

# **Epidemiological studies of enhanced Brain/CNS Cancer incidence and mortality from EMR and EMF exposures**

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**O.N.Z.M: Royal honour: Officer of the New Zealand Order of Merit**

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## **Abstract:**

A very large number of epidemiological studies relate EMF and EMR exposures to Brain/CNS Cancers and a large laboratory set of studies show that the EMF fields and EMR damage DNA. Taken together, they give robust support for the hypothesis that oscillating Electromagnetic Fields and Radiation are a Ubiquitous Universal Genotoxic Carcinogen. Brain Cancer is shown to be elevated in over 400 exposed groups with over 50 dose-response relationships. Both residential studies and occupational studies show elevated, significantly raised and dose-response increased Brain/CNS Cancer rates from EMF/EMR chronic exposures. The evidence is substantially higher than the classical causal linkage. The EMF/EMR fields have been introduced into homes, schools, buildings, factories and along streets, covering more and more of the areas in the developed world over the past century. Over the 20<sup>th</sup> century these fields have contributed a major proportion of the increase in cancer, by a factor of 50 to 80% of the 6- to 7-fold total increase, because of the unique ubiquitous nature of exposures to the EM fields and the RF/MW radiation. There is robust evidence of the oscillating electromagnetic spectrum from ELF to RF/MW being Genotoxic and Carcinogenic. Therefore this generates the Ubiquitous Genotoxic Carcinogen Effect (UGCE) which results from the absence of a non-exposed control group. The UGCE has been almost universally ignored in published epidemiological studies even though together they support and confirm the hypothesis. The UGCE, along with the Healthy Worker Effect, mean that the epidemiological cancer Odd Ratios (OR) and Relative Risks (RR) are grossly under-estimated because of the lack of a non-exposed control group. The genotoxic nature of these fields is so strong that exposed parents pass cancer, including Brain Cancer, on to their children. This review shows that there is strong and robust evidence that chronic exposures to ELF/RF/MW fields across the spectrum, through strength, consistency, biological plausibility and many dose-response relationships, cause increased rates of Brain/CNS Cancer from residential and occupational exposures. There is no safe threshold because of the genotoxic nature of the biological mechanism.

## **Introduction:**

The brain is a highly complex and sensitive electromagnetic organ that uses a wide range of ELF frequencies for its natural functions of thinking, seeing, emotions and memory. Hence there are classical physics concepts to explain interactions between external EM fields and the brain tissue and activity. Resonance, absorption and interference are primary processes. Cherry (1) shows that there is very strong evidence to support the hypothesis that the Schumann Resonance (SR) Signal is detected by the brain, and the SR signal synchronizes the ELF activity of the brain. Adey (2,3) shows that brain tissue

responds to external ELF modulated signals by altering the rate of flux of calcium ions through neurons, at extremely low induced electric field intensities down to  $10^{-8}$  V/cm. The brain's circadian and ELF activity is synchronized by this signal with a matching frequency range being resonantly absorbed in the brain tissue. Solar and Geomagnetic Activity (S-GMA) induces changes in human health, including cancer, through modulating the SR signal, altering brain activity and altering melatonin production. The SR signal is a mainly tropically sourced radiating ELF signal, that has been chronically globally available. The SR signal has a mean vertical electric field strength in the range 0.22-1.12 mV/m ( $0.013$ - $0.33$  pW/cm<sup>2</sup>), averaging about  $0.1$  pW/cm<sup>2</sup>. The magnetic field component is typically in the range 1 to 6 pT (4).

The natural electromagnetic sensitivity of the brain gives a strong basis for accepting that electromagnetic field and radiation exposures at thousands to millions of times higher intensity than the natural SR signal, can damage brain tissue and could cause brain cancer if the damage is genetic. For mobile phones the user's head is exposed to over a billion times higher intensity than the Schumann Resonance signal. A second vital factor for brain damage is the primary need for damaged brain cells to be repaired if possible, because of the nearly total lack of replacement. Melatonin plays a vital role in free radical scavenging and in the competence of the immune system, Reiter and Robinson (5).

With S-GMA activity, though the Schumann Resonance signal, altering human melatonin, Cherry (1), then it is shown to be causally associated with a homeostatic relationship with variations in rates of cancer, cardiac, reproductive and neurological diseases and mortality, though a large body of multiple, independent studies. Cherry also shows that similar effects are identified to be significantly and dose-response elevated in people in electrical occupations.

### **Association to Causal Relationships:**

When aiming to protect public health from chronic exposures that could cause serious health effects, such as cancer, a precautionary approach is appropriate. This review assessment relies primarily on the guidance given by Sir Austin Bradford Hill, (6). Sir Austin gives assessment "view points" of various kinds of evidence and data to take the evaluation from association to causation. "Biological Mechanisms" are helpful but not necessary. His first view point is "Strength" of the association which can show a causal effect, but the absence of strength does not dismiss a causal effect. Secondly he finds "Consistency" and "Specificity" helpful, but not always appropriate for all substances. His only necessary condition is "Temporality", that is, exposure must occur before disease develops. The strongest single evidence is "Biological Gradient". A dose-response relationship provides a "simple explanation" places the causation question "in a clearer light". Sir Austin is aware of the limitations of statistical analysis because of the small group numbers that are often involved. He reports on a causal relationship that never involved a statistical relationship in small groups of cardroom workers exposed to dust with respiratory disease. Hence elevated, but non-significant risk rates are appropriate, especially when case sample sizes are small. Taken together they can support the causal assessment.

