5.1) and in the 50-100m range for CLL, RR = 1.6 (1.0-2.5). For cumulative exposure over 2μT-yrs, RR = 3.5 (1.0-12) for AML, Feychting et al. (72). The All Leukaemia and AML showed dose-response increases with cumulative magnetic field exposure. For the calculated magnetic field strength closest to the time of diagnosis the All Leukaemia, AML and CML showed dose-response trends, with AML rates reaching RR = 2.2 (0.7-6.8) and CML reaching RR = 3.2 (0.9-11) for ≥2mG.

Feychting et al. (73) conducted a case-control study of adult Leukaemia and CNS Tumours in association with separate and combined residential and occupational

magnetic field exposures. For residential exposures showed elevated AML, RR = 1.3 (0.4-5.0), while occupational exposure elevated All Leukaemia, AML and CLL. Then both exposures were combined all were elevated and most significantly so. All Leukaemia, RR = 3.7 (1.5-9.4); AML, RR = 6.3 (1.5-26); CML, RR = 6.3 (1.5-26.7); and CLL, RR = 2.1 (0.4-10.4). They also found exposure-based trends for Leukaemia and each of its sub-types.

Savitz and Loomis (74) found that electricians have significantly elevated leukaemia, RR = 2.5 (1.08-5.8), after 20 years of employment. For the total cumulative exposures there is a dose-response trend for AML, RR(Trend) = 1.04 (0.93-1.18), with a peak rate of RR = 1.62 (0.51-5.12), n=5. For CLL the trend rate for exposure over the past 2-10 years is RR (Trend) = 1.47 (0.52-4.20). There were very small case numbers in the higher exposure groups, between n=0 to 11.

An office in a commercial building was immediately above a 12kV substation with three transformers. Measured magnetic fields before 1992 were 190mG at floor level and 90mG at 4 feet above the floor. For the 254 employees who had been in the office for less than 2 years there was one cancer case. For 156 who had been in the officer longer, there were 7 cancer cases, difference p=0.0057. For the cancer rate as a function of the years of employment there was a significant trend, p =0.00337, Milham (75). One of the cancer cases involved Lymphoma. For 5-15 years OR = 15.1 (1.72-132.9), p = 0.0075, n=4.

In North Sydney in Australia, adult people living in the vicinity of three TV/Radio masts the Total Leukaemia incidence rate is significantly elevated, RR = 1.24 (1.09-1.40), with Lymphatic Leukaemia, RR = 1.32 (1.09-1.59) and Other Leukaemia RR = 1.67 (1.12-2.49). The mortality rates are also significantly raised for Lymphatic Leukaemia, RR = 1.39 (1.0-1.92) and other Leukaemia, RR = 1.57 (1.01-2.46). The homes were directly exposed to 0.2 to 5$\mu W/cm^2$. The inside RF/MW exposures were measured and showed that they were over 100 times smaller than the direct exposure at the roof level, Hocking et al. (54) and McKenzie et al. (56). Therefore the mean chronic personal exposures were less than 0.002 to 0.05$\mu W/cm^2$.

Li et al (76) found significantly elevated and a significant trend for adult All Leukaemia related to residential magnetic field exposures in Taiwan, OR = 1.4 (1.0-1.9), Trend p=0.04. The highest individual rate was for ALL, OR = 1.7 (1.0-3.1).

Pfluger and Minder (95) showed the Swiss electric train drivers exposed to 16.7Hz magnetic fields, had significantly reduced melatonin. Minder and Pfluger (96) found that depending on the level of the organ that the measured magnetic field strength the Leukaemia rate was elevated, adjusted for age and month. For the cumulative highest exposure at the Thorax, RR = 1.64 (0.64-4.19). For more than 6 month exposed to more than 100mG at the Head, RR = 1.65 (0.65-4.20), at the Thorax, RR = 2.27 (1.10-5.36) and at the Feet, RR = 2.08 (0.82-5.29).

With more and more published studies the cumulative evidence gets stronger and stronger. However, often studies published more recently, have reported weaker results and weaker conclusions. There are for two main probable reasons. The first is that the background reference rates are rising because increasing exposures particularly to RF/MW radiation, the UGCE (5, 57). The second reason is the progressive strengthening the assessment approach, for example Savitz (28).

A large, refined job-exposure matrix survey of US Electric Utility workers, Savitz et al. (97), found higher Brain Cancer magnetic field associations than for Leukaemia. It is a case-cohort study so the reference group are also electric utility workers, not a non-exposed group. The study attempted to find the exposure gradient from personal exposure assessments. The size of the relative risks are small because of the moderately exposed reference group. The Cumulative Exposure assessment shows more consistent trends than the Average Exposure. For a career exposure with a 2-year lag, there is a significant, linear trend, p=0.03, peaking at RR = 1.44 (0.53-3.91). The highest individual exposure is RR = 1.67 (0.91-3.04) for 2-10 years of exposure in the range 0.38-0.68μT-years. This is consistent with the peak latency period of 7 years (2).

In seeking evidence of causation it is helpful to seek if occupational exposure effects are also found in residential studies. RF/MW radiation has been shown to have significantly elevated Leukaemia rates in military exposed staff (22) with a significant dose-response (59), and for Amateur Radio Operators (87). Elevated childhood Leukaemia around Radio/TV towers has been found in multiple studies (54-58) and in adults (54, 58, 77, 78). In the results of 2 UK studies, Dolk et al. (77, 78), they found a high adult Leukaemia rate near the Sutton Coldfield TV tower very near Birmingham but not around any of the other 20 towers studied. They were unaware of any of the many genotoxic studies of RF/MW.

Cherry (57, 98) explains the difference of their results as the population distribution and the exposure regimes. Taking both into account explains the results and dose-response relationships. Hence Cherry (98) concluded that their results are indicative of a causal relationship between RF/MW exposure and Adult Leukaemia. Goldsmith (99) describes the results of these studies as “The end of innocence for radiofrequency exposures from TV broadcast towers and Cancer.”

Since the US EPA staff assessment in 1990 there have been many more studies showing elevated, significantly elevated and dose-response trends in Adult and Children Leukaemia and Lymphoma from chronic low-level ELF and RF/MW radiation exposures. Therefore there is more than enough evidence to declare ELF and RF/MW human carcinogens.

Electric Field and Magnetic Field Contrasts:

A basic understanding of physics is very important for EMF/EMR epidemiological studies. For EMR this includes the RF/MW radial exposure patterns around broadcast masts (57) and for EMF the fundamental relationships between electric and magnetic fields in different electric current and energy supply situations. In a single supply cable the electric field is proportional to the voltage and the distance to the “earth”. The oscillating voltage produces an oscillating current when the circuit is opened. The oscillating electric current induces an oscillating magnetic field, whose strength is proportional to the current, Faraday’s Law. The proportion factor between the voltage (V) and the current (i) is the resistance (R). For AC currents $i = V \sin \omega t/R$, where ω is the angular frequency and t is the time. For the peak $V = iR$ (Ohm’s Law). The electric energy supply $En = i^2R = iV$, where “i” is the root mean squared (rms) current of AC power supply.

Therefore in power supply situations the higher the voltage the lower the current is need to supply a given energy amount. Since the magnetic field is proportional to the current, in power supplies the higher the voltage (and the electric field gradient) then the lower the current and the magnetic field. Hence in countries with 110V AC power supplies there are

more than twice higher currents and magnetic fields for a given energy supply than countries that have 240V AC power supplies. In power supply utility situations a wide range of voltages, up to 100s of kV, are used with very different currents and electric fields and inverse levels of magnetic fields.

Guenel et al. (100) found that in French Electric Utility workers, using an extensive job exposure matrix assessment, for the Leukaemia, the higher the electric field exposure the lower the cancer rate was, when adjusted for magnetic fields and socio-economic status. This occurred quite strongly for the 10-year latency analysis. This is likely to be consistent with the inverse relationship for magnetic field strengths.

Kheifets et al. (101) investigated the cancer rates in power line workers in Los Angeles. They found that the job exposure rating differed considerably for magnetic and electric field measurements. For direct (unadjusted) electric field exposures the Leukaemia rates were erratically elevated, but with very small numbers in the medium and high exposure groups. Kheifets et al discuss the complexities of electric fields that are strongly perturbed by conducting objects.

A basic understanding of physics, including Ohm's Law, helps to explain much of the above observed outcomes. They could explain why magnetic field adjusted leukaemia rates in Guenel et al. showed a reduction with the strength of the electric field, while Kheifets et al. don't adjust for magnetic field exposures and Leukaemia rates are erratically elevated, but generally lower for the highest electric field group. This group could well be exposed to weaker magnetic fields and induced currents. The 10-year latency, trend reduction in leukaemia with higher electric fields could be associated with a trend of higher magnetic field exposure.

In contrast with the apparent Guenel et al. result, several other studies show that magnetic fields enhance AML rates. For example, Airline pilots, who are known be exposed to above average ELF magnetic and RF/MW fields, show a very significantly higher AML rate, SIR = 4.72 (2.05-9.31), Band et al. (102).

Bias in Cohort Studies – General Public reference group:

Two major Danish cohort studies, Johansen and Olsen (103) and Johansen et al. (104) provide examples of the failure to account for the Healthy Worker Effect (HWE) and the Ubiquitous Genotoxic Carcinogen Effect (UGCE). When carrying out these nation-wide cohort studies the reference group is the general population that has a somewhat higher cancer rate than the workers or the typical cell phone uses. This results in SIRs well below 1.0, in the range 0.5 to 0.7 in several groups. A WHO book recognises the impact of the HWE and estimates the worker's disease rates as 70 to 90% of the general population. These Danish studies take it down to 50 to 70%. The WHO text (105) describes the Control Group as "Not Exposed" in contrast to the "Exposed" Case Group. It also recognizes the Healthy Worker Effect. This points to the importance of the UGCE for EMR because there is no not exposed group. Together these adjustment effects fully explain why the two Danish cohort studies find much lower Leukaemia rates that dozens of other more appropriate studies.