### **Biological Mechanisms:**

Three biological mechanisms are relevant for the etiology of brain cancer in relation to EMF/EMR exposures, calcium ion in/efflux, melatonin reduction and DNA damage.

#### **Calcium ion in/efflux:**

Calcium ion in/efflux is a non-thermal resonant absorption mechanism for neurons and altered cellular calcium ion concentrations are related to cancer in the same manner as some chemical carcinogens, such as TPA, Balcer-Kubiczek (7). Blackman (8) reviews the published research on calcium ion efflux and concludes that it is an established biological mechanism from ELF modulated EMF/EMR exposure.

#### **EMR/EMF Melatonin reduction:**

Rosen, Barber and Lyle (9) state that seven different laboratories have reported suppression of nighttime rise in pineal melatonin production in laboratory animals. They show that a 50  $\mu$ T, 60 Hz field with a 0.06 $\mu$ T DC field, over 10 experiments, averages a 46% reduction in melatonin production from pinealocytes.

Electrical workers, and occupational situations where people are exposed to mixed ELF and RF fields, are the most studied people about melatonin reduction and multiple, independent studies confirm that ELF and RF fields reduce melatonin, (10-23). Two recent studies (24, 25) recorded significant melatonin reduction in women in EMF residential exposure situations. Burch et al. (16, 18) involved cell phone use, and Burch et al. (19) a significant dose-response reduction of melatonin from increased geomagnetic activity of around 30nT. Together the body of studies gives sufficient evidence for a causal effect of EMF/EMR reduction of melatonin in animals and humans.

#### **DNA Damage:**

A genotoxic agent causes Cancer. It damages DNA and causes enhance cell death and neoplastic mutations. DNA damage is shown by chromosome aberrations, micronuclei formation, DNA strand breakage, neoplastic transformation, altered cell proliferation and enhanced oncogene activity. RF/MW radiation significantly enhances chromosome aberrations in many studies (26-47). Eleven show significant micronuclei formation (37-47) and four of these studies show dose-response relationships (42-47). Eight studies from five independent laboratories show direct DNA strand breakage (40, 48-54). One of these studies shows a dose-response (49) and another shows an extremely significant DNA strand breakage,  $p < 0.0001$ , at a very low exposure level, SAR = 0.0024W/kg, (54).

Two of the DNA studies (52,53) claim that their data does not show that RF/MW radiation produces DNA-strand breakage. However, their data analyzed with a 2x2, cutoff approach shows significant DNA breakage followed by significantly enhanced DNA repair dependent on exposure period. There is highly substantial evidence that RF/MW is genotoxic, exceeding the classical level of an established biological mechanism. Since RF/MW is genotoxic, therefore it causes cancer. A genotoxic substance has no safe exposure level because it damages the DNA cell-by-cell.

In 1989 El Nahas and Oraby (55) observed significant dose-response dependent micronuclei increase in 50 Hz exposed mice somatic cells. Elevated CAs have been recorded in a number of workers in electrical occupations. In Sweden Nordenson et al. (56) found significant CA in 400 kV-substation workers and with 50 Hz exposures to peripheral human lymphocytes, Nordenson et al. (57, 58), human amniotic cells and lymphocytes from electric train drivers, Nordenson et al. (59). Significant CA in human lymphocytes exposed to 50 Hz fields are also reported by multiple independent studies (60-64). Skyberg et al. (63) collected their samples from high-voltage laboratory cable splicers and Valjus et al. (64) from power linesmen. Several other studies showing ELF associated CAs (65-71). Tofani et al. (69) found that significant micronuclei formation was associated with resonant ELF fields at resonant  $\text{Ca}^{2+}$  frequencies combined with static fields. This cited research currently involves 17 studies showing DNA damage from ELF exposure.

Three independent laboratories have also published data on ELF induced DNA strand breaks confirming that ELF fields damage DNA strands; Lai and Singh (72), Svedenstal et al. (73-75), and Ahuja et al. (76, 77). Lai and Singh also demonstrate the involvement of free radicals and the protective effect of melatonin. With the evidence above that EMR reduces melatonin this confirms that reduced melatonin causes higher concentrations of free radicals that produce more DNA strand breaks from EM exposure from ELF to RF/MW frequencies. Increased DNA strand breaks will result in increased chromosome aberrations.

Multiple evidence from independent laboratories established that EMR from ELF to RF/MW causes DNA single- and double-strand breaks at very low, non-thermal exposure levels. This extends and confirms the evidence that oscillating electromagnetic fields and radiation are genotoxic from chromosome aberration, micronuclei formation and DNA strand breaks studies. It is accepted that a genotoxic substance is a causal agent for cancer.