With the wide-spread usage of mobile telephones there are many members of society exposing themselves to quite high exposure levels for prolonged periods, as exposing nearby people to elevated levels of pulsed RF/MW exposures. With many studies

showing that ELF and RF/MW radiation enhance the rates of Leukaemia/Lymphoma in exposed populations, it is predicted that this will also occur in cell phone users. Morgan et al. (79) studied a cohort of Motorola employees. People were classified as being in high, moderate, low and background RF exposure groups. By using the general population in 4 states as the reference group, including the elderly with high disease rates, the overall mortality rate was SMR = 0.66 (0.64-0.67) and the overall cancer rate was SMR = 0.78 (0.75-0.82). This shows a pronounced HWE, which is acknowledged by the authors (a rare event). However they make no adjustments for it. The highest elevated cancer type was Hodgkin's Lymphoma, SMR = 1.14. In the ranked exposure assessment the Hodgkin's Disease showed a dose-response increases from, RR = 1 for reference, to RR = 1.72 (0.48-5.09) for low and RR = 3.2 (0.73-10.4) for medium exposures. If this is adjusted for the HWE then the medium exposure has RR = 4.1.

None of the above cited studies have adequately dealt with the UGCE and very few with the HWE, hence the Leukaemia/Lymphoma rates from EMR exposure are grossly underestimated. No available critical reviews have recognized the lack of these effects.

Critical reviews:

Two Critical Review papers, McCann, Kheifets and Rafferty (106) and Elwood (107) show strong dismissive bias (PDA). Both reviews record industrial connections. An independent review by the eminent Environmental Epidemiologist, the late Professor John Goldsmith, Goldsmith (108), published in the same journal as the other two papers, comes to much stronger conclusions about the association of EMR and Cancer.

McCann et al. set out valuable and appropriate risk assessment approaches and methodology to evaluate the Cancer Risk from EMF exposures. Their fourth point illustrates the dismissive bias. It states:

"4) Lack of evidence of dose-response and the apparent lack of DNA reactivity of EMF suggest that a safety (or uncertainty) factor or margin of exposure type risk characterization may be most appropriate;"

McCann et al. cite none of the over 20 studies cited by Cherry (5) showing that EMF damages DNA. There is a wealth of dose-response relationships cited above, in over 30 studies, starting with the two first studies of Wertheimer and Leeper. They also include a meta-analysis for Brain Cancer of the second author, Kheifets et al. (19). The evidence cited here including the dose-response relationships and the genotoxic carcinogen mechanism, shows that there is no safe threshold and so that a *de minimus* exposure standard approach is appropriate.

Elwood follows the usual cancer assessment approach looking for strength of association, specificity and consistency, as expected for chemical carcinogens. He concludes: "The epidemiologic evidence falls short of the strength and consistency of evidence that is required to come to a reasonable conclusion that RF emissions are a likely cause of one or more types of human cancer." To support his argument and conclusions Elwood cites 5 studies in his Table 3 showing the result of occupational RF exposure and Amateur Radio Operators. On one hand the data appears to be weak and inconsistent. On the other hand it does show, in multiple independent studies, that whole body, far-field RF exposures, results in elevated cancer rates across many body organs.

There are problems with identifying a non-exposed reference group with all the five papers cited. Adjusting the data for the No-Exposure Factor of 2, rather than using the NEF=4, that is justified above, all cancer rates in Elwood Table 3, except 3 individual cancer groups, will be elevated and the 20 originally significant rates are raised to include 43 groups.

In contrast to the two reviews cited above, and consistent with the evidence summarized here, after reviewing the residential and occupational RF exposure epidemiological studies available at that time, Goldsmith (108), concluded "Available data suggest that RF radiation be considered a carcinogenic risk, a position already taken in an internal U.S. E.P.A. document (109) in 1990 when there was much less evidence of the potential harmfulness of RF radiation." The evidence is now even stronger, including the doubling of lymphomas in mice in far-field exposure to cell phone radiation, Repacholi et al. (110).

Summary and Conclusions:

The Open Minded Approach of this review was facilitated through tutoring by Professor John Goldsmith and by the discovery that a natural globally available ELF signal, the Schumann Resonance (SR) signal is used by nature to synchronize intelligent and active brains, Cherry (111). Solar Activity modulates the SR signal through the Solar Wind modulating the earth's magnetic field and the ionosphere. The altered SR signal alters human melatonin, the higher the signal the lower the melatonin. This produces Solar Cycle and Solar Storm associated modulating Cancer, Cardiac, Reproductive and neurological effects that have been detected in large human populations in a large body of published literature (111).

Cherry predicts that since these human health effects are associated with the SR signal of about 0.1pW/cm^2 (magnetic component, 4pT) then it is highly probable that electrical occupations will show the same effects because they experience signals in the range 1 to 10μT (10 to 100mG), around a million times stronger. This is shown to be true (111) and with many studies cited here. In the context of this review it is noted that residential magnetic fields, typically in the range 0.01 to 0.5μT (0.1 to 5mG). It is logical that these fields, being around 50,000 times higher than the SR signal, will produce elevated cancer rates, especially leukaemia. The reviewed evidence shows very strong confirmation of this with many dose-response trends in leukaemia/lymphoma and All Cancer, across the residential exposure range, for children and adults, starting with Wertheimer and Leeper, and Lester and Moore.

The approach taken in this Review are consistent with those promoted by Mc Cann et al. and Elwood, but comes to very different conclusions, by applying more appropriate whole body exposure understanding, with more appropriate physics understanding of the different nature of electric and magnetic fields in ELF situations, and the higher biological impact of RF/MW exposures, along with the strongly justifiable Ubiquitous Universal Genotoxic Carcinogen Effect and the related Healthy Worker Effect.

The best explanation for the observed effects in the very large body of epidemiological evidence of cancer and laboratory evidence of Genotoxicity is that across the spectrum oscillating electromagnetic fields are a Ubiquitous Universal Genotoxic Carcinogen. This explains a high proportion of the cancer rate that has risen over the past 100 years and the weakening of the occupational results in recent studies that use the general population as the reference group. There is an absence of a No-Exposure group.

In the context of the natural environment it is evident that the adverse health effects observed to have elevated rates in “electrical workers” are being elevated in the general population because all, including the more vulnerable very young, very old and very sick, are living in fields that are typically 10 times lower than occupational chronic mean exposures. Electric Utility and military employees spend most of their time in them too.

With Leukaemia having risen by a factor of 7 to 8 over the 20th Century, a conservative estimate of a No-Exposure Factor = 4 for adjusting for the UGCE and HWE results in almost All Cancer rates being significantly elevated in all groups studied.

None of the studies specifically dealt with the No-Exposure Factor effect. Some studies, through their extensive exposure assessments deal with part of this effect by showing dose-response trends. The failure to deal with this effect grossly under-estimates the cancer rates associated with EMF/EMR exposures. Using a No Exposure Factor of 4, is conservative but it raises also every OR and RR rate well over 1.0. With the high exposure Leukaemia rates being in the range RR = 4 to 12, being raised to RR =16 to 48.

It is shown by a large body of evidence that oscillation electromagnetic fields and radiation damage DNA, reduce melatonin and alter cellular calcium ions, and that they cause elevated Leukaemia/Lymphoma rates in human populations associated with natural EMR, residential exposures and occupational exposures, including the military. Along with other open-minded reviews (5), it is well established that EMF/EMR is a Ubiquitous Universal Genotoxic Carcinogen with no threshold of no effect. Public health standards should be set at *de minimus* levels in order to reduce the serious health effects that are largely avoidable by applying safer design and using low exposure technology.

References:

1. Wertheimer, N. and Leeper, E., 1979: “Electrical wiring configurations and childhood cancer”. Am J Epidemiology 109(3): 273-284.

2. Wertheimer, N. and Leeper, E., 1982: “Adult cancer related to electrical wires near the home”. Int J Epidemiology 11(4): 345-355.

3. Savitz, D.A., Wachtel, H, Barnes, F.A., John, E.M. and Tvrdik, J.G., 1988: “Case-control study of childhood cancer and exposure to 60 Hz magnetic fields”. Am J Epidemiology 128: 21-28.

4. Milham, S., 1998: “Carcinogenicity of electromagnetic fields”. Eur J Oncol 3 (2): 93-100.

5. Cherry, N.J., 2002: “Epidemiological studies of enhanced Brain/CNS Cancer incidence and mortality from EMR and EMR exposures”. Submitted to Public Health Reviews.

6. Dorland, 1994: “Dorland’s illustrated Medical Dictionary, 28th Edition”. Publ. W.B. Saunders, Philadelphia, 1940pp.

7. Hill, A. B., 1965: “The Environment and Disease: Association or Causation?" Proc. Royal Society of Medicine (U.K.). 295-300.

8. Lindgren, M., Gustavsson, M., Hamnerius, Y. and Galt, S., 2001: “ELF magnetic fields in a city environment”. Bioelectromagnetics 22: 87-90.

9. Milham, S., Hatfield, J.B. and Tell, R.,1999: “Magnetic fields from steel-belted radial tires: implications for epidemiologic studies”. Bioelectromagnetics 20(7): 440-445.

10. Vistnes, A.I., Ramberg, G.B., Bjornevik, L.R., Tynes, T. and Haldorsen, T., 1997: “Exposure of children to residential magnetic fields in Norway: is proximity to power lines an adequate predictor of exposure?”. Bioelectromagnetics 18(1): 47-57.

11. Vignati, M. and Giuliani, L., 1997: “Radiofrequency exposure near high-voltage lines”. Environ Health Perspect. 105 Suppl 6: 1569-1573.

12. Mild, K.J., 1980: "Occupational exposure to radio-frequency electromagnetic fields”. Proc IEEE, 68(1): 12-17.

13. Kaune, W.T., Miller, M.C., Linet, M.S., Hatch, E.E., Kleinerman, R.A., Wacholder, S., Mohr, A.H., Tarone, R.E. and Haines, C., 2002: “Magnetic fields produced by hand held hair dryers, stereo headsets, home sewing machines, and electric clocks. Bioelectromagnetics 23(1): 14-25.

14. Tell, R.A. and Mantiply, E.D., 1980: "Population exposure to VHF and UHF broadcast radiation in the United States". Proc IEEE, 68(1): 6-12.

15. Mantiply, E.D., Pohl, K.R., Poppell, S.W. and Murphy, J.A., 1997: "Summary of measured radiofrequency electric and magnetic fields (10 kHz to 30 GHz) in the general and work environment". Bioelectromagnetics 18: 563-577.

16. Bernardi, P., Cavagnaro, M., Pisa, S. and Piuzzi, E., 2000: “Human exposure to radio base-station antennas in the urban environment”. IEEE Trans Micro Theo and Tech 48(11): 1996-2002.