### **Exposure Situations:**

All people in modern homes that have electric energy have wires and appliances that generate AC 50/60Hz electric fields from voltage and magnetic fields when currents flow. Similar or stronger fields are experienced on roads from the overhead and underground power cables. All modern buildings also have power supplies and ELF fields. High voltage power lines Vignati and Giuliani (78). Many modern appliances at home and work also produce RF/MW radiation fields, Mild (79) and Mantiply et al. (80). Urban and rural areas have detectable and usable RF/MW from Radio and TV stations, Tell and Mantiply (81) and cell phone base stations Bernardi et al. (82). Occupations are identified as having above average exposures, such as “electrical and electronic occupations”.

It is basic physics that when a wire is connected to the AC power supply there is a voltage along the length of the wire producing an AC electric field. When the electrical device is turned on an electric current flows producing an AC magnetic field that is added to the electric field forming an electromagnetic field. This produces stronger induced fields than the simple electric field and is more closely associated with biological and health effects.

All people using personal computers are exposed to mixed EMF/EMR signals from the VDT, including children using play stations, Kaune et al. (83). Welders and metal workers are moderate to highly exposed, Skotte and Hjollund (84). Hence an ELF review and meta-analysis of brain tumours, Kheifets et al. (85), included six studies involving welding staff. Airline crews are exposed to RF/MW and ELF fields, Nicholas et al. (86, 87).

All electric motors in operation, including vacuum cleaners, hair driers and sewing machines, or from lathes, drills, appliances and cranes in factories, produce very high local ELF fields. Some questions have been raised about the appropriateness of spot measurements and estimates of mean chronic exposures, such as Wiring Codes. All local, intermediate and high voltage power lines have variable loads and currents, crating variable strengths of the electromagnetic fields, with typical daily, weekly and seasonal patterns. Hence a single spot measurement does not represent the chronic mean exposure of people living or working near these lines. Longer term average or frequency distributions of fields are closely approximated by Wire-Codes that were developed to take into account the current loads and hence the mean electromagnetic fields.

In a San Francisco Adult Glioma study Wrensch et al. (88) measured residential fields and found that they correlated very well with the Wertheimer-Leeper and Kaune-Savitz Wire Codes. For example, for the 90<sup>th</sup> percentile measured front door fields, Table 1.

Table 1: Relationship between measured residential magnetic fields and the wiring codes of Wertheimer and Leeper and Kaune and Savitz, (88)

Wertheimer-Leeper Wire Code from very low to very high					
	VLCC	OLCC	OHCC	VHCC	
Magnetic Field (mG)	0.6	1.4	2.1	2.7	Trend p<0.005
Kaune-Savitz Wire Code					
	Low	Medium	High		
Magnetic Field (mG)	1.2	1.6	2.6		Trend p=0.055

Heavy cell phone usage of many hours per day can in some circumstances approach a similar daily mean exposure of the head as radar maintenance workers because of the proximity of the cell phone aerial to the user's head. Because cell phone handsets produce ELF and RF/MW signals and because the EMR Spectrum Principle shows that the biological and health effects are linked across the EMR spectrum, it is appropriate to consider studies involving ELF, mixed and RF/MW exposures.

The ubiquitous nature of EMF and EMR fields is a problem for health effects and for identifying an unexposed reference group. This grossly under-estimates the comparative Odds and Risk Ratios.

### **Cancer Latency and Development:**

Cancer starts with initiation from DNA damage in a cell that survives and reproduces it mutated cancer DNA change. Continued exposure promotes the cancer with opposition from the immune system attempting to eliminate "foreign" cells. In the third stage the cancer progresses into a detectable tissue change (3). Childhood cancer is a very

different situation than for adult cancer. Young children have low melatonin levels, a highly protective free radical scavenger, and weak immune systems. This allows cancer that is initiated in utero or in early life, to be promoted quickly. In very young children brain cancer and leukaemia can be diagnosed in the first year of life giving a cancer latency of months. For example, Selvin et al. (89) report that 5 out of 35 children with brain cancer developed this within 0-2 years. The evidence of EMF/EMR signals being genotoxic predicts that exposure of parents could pass defects and disease such as cancer, including ALL and Brain/CNS Cancer, on to children. This is confirmed by several studies (90-104). Parents with Cancer pass on an increased risk of Brain Cancer to their children (104). The first formal epidemiological study, Wertheimer and Leeper (105) found significant elevation of Total Cancer in High Current Code exposed 0-5 year olds, with birth address, RR = 1.40 (1.14-1.72),  $p=0.0023$ , and with their death address, RR = 1.49 (1.22-1.82),  $p=0.0003$ . With mean household exposures of about 3 mG 100% (n=6) of the childhood cancer cases lived in this situation. This shows that very young children are very susceptible to Cancer, including Brain Cancer from domestic exposure to very low intensity ELF fields and RF/MW signals. This is confirmed by many studies cited below.