17. International Commission on Non-Ionizing Radiation Protection (ICNIRP), 1998: "Guidelines for limiting exposure to time-varying electric, and electromagnetic fields (up to 300 GHz) - ICNIRP Guidelines". Health Physics, 74(4): 494-522.

18. Skotte, J.H. and Hjollund, H.I., 1997: “Exposure to welders and other metal workers to ELF magnetic fields”. Bioelectromagnetics 18: 470-477.

19. Kheifets LI, Afifi AA, Buffier, Zhang ZW., 1995: "Occupational electric and magnetic field exposure and brain cancer: a meta-analysis". J Occup Environ Med 37(12): 1327-1341.

20. Nicholas, J.S., Lackland, D.T., Butler, G.C., Mohr, L.C. Jr., Dunbar, J.B., Kaune, W.T., Grosche, B. and Hoel, D.G. and., 1998: “Cosmic radiation and magnetic field exposure to Airline Flight Crews”. Am J Ind Med. 34: 574-580.

21. Nicholas, J.S., Butler, G.C., Lackland, D.T., Hood, W.C. Jr, Hoel, D.G. and Mohr, L.C. Jr., 2000: “Flight deck magnetic fields in commercial aircraft”. Am J Ind Med. 38(5): 548-554.

22. Reiter, R.J. and Robinson, J, 1995: "Melatonin: Your body's natural wonder drug". Publ. Bantam Books, New York.

23. Szmigielski, S., 1996: "Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation". Sci Total Env 180: 9-17.

24. Wrensch, M., Yost, M., Miike, R., Lee, G. and Touchstone, J., 1999: “Adult Glioma in relation to residential power frequency electromagnetic field exposures in the San Francisco

Bay area". Epidemiology 10(5): 523-527.

25. Dockerty, J.O., Elwood, J.M., Skegg, D.C. and Herbison, G.P., 1998: "Electromagnetic field exposures and childhood cancers in New Zealand". Cancer Causes and Control 9(3): 299-309.

26. Dockerty, J.O., Elwood, J.M., Skegg, D.C. and Herbison, G.P., 1999: "Electromagnetic field exposures and childhood leukaemia in New Zealand". Lancet 354: 1967-1968.

27. Michaelis J, Schuz J, Meinert R, Zemann E, Grigat JP, Kaatsch P, Kaletsch, U, Miesner A, Brinkmann K, Kalkner W, Karner H. 1998 Combined risk estimates for two German population-based case-control studies on residential magnetic fields and childhood acute leukemia. Epidemiology. 9(1): 92-94.

28. Savitz, D.A., 2001: "Invited commentary: electromagnetic fields and cancer in railway workers. Am J Epidemiology 153(9): 836-838; discussion 839-840.

29. Green, L.M., Miller, A.B., Agnew, D.A., Greenberg, M.L., Li, J., Villeneuve, P.J. and Tibshirani, R., 1999: "Childhood leukaemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada". Cancer Cause and Control 10: 233-243.

30. Court-Brown, W. M., Doll R., 1961: "Leukaemia in childhood and young adult life: Trends in mortality in relation to aetiology". BMJ 26: 981-988.

31. Milham, S. and Ossiander E.M., 2001: "Historical evidence that residential electrification caused the emergence of the childhood leukaemia peak". Medical Hypotheses 56(3): 1-6.

32. Kraut, A., Tate, R. and Tran, N.M., 1994: "Residential electric consumption and childhood cancer in Canada (1971-1986)". Arch Environ Health 49(3): 156-159.

33. Hatch, E.E., Linet, M.S., Kleinerman, R.A., Tarone, R.E., Severson, R.K., Hartsock, C.T., Haines, C., Kaune, W.T., Friedman, D., Robison, L.L. and Wacholder, S., 1998: "Association between childhood Acute Lymphoblastic Leukemia and use of electrical appliances during pregnancy and childhood". Epidemiology 9(3): 234-245.

34. Feychting M, Ahlbom A., 1993: "Magnetic fields and cancer in children residing near Swedish High-voltage power lines". Am J Epidemiology 138 (7): 467-481.

35. Feychting M, Schulgen G, Olsen JH, Ahlbom A., 1995: "Magnetic fields and childhood cancer-pooled analysis of two Scandinavian studies". Europ J Cancer 31A (12): 2035-2039.

36. Fajardo-Gutierrez A, Garduno-Espinosa J, Yamamoto-Kimura L, Hernandez-Hernandez DM, Gomez-Delgado A, Mejia-Arangure M, Cartagena-Sandoval A, Martinez-Garcia MC. 1993 [Residence close to high-tension electric power lines and its association with leukemia in children] Bol Med Hosp Infant Mex. Jan;50(1):32-8. Spanish.

37. Greenland S, Sheppard AR, Kaune WT, Poole C, Kelsh MA. 2000 A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology 11(6): 624-634.

38. Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, Linet M, McBride M, Michaelis J, Olsen JH, Tynes T, Verkasalo PK. 2000 A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer. 83(5): 692-698.

39. Verkasalo PK, Pukkala E, Hongistro MY, Valjus JE, Jarvinen PJ, Heikkila, KV, Koskenvuo M., 1993: "Risk of cancer in Finnish children living close to power lines". BMJ 307(6909): 895-899.

40. Tynes T, Haldorsen T., 1997: "Electromagnetic fields and cancer in children residing near Norwegian high-voltage power lines". Am J Epidemiology 145(3): 219-226.

41. Savitz, D.A., Esther, J.M. and Kleckner, R.C., 1990: “Magnetic field exposure from electric appliances and childhood cancer”. Am J Epidemiology 131(5): 763-773.

42. Linet MS, Hatch EE, Kleinerman RA, Robison LL, Kaune WT, Friedman DR, Severson RK, Haines CM, Hartsock CT, Niwa S, Wacholder S, Tarone RE. 1997: “Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. N Engl J Med. 337(1): 1-7.

43. Auvinen A, Linet MS, Hatch EE, Kleinerman RA, Robison LL, Kaune WT, Misakian M, Niwa S, Wacholder S, Tarone RE. . 2000 Extremely low-frequency magnetic fields and childhood acute lymphoblastic leukemia: an exploratory analysis of alternative exposure metrics. Am J Epidemiol 152(1): 20-31.

44. Bianchi N, Crosignani P, Rovelli A, Tittarelli A, Carnelli CA, Rossitto F, Vanelli U, Porro E, Berrino F., 2000: “Overhead electricity power lines and childhood leukemia: a registry-based, case-control study”. Tumori 86(3): 195-198.

45. Wartenberg D., 1998 Residential magnetic fields and childhood leukemia: a meta-analysis. Am J Public Health 88(12): 1787-1794.

46. Coghill, R.W., Steward, J., and Philips, A., 1996: “Extra low frequency electric and magnetic fields in the bedplace of children diagnosed with leukaemia: a case-control study”. Eur J Cancer Prev. 5(3): 153-158.

47. London SJ, Thomas DC, Bowman JD, Sobel E, Cheng TC, Peters JM. 1991 Exposure to residential electric and magnetic fields and risk of childhood leukemia. Am J Epidemiology 134(9): 923-937.

48. Angelillo IF, Villari P. 1999; Residential exposure to electromagnetic fields and childhood leukaemia: a meta-analysis. Bull World Health Organ. 77(11):906-15.

49. Hicks, N., Zack, M., Caldwell, G.G., Fernbach, D.J., and Falletta, J.M., 1994: “Childhood cancer and occupational radiation exposure in parents”. Cancer 53: 1637-1643.

50. Olsen, J.H., de Nully Brown, P., Schugen, G. and Jensen, O.M., 1991: “Parental employment at time of conception and risk of cancer in offspring”. Eur J Cancer 27(8): 958-965.

51. Infante-Rivard, C., 1995: “Electromagnetic field exposure during pregnancy and childhood leukaemia”. Lancet 346 (July 15): 177.

52. Johnson, C.C. and Guy, A.W., 1972: "Non-ionizing electromagnetic wave effects in biological materials and systems". Proc IEEE 60(6): 692-718.

53. Schwan, H.P. and Foster, K.R., 1980: "RF-Field interactions with biological systems: electrical properties and biophysical mechanisms". Proc IEEE 68(1): 104-113.

54. Hocking, B., Gordon, I.R., Grain, H.L., and Hatfield, G.E., 1996: “Cancer incidence and mortality and proximity to TV towers”. Medical Journal of Australia, Vol 165, 2/16 December, pp 601-605.

55. Maskarinec, G. Cooper, J. and Swygert, L., 1994: "Investigation of increased incidence in childhood leukemia near radio towers in Hawaii: Preliminary observations". J. Environ Pathol Toxicol and Oncol 13(1): 33-37.

56. McKenzie, D.R., Yin, Y. and Morrell, S., 1998: "Childhood incidence of acute lymphoblastic leukaemia and exposure to broadcast radiation in Sydney - a second look". Aust NZ J Pub Health 22 (3): 360-367.

57. Cherry, N.J., 2002: "Childhood Cancer in the vicinity of the Sutro Tower, San Francisco". In press Int J Occup Environ Health.

58. Michelozzi, P., Capon, A., Kirchmayer, U., Forastiere, F., Biggeri, A., Baraca, A. and Perucci, C.A., 2002: "Adult and childhood Leukaemia near a high-power radio station in Rome, Italy". Am J. Epidemiology 155(12): 1096-1103.

59. Robinette, C.D., Silverman, C. and Jablon, S., 1980: "Effects upon health of occupational exposure to microwave radiation (radar)". Am J Epidemiology 112(1): 39-53.

60. Szmigielski, S., Sobiczewska, E. and Kubacki, R., 2001: “Carcinogenic potency of microwave radiation: overview of the problem and results of epidemiological studies on Polish military personnel”. Eur J Oncol 6(2): 193-199.

61. Lester, J.R., and Moore, D.F., 1982a: “Cancer incidence and electromagnetic radiation”. Journal of Bioelectricity 1(1): 59-76.

62. Severson, R.K., Stevens, R.G., Kaune, W.T., Thomas, D.B., Heuser, L., Davis, S., and Sever, L.E., 1988: “Acute Non-Lymphocytic Leukaemia and residential exposure to power frequency magnetic fields”. Am J Epidemiology 128(1): 10-20.