Solid tumors typically take 4 to 30 years to develop in adults. Wertheimer and Leeper (106) found that the latency between beginning magnetic field exposures and diagnosis of adult cancer typically fell into the range 4 to 9 years, peaking at 7 years. For adults, high occupational exposure to a strong genotoxic substance can accelerate the development of cancer significantly, from initiation, through promotion to progression to a detectable cancer. Radar exposed workers in Israel include one man out of a group of 25 was exposed to the radar at age 18 and was diagnosed with a brain cancer at age 19, Richter et al. (107). This man came from a cohort of 25 soldiers in radar units who were frequently exposed to high peak exposures ( $5000 \mu\text{W}/\text{cm}^2$ ) among whom 6 others were reported to have cancers (1 Melanoma and Lymphoma, two Leukaemias, one Lymphoma, one benign Liver Cancer and one Brain Cancer).

Based on estimated relative risks for this group were in the range 50-100, and application of the principles that (1) there is no threshold for a genotoxic carcinogen, (2) that from high exposures in small populations predict risks from lower exposures, the authors estimated thresholds for NOAEL in the range of  $10\text{-}100 \mu\text{W}/\text{cm}^2$  for all tumors, and  $<10 \mu\text{W}/\text{cm}^2$  for special tumors. This is in the range of those reported by Goldsmith (108, 109) in his re-analysis of the Moscow US Embassy data. However these were outside peak measurements and inside mean personal exposures were about 100 times lower, i.e.  $<0.1 \mu\text{W}/\text{cm}^2$ .

Zaret (110) reports that two men, out of a group of 18 radar-exposed workers in the United States, developed Astrocytoma. Expressing rates as per 100,000 p-yrs. Assuming that the exposure/latency period was 10 years, this gives an incidence rate of 1111. Compared with the SEER adult 30-34 yr old male Astrocytoma rate in 1974 of 0.68 per 100,000 p-yrs. This gives:

$$\text{RR} = 1634 (385\text{-}6939), n=2, p=0.0000009$$

The bracket contains the 95% Confidence Interval range. The childhood brain cancer rate in close vicinity (<500m) to the powerful RF/MW emitting Sutro Tower, In San Francisco, is, Cherry (111)

$$\text{RR} = 64.2 (10.8\text{-}382), n=2, p=0.00103$$

The low level chronic mean residential exposure associated with this elevated cancer rate is in the order of 0.2 to 0.5 $\mu$ W/cm<sup>2</sup>. These very high cancer rates from RF/MW radiation exposures are consistent with the EMR Spectrum Principle. This shows that the higher the carrier frequency, the lower the tissue dielectric constant and the higher the induced electric field gradient and induced tissue current, (2, 78, 112, 113)

### **All Cancer Studies:**

Some studies use All Cancer incidence or mortality for residential or occupational exposure studies. All Cancer incidence includes Brain/CNS cancer, around 26% for children <20 years in the SEER registry and for adults it is a far smaller proportion, less than 1.5%. In the first published epidemiological study of ELF exposures and childhood cancer, Wertheimer and Leeper (105), and adult cancer, Wertheimer and Leeper (106), only the combined All Cancer group was presented. They used the classical John Snow foot leather approach to assess the environmental conditions at the birth and death addresses of the children with cancer. Dr Leeper, as a physicist, used a gauss meter to measure typical fields, and developed the wiring current configuration code assessment based on current strengths. Both of these studies showed significant dose-response increases in cancer as a function of assessed current strength. Very extensive work was done on possible confounding factors, none of which weakened the results. Hence they suggested that the homes with High Current Configurations (HCC) and cancer may be causally linked because of the dose-response relationship, the consistency between both studies and the lack of confounding factors.

In the independent follow-up study, Savitz et al. (114), the results were basically confirmed. However they used a different wire configuration code and found that the wire codes were significantly associated with childhood cancer with High/Low comparisons, OR = 1.53 (1.04-2.26), for All Cancer, OR = 1.54 (0.9-2.63) for Leukaemia and OR = 2.04 (1.11-3.76) for Brain Cancer. The data-set contained 356 childhood cancer cases, with Leukaemia (28.9%), Brain Cancer (18.8%), Lymphoma (9.8%), Soft Tissue Tumours (9.0%) and Other Cancer (33.4 %). Hence studies that only identify All Cancer, include Brain Cancer, Leukaemia and Lymphoma and other cancers.

Combining the original and follow-up studies the results are classically assessed, Hill (6), as a causal link between the electromagnetic fields from power supply wiring and appliances and Cancer, including Brain Cancer, Leukaemia and Lymphoma, but also all other cancers. At that time Savitz et al. consider their results weak because of the lack of laboratory evidence of a cancer-promoting effect, such as DNA damage. The laboratory evidence EMR is genotoxic is now available from multiple independent laboratories, cited above. We also now have a large volume of epidemiological studies strongly supporting and robustly confirming the causal relationship between EMF/EMR and cancer, especially Brain Cancer and Leukaemia.