63. McDowall, M.E., 1986: “Mortality of persons resident in the vicinity of electricity transmission facilities”. Br J Cancer. 53(2): 271-279.

64. Wertheimer, N. and Leeper, E., 1989: Re: “Acute Non-Lymphocytic Leukaemia and residential exposure to power frequency magnetic fields”. Am J Epidemiology 130: 423-425.

65. Flodin, U., Fredriksson, M., Persson, B., Hardell, L. and Axelson, O., 1986: “Background radiation, electrical work, and some other exposures associated with acute myeloid leukemia in a case-referent study”. Arch Environ Health 41(2): 77-84.

66. Coleman, M.P., Bell, C.M., Taylor, H.L. and Primic-Zakelj, M., 1989: “Leukaemia and residence near electricity transmission equipment: a case-control study”. Br J Cancer 60(5): 793-798.

67. Bethwaite, P., Cook, A., Kennedy, J. and Pearce, N., 2001: “Acute leukemia in electrical workers: a New Zealand case-control study”. Cancer Causes Control. 12(8): 683-689.

68. Matanoski, G.M., Elliott, E.A., Breysse, P.N. and Lynberg, M.C., 1993: ”Leukemia in telephone linemen”. Am J Epidemiology 137(6): 609-619.

69. Dosemeci, M., and Blair, A., 1994: "Occupational Cancer Mortality Among Women Employed in the Telephone Industry". J Occup Med 36 (11): 1204-1209.

70. Theriault, G., Goldberg, M., Miller, A.B., Armstrong, B., Guenel, P., Deadman, J., Imbernon, E., To. T., Chevalier, A. and Cyr, 0., etal., 1994: "Cancer risks associated with occupational

exposure to magnetic fields among electric utility workers in Ontario and Quebec, Canada, and France: 1970-1989". Am J Epidemiology 139(6): 550-572.

71. Armstrong, B., Theriault, G., Guenel, P., Deadman, J., Goldberg, M. and Heroux, P., 1994: "Association between exposure to pulsed electromagnetic fields and cancer in electric utility workers in Quebec, Canada and France". Am J Epidemiology 140(9): 805-820.

72. Feychting M, Ahlbom A., 1994: "Magnetic fields, Leukaemia, and central nervous system tumours in Swedish adults residing near High-voltage power lines". Epidemiology 5: 501-509.

73. Feychting, M., Forssen, U. and Floderus B., 1997: “Occupational and residential magnetic field exposure and Leukemia and central nervous system tumors”. Epidemiology 8(4): 384-389.

74. Savitz, D.A. and Loomis, D.P., 1995: “Magnetic field exposure in relation to leukaemia and brain cancer among electric utility workers”. Am J Epidemiology 141(2): 123-134.

75. Milham, S. Jr., 1996: “Increased incidence of cancer in a cohort of office workers exposed to strong magnetic fields. Am J Ind Med. 30(6): 702-704.

76. Li, C.I., Theriault, G. and Lin, R.S., 1997: “Residential exposure to 60-Hertz magnetic fields and adult cancers in Taiwan”. Epidemiology 8: 25-30.

77. Dolk, H., Shaddick, G., Walls, P., Grundy, C., Thakrar, B., Kleinschmidt, I. and Elliott, P., 1997a: “Cancer incidence near radio and television transmitters in Great Britain, I - Sutton-Coldfield transmitter”. American J. of Epidemiology, 145(1): 1-9.

78. Dolk, H., Elliott, P., Shaddick, G., Walls, P., Grundy, C., and Thakrar, B.,1997b: “Cancer incidence near radio and television transmitters in Great Britain, II All high power transmitters”. American J. of Epidemiology, 145(1): 10-17.

79. Morgan RW, Kelsh MA, Zhao K, Exuzides KA, Heringer S, and Negrete W., 2000: "Radiofrequency exposure and mortality from cancer of the brain and lymphatic/hematopoietic systems". Epidemiology 11(2): 118-127.

80. Archimbaud, E., Charrin, C., Guyotat, D., and Viala, J-J, 1989: "Acute myelogenous leukaemia following exposure to microwaves". British Journal of Haematology, 73(2): 272-273.

81. Lester, J.R., and Moore, D.F., 1982b: “Cancer mortality and air force bases”. Journal of Bioelectricity, 1(1): 77-82.

82. Lester, J.R., 1985: “Reply to: Cancer mortality and air force bases, a re-evaluation”. Journal of Bioelectricity, 4(1): 129-131.

83. Wright,W.E., Peters, J.M. and Mack, T.M., 1982: “Leukaemia in workers exposed to electrical and magnetic fields”. Lancet Nov 20;2(8308):1160-1.

84. Milham S., 1985: "Mortality in workers exposed to electromagnetic fields". Environ Health Perspectives 62: 297-300.

85. UK Registrar General, 1986: “Occupational Mortality”. The Registrar general’s decennial supplement for Great Britain, 1979-80, 1982-83, Part 1 Commentary, London: Her Majestry’s Stationery Office.

86. Calle, E.E. and Savitz, D.A., 1985: “Leukemia in occupational groups with presumed exposure to electrical and magnetic fields”. N Engl J Med. 313(23): 1476-1477.