### **Brain Cancer Studies:**

In summary the published epidemiological studies on EMR/EMF association with Brain Cancer involves over 100 studies (104-203, 205, 207-222), showing elevated Brain Cancer incidence and mortality rates in over 400 groups. Around 40 studies show at least



one significantly elevated Brain Cancer rate in a total of over 130 exposed groups. There are over 25 studies (from All Cancer, 105, 106, 114, 117 and 172; from Brain/CNS Cancer 85, 111, 131, 139, 140, 142, 143, 146, 147, 151, 152, 154, 173-180, 184, 190, 192, 209, 221) with more than 50 dose-response relationships with 29 specifically identified as being significant trends. This definitely supports a causal link between EMF/EMR and Brain Cancer.

The epidemiological evidence is summarized below by in major exposed groups, including: "Military radio and radar exposures", pilots and aircrew, "electrical occupations" and other occupational exposures, residential exposures, and cell phone users.

### **Military Radio and Radar Exposures:**

The Korean War study, Robinette et al. (115), involved a job exposure matrix 5% survey that showed significant dose-response increases in all mortality and Respiratory Cancer in the survey group. For All Cancer MR = 1.45. In the occupational groups ET was a low and FT a moderate exposure group. There were only 8 brain cancer cases between them but a 2x2 analysis gives (FT/ET) RR = 2.38 (0.57-9.95), n=3. The RD and RM groups were operators compared to all other groups that were more highly exposed as equipment repairers. Other comparisons give: AE/(RD+RM), RR = 1.96 (0.24-15.89) n=1, and FT/(RD+RM), RR = 2.52 (0.65-9.73), n=3.

After Zaret (110) reported 2 Astrocytomas in a group of 18 radar repair workers, RR = 1634, the results of the epidemiological study of Lilienfeld et al. (116), concerning the health effects in staff and dependents at the U.S. Embassy in Moscow are not surprising. The chronic radar exposure began in 1953 and continued into the 1970's. Staff and families typically had a 2-year tour of service. Mean personal long-term exposures were well less than  $1\mu\text{W}/\text{cm}^2$ . Blood tests showed significantly elevated chromosome aberrations, Goldsmith (109). Staff and dependents showed elevated cancer rates, including one adult dependent group showing a significant elevation of brain cancer OR = 20 (2.4-72.2),  $p < 0.01$ , n=2.

These results are supported and confirmed by the residential radar exposure studies of Lester and Moore (117-119). They involved All Cancer, that includes brain cancer, and showed a significant ( $p=0.03$ ) dose-response increase in cancer in Wichita, Kansas, significantly elevated cancer in counties with radars in Air Force Bases and in cities near to Air Force Bases.

The Polish Military study is the largest and best exposure assessment study to date, Szmigielski (120). The 1996 study showed a significant increase in All Cancer, OR = 2.07 (1.12-3.58), and Brain/CNS Cancers, OR = 1.91 (1.08-3.47). The follow-up study included a prospective study showing a dose-response increase in All Cancer with recorded peak exposure. The Brain/CNS Cancer rate rose to RR = 2.70,  $p < 0.01$ , Szmigielski, Sobiczewska and Kubacki (121).

Therefore multiple independent studies show that radar from moderately high to extremely low chronic exposures to pulsed microwaves from radars, significantly enhances Brain Cancer rates.

### **Pilots and Aircrew:**

Pilots and aircrew are exposed to moderately high ELF and frequent RF/MW exposures from radio, radar and visual displays. Band et al. (122) found that Canadian male commercial airline pilots had significantly higher All Cancer rates, including SMR = 4.17 (1.4-9.5) for Brain Cancer. Salisbury et al. (123) also found elevated Brain Cancer rates in British Columbian pilots (20-65yrs) PMR = 195 (53-501), n=4. British Airways pilots also have significantly elevated rates All Cancer, PMR = 1.31 (1.1-1.55) and Brain Cancer PMR = 2.68 (1.23-5.08), n=9, Irvine and Davies (124). Band et al. (125) show a Healthy Worker Effect for Air Canada pilots, All mortality SMR = 0.63 (0.56-0.7) and all cancer mortality SMR = 0.61 (0.48-0.76). For Brain Cancer the incidence rate is SIR = 1.53 (0.72-2.87). If this is adjusted for the HWE with the SIR = 0.71 for all cancer, then it becomes SIR = 2.15.

United States Air Force Aircrew were studied by Grayson and Lyons (126, 127) in relation to their cancer rates. They found that the Brain/CNS cancer rate compared with the SEER rate was SIR = 0.71 (0.30-1.40). When the aircrew rate was compared with other USAF officers, then SIR = 1.20 (0.52-2.78), and example of the HWE because the USAF officers have a lower cancer rate than the general population in the SEER register. They then carried out a job-exposure matrix assessment of personal exposures to ionizing, ELF and RF/MW radiation. For ionizing radiation OR = 0.58 (0.22-1.52), for ELF OR = 1.28 (0.95-1.74) and for RF/MW exposure OR = 1.39 (1.01-1.90) for Brain Cancer incidence, Grayson (128). This also shows a reduction bias of the HWE that is stronger in uniformed services. Ionizing radiation is a proven genotoxic carcinogen. Even if its OR was raised to 1.0 it would raise RF/MW to OR = 2.4. This study shows that the effect of ELF and RF/MW on the rate of Brain Cancers is somewhat greater the Ionizing radiation. This supports the EMR relationships of commercial airline crew to elevated Brain Cancer rates.

Nicholas et al. (129) investigated mortality in US commercial pilots and navigators. Their mortality rates were compared with occupational mortality rates from 24 States. This creates a HWE. For Brain Cancer O/E = 1.49 (0.9-2.33), n=19.

Pilots and Aircrew are chronically exposed to ELF and RF/MW fields in their work. This results in significant elevation of Brain Cancer Incidence and Mortality rates.

### **Occupational Exposures:**

Two early studies, Milham (130) and Lin et al. (131) studies cancer risks in U.S. electrical workers. Milham used Washington State cancer mortality data and found a significant increase in Brain Cancer, PMR = 1.23,  $p < 0.05$ , for all workers combined. Electricians had PMR = 1.55,  $p < 0.01$ , Power Station Operators, PMR = 130, Motion Picture Operators, PMR = 1.88 and Aluminum Workers, PMR = 137. Lin et al. attempted to rate the workers probable exposure level into 4 categories. For Glioma and Astrocytoma this resulted in a significant dose-response increase,  $p < 0.01$ , and for all Brain Tumours, trend  $p < 0.05$ . Tornqvist et al. (132) found elevated Brain Cancer for power linemen, SMR = 1.5 (0.9-2.4). A review of occupational exposures and Brain Cancer, Thomas and Waxweiler (133), cited the above cited studies and others involving ELF exposures for electricians, SMR = 2.21\* (134), sMOR = 3.14 (135), and PIR = 1.42 (136); linemen, telegraph, telephone servicemen, PMR = 2.07 (137) and welders, SRR = 1.44\* (138).

Thomas et al. (139) showed a synergistic relationship between RF/MW exposure and lead from soldering, and Astrocytoma incidence with years of work in electronic manufacturing jobs. For all lead exposure RR = 1.1 (0.8-1.6). Adjusting the Electronics manufacturing workers rates for this gives an astrocytomas rate of RR = 3.0 for <5 yrs, RR =6.9 for 5-19 yrs and RR =9.5 for  $\geq 20$  yrs, trend  $p = <0.01$ . Park et al. (140) carried out a similar study in a factory manufacturing Aerospace Electromechanical Systems. They found an extremely significant elevation of Brain Cancer Mortality, PMR = 4.2,  $p=0.00001$ . Among hourly employees the rate was PMR = 4.4,  $p=0.0005$  and for those working for less than 20 years PMR = 8.7,  $p= 0.000003$ . Park et al. refer to Thomas et al. but investigate the exposures to CFCs and solvents. None of the solvents mentioned are associated with brain cancer in a MEDLINE search. There is no doubt that the employees were chronically exposed to EMF fields from power supplies, motors and equipment. Their duration of employment leads to an exponential rise in Brain Cancer mortality, primarily Astrocytoma, and elevated rates of many other cancers, consistent with “electrical occupations”.

Kheifets et al. (85) carried out a meta-analysis of occupational electric and magnetic exposures and Brain Cancer. Out of 52 available studies they chose 29 as appropriate for inclusion in the meta-analysis. Six of the studies showed sufficient exposure information to produce a pooled dose-response relationship. This resulted in Low: RR = 1.23 (1.06-1.42); Middle: RR = 1.36 (1.1-1.68); and High: RR = 1.61 (1.28-2.04), trend  $p=0.008$ . The pooled analysis using eight weighting strategies, resulted in all showing significantly elevated Brain Cancer. The summary by year of publication shows that all are significantly elevated with a progressive declining trend from 1985 to 1994. The SEER data shows a rising trend of Brain Cancer in the general population from 8.4/100,000 in the mid 1980's to 9.4 in the early 1990's. This would account for much of the occupational cancer rate declining trend. Electromagnetic fields cause increased rates of brain cancer in occupations, through a genotoxic mechanism. Thus because the whole population lives in ELF and RF fields, they contribute to the rising rates of brain cancer.

Since 1994 over 20 additional studies have been published showing that electrical workers and other occupational ELF and RF/MW exposures have enhances Brain Cancer rates, including several dose-response trends. Dosemeci and Blair (141) found significantly elevated Brain Cancer Mortality in Women working in the telephone industry, MOR = 2.1 (1.2-3.7). Theriault et al. (142) combined three large Electrical Utility workers groups from Ontario, Quebec and France. Extensive magnetic field measurements were taken to estimate the cumulative chronic exposures of the workers. When combined the All Cancer rates were lower than OR=1.0 showing a Healthy Worker Effect. For Malignant Brain Cancer there was a dose-response,  $p=0.065$  for 0-20 years of work and for the exposure  $>90^{\text{th}}$  percentile exposure, OR = 5.90 (0.37-94.9). For Astrocytoma the same trend has  $p=0.1$  and  $>90^{\text{th}}$ , OR = 11.1 (1.44-85.6). For all employment  $>90^{\text{th}}$  OR = 28.48(1.76-461) with a dose response trend,  $p=0.02$ . By dividing the workers into 4 exposure groups the OR for the trend of increasing Astrocytoma was OR =9.41 (1.07-82.79).

Savitz and Loomis (143) give evidence of the Healthy Worker effect in US Electric Utility workers. Their overall mortality rate is SMR = 0.77 (0.76-0.78) and for all cancer, SMR = 0.86 (0.84-0.89). For exposure in the past 2-10 years the Total Mortality increases significantly by 4% percent of RR per  $\mu\text{T}$ -year, by 10% for All Cancer and by 94% for Brain Cancer, RR = 1.94 (1.34-2.81) per  $\mu\text{T}$ -year. The dose-response increase in Brain Cancer

is highly significant,  $p = 0.009$ , peaking at  $RR = 2.56$  (1.35-4.86) for  $\geq 0.7 \mu\text{T}\cdot\text{year}$ . This is consistent with the 4-9 year Brain Cancer latency shown by Wertheimer and Leeper (106).

Chinese electrical women workers have  $SIR = 2.2$  (0.6-5.5), Heineman et al. (144), English electrical workers, for Brain and Meninges Cancer,  $PRR = 114$  (102-129) for men,  $PRR = 140$  (77-236) for women and  $PRR = 116$  (103-130) for all workers. For Malignant Brain Cancer  $PRR = 115$  (100-133) for men,  $PRR = 202$  (105-353) for women and  $PRR = 118$  (103-136) for all workers, Fear et al. (145). US electronics industry workers, cited as RF/MW exposed by ICNIRP (223), have significantly higher incidence of glioma mortality after 10 years of occupational exposures,  $OR = 3.9$  (1.2-12.4). For computer programmers chronically exposed to RF fields from VDTs, they had a significant dose-response increase in Brain Cancer mortality, trend  $p = 0.04$ , peaking after 10 years at  $OR = 2.8$  (1.1-7.0), (146).

In France electrical workers have a significant dose-response increase in Brain Cancer incidence after 10 years of latency, trend  $p < 0.02$ , peaking at  $OR = 2.15$  (0.63-7.26) after  $> 295 \text{ V/m}\cdot\text{years}$ , Guenel et al. (147). Plastic-Ware female workers in Italy, exposed to RF signals have a 10-fold increase in Brain Cancer Mortality, Lagorio et al. (148). Kaplan et al. (149) investigated the occupational risks for Brain Tumour in Israel. For electrical and electronic manufacture and communication work, All Brain Tumors (BT)  $OR = 1.3$  (0.5-3.5), malignant BT  $OR = 2.2$  (0.5-9.3). For telephone and radio operators and electricians, All BT  $OR = 1.2$  (0.3-5.2) and Malignant BT  $OR = 1.4$  (0.4-8.7). In Denmark Johansen and Olsen (150) found that All Cancer was significantly raised in men,  $SIR = 1.07$  (1.03-1.11) and elevated for women,  $SIR = 1.03$  (0.92-1.14). For Brain Cancer only the women's rate was elevated,  $SIR = 1.33$  (0.7-2.2).

In Sweden Rodvall et al. (151) found a significant, trend  $p < 0.05$ , dose-response in Glioma associated with the median magnetic field exposure levels peaking at  $RR = 1.5$  (0.6-4.1) for  $> 0.19 \mu\text{T}$  for  $> 5$  years. For Meningioma  $RR = 1.5$  (0.3-7.3) for being exposed to 5 or more years. For the  $0.12\text{-}0.19 \mu\text{T}$  median exposure group, Glioma  $RR = 1.9$  (1.0-3.5). Also in Sweden, Floderus, Stenlund and Persson (152) found weak dose-response increase of malignant Astrocytoma (III-IV) in male occupational magnetic field exposures peaking at  $> 0.116 \mu\text{T}$  with  $RR = 1.3$  (1.2-1.5).

In Switzerland the electric train drivers were shown to have reduced melatonin, Pfluger and Minder (12). Minder and Pfluger (153) took extensive magnetic fields exposures found increased brain cancer in some driver groups, especially the shunting year engineer,  $RR = 5.06$  (1.21-21.2) and also in Train attendants,  $RR = 2.67$  (0.75-9.62). This confirms the results of Tynes, Jynge and Vistnes (141) who found elevated Brain Cancer in Norwegian Railway workers.

US women also get significantly elevated brain Cancer rates of 20% from chronic exposures to electromagnetic fields. For the High exposure group  $OR = 1.3$  (1.0-1.6), Cocco et al. (154).

In addition to the papers summarized here there are many others supporting and confirming the conclusion that in many occupation ELF/RF/MW exposure situations elevate Brain Cancer rates, including significant and with dose-response trends, (155-

179). These include electricians, electric utility employees, amateur radio operators and VDT exposed programmers.

With so many studies showing increased Brain Cancer rates for occupational EMF exposures, including many from Professor David Savitz's group, it is good to have a study that reduces the uncertainties of exposure levels. Savitz et al. (180) carried out a refined Job-Exposure Matrix assessment using 2842 measurements in 1060 job situations of electrical utility workers in the United States to assess personal cumulative exposures. For the 2-year lag analysis the highest exposed group had RR = 2.5 (0.98-6.33). For the 2-10 yr lag RR = 2.38 (1.14-5.00) and for 10-20 yr lag RR = 2.25 (0.94-5.38). This confirms the strongest relationships are with the highest cumulative exposures and the 2-10 year latency period.

With over 60 occupational studies showing increased incidence of Brain Cancer from ELF/RF/MW exposures, it is not surprising that the latest published study, Villeneuve et al. (181) found a non-significant increased risk of Brain Cancer, OR = 1.33 (0.75-2.36) for men exposed to  $>0.3\mu\text{T}$  and a significant increase for Glioblastoma multiforme, OR = 5.36 (1.16-24.78). A significant,  $p = 0.02$ , increased risk was found with cumulative time-weighted magnetic field exposure.

### **Residential EMF/EMR Brain Cancer Studies:**

Residential epidemiological studies are valuable because of the generally much lower chronic field exposure levels with the absence of the involvement of electric shocks, and the broad public health implications. The first two studies in this topic were for residential cancer cases, Wertheimer and Leeper (105,106). With their confirmation by Savitz et al. (114) these three studies, with dose-response relationships, supported by genotoxic evidence, show a classically causal relationship. They are now backed up and confirmed by a large body of published research. Together they challenge the very high Western allowed ELF and RF exposure levels in Standards that obviously do not protect children and adults from cancer caused by residential field exposures. The guideline for 24 hr general public exposure to ELF fields is 5000 V/m and  $100\mu\text{T}$  (2000mG), IRPA (182). This is set to avoid shocking induced electric currents.

Tomenius (183) found that children living near 200 kV powerlines in Sweden had elevated Nervous System Tumours, RR = 3.73 (1.07-12.94),  $p=0.025$ . Total cancer for children living in fields over  $0.3\mu\text{T}$  were RR = 5.42 (1.51-19.52),  $p=0.0036$ . Savitz, John and Kleckner (184) studied cancer rates from prenatal exposures to electric appliances, such as electric blankets, heated water beds, bedside electric clocks and hair dryers. The childhood brain cancer rate was elevated from electric blanket use, OR = 1.8 (0.9-4.0). When adjusted for income and wire code, OR = 2.7 (1.0-7.1). The length of time using electric blankets for <8hour, 8 hours and > 8 hours produced a dose-response increased brain cancer rate, OR =1.5 (0.4-5.7), 3.1 (1.2-8.5) and 4.6 (0.5-39), respectively. Exposure during the first trimester produced the highest risk, OR = 4.0 (1.6-9.9).

Schreiber et al. (185) found higher brain cancer rates in women living near electric transmission equipment, SMR = 175 (20-633) from a very small cancer registry. For people living more than 100m from powerlines, SMR = 196 (40-574). In Finland Verkasalo et al. (186) found that boys exposed to  $>0.2\mu\text{T}$  had SIR = 4.2 (1.4-9.9) and for cumulative

exposure  $>0.4\mu\text{T}$  -years, SIR = 4.2 (1.7-8.6) for brain cancer. Children in Denmark exposed to  $\geq 0.4\mu\text{T}$ , OR = 6.0 (0.7-44). They found that the total cancer rate in children rose with the high exposure levels and historically as the use of electricity rose.

Feychting and Ahlbom (187) found a significant trend,  $p = 0.005$ , for magnetic field strength and Childhood Leukaemia but the sample size for Brain Cancer was very small. It showed elevated rates when living between 51-100m of powerlines, RR = 1.4 (0.5-3.1) and in fields 0.1-0.19 $\mu\text{T}$ , RR = 2.5 (0.9-6.6). At a higher exposure RR = 1.5 (0.4-4.9) but there were only 5 cases. This was based on 33 childhood CNS Cancer cases. A follow-up study involving 223 adult CNS Cancer cases, Feychting and Ahlbom (188), when broken into separate cancer types also had very small samples. Astrocytoma I-II were elevated for 0.1-0.19 $\mu\text{T}$ , RR = 1.4 (0.6-3.0) and Astrocytoma III-IV for living 51-100m from power lines, RR = 1.3 (0.8-2.0). To overcome the small case samples Feychting et al. (189) pooled two Scandinavian studies of childhood cancer and magnetic fields. For the Danish study highest exposure RR = 7.8 (1.1-55.7). When they were combined,  $n=3$  and RR = 2.3 (0.6-8.0).

Washburn et al. (190) reviewed the residential studies of childhood cancer from EMF exposure, and produced a meta-analysis. For Brain/CNS cancer RR = 1.89 (1.34-2.67). For the maximum