87. Milham, S., 1988: "Increased mortality in amateur radio operations due to lymphatic and hematopoietic malignancies". Am J Epid 127(1): 50-54.

88. Garland FC, Shaw E, Gorham ED, Garland CF, White MR, and Sinsheimer PJ., 1990: “Incidence of leukemia in occupations with potential electromagnetic field exposure in United States Navy personnel”. Am J Epidemiology. 132(2): 293-303.

89. Coleman, M. and Beral, V., 1988: “A review of epidemiological studies of the health effects of living near or working with electricity generation and transmission equipment”. Int J Epidemiology 17(1): 1-13.

90. Guberan, E., Usel, M., Raymond, L., Tissot, R. and Sweetnam, P.M., 1989: “Disability, mortality, and incidence of cancer among Geneva painters and electricians: a historical prospective study”. Br J Ind Med 46(1): 16-23

91. Bastuji-Garin, S., Richardson, S. and Zittoun, R., 1990: “Acute leukaemia in workers exposed to electromagnetic fields”. Eur J Cancer 26(11-12): 1119-1120.

92. Pearce, N, Reif, J. and Fraser, J., 1989: “Case-Control studies of cancer in New Zealand electrical workers”. Int J Epidemiology 18(1): 55-59.

93. Sibbison, J.B., 1990: “USA: Danger from electromagnetic fields”. The Lancet, 14 July 1990: 106.

94. Sibbison, J.B., 1991: “USA: White House Interference?” The Lancet 337, 2 March 1991: 544.

95. Pfluger, D.M. and Minder, C.E., 1996: "Effects of 16.7 Hz magnetic fields on urinary 6-hydroxymelatonin sulfate excretion of Swiss railway workers". J Pineal Research 21(2): 91-100.

96. Minder, C.E. and Pfluger, D.H., 2001: "Leukemia, brain tumors, and exposure to extremely low frequency electromagnetic fields in Swiss railway employees". Am J Epidemiology 153(9): 825-835.

97. Savitz, D.A., Cai, J,., van Wijngaarden, E., Loomis, D., Mihlan, G., Dufort, V., Klechner, R.C., Nylander-French, L, Kromhout, H. and Zhou, H., 2000: “Case-control analysis of brain cancer and leukemia in electric utility workers using a refined magnetic field job-exposure matrix”. Am J Ind Med 38(4): 417-425.

98. Cherry, N, 2001: Re: “Cancer incidence near radio and television transmitters in Great Britain, II All high power transmitters, Dolk et al. 1997 a,b in American J. of Epidemiology, 145(1):1-9 and 10-17. Comment in American J of Epidemiology 153(2): 204-205.

99. Goldsmith, J.R., 1997: “TV broadcast towers and cancer: the end of innocence for radiofrequency exposures”. Am J Ind Med 32: 689-692.

100. Guenel, P., Nicolau, J., Imbernon, E., Chevalier, A. and Goldberg, M., 1996: "Exposure to electric field and incidence of leukaemia, brain tumours, and other cancers among French electric utility workers". Am J Epidemiology 144(12): 1107-1121.

101. Kheifets, L.I., London, .S.J. and Peters, J.M., 1997: “Leukaemia risk and occupational electric field exposure in Los Angeles County, California”. Am J Epidemiology 146(1): 87-

90.

102. Band, P.R., Spinelli, J.J., Ng, V.T., Moody, J. and Gallagher, R.P., 1990: "Mortality and cancer incidence in a cohort of commercial airline pilots". Aviat Space Environ Med 61(4): 299-302.

103. Johansen, C. and Olsen, J.H., 1998: "Risk of cancer among Danish utility workers-a nationwide cohort study". Am J Epidemiology 147(6): 548-555.

104. Johansen, C., Boice, J.D., McLaughtin, J.K., and Olsen, J., 2001: "Cellular telephones and cancer- a nationwide cohort study in Denmark". J Nat Cancer Inst 93(3): 203-207.

105. Beaglehole, R., Bonita, R. and Kjellstrom, T, 1993: "Basic epidemiology". World Health Organization, Geneva, 174pp.

106. McCann, J, Kheifets, L. and Rafferty, C., 1998: “Cancer risk of extremely low frequency electric and magnetic fields: a critical review of methodology”. Environ Health Perspectives 106(11): 701-717.

107. Elwood, J.M., 1999: "A critical review of epidemiological studies of radiofrequency exposure and human cancers". Environ Health Perspective Feb (Suppli 1): 155-168.

108. Goldsmith, J.R., 1997: "Epidemiologic evidence relevant to radar (microwave) effects". Environmental Health Perspectives, 105 (Suppl 6): 1579-1587.

109. U.S.E.P.A, 1990: United States Environmental Protection Agency, unpublished data, cited by Sibbison JB, USA: Danger from electromagnetic fields, Lancet 336(8707): 106.

110. Repacholi, M.H., Basten, A., Gebski, V., Noonan, D., Finnie, J. and Harris, A.W., 1997: “Lymphomas in E mu-Pim1 transgenic mice exposed to pulsed 900 MHZ electromagnetic fields. Radiat Res. 147(5): 631-640.

111. Cherry, N.J., 2002: "Schumann Resonances, a plausible biophysical mechanism for the human health effects of Solar/Geomagnetic Activity". Natural Hazards (In Press for July 2002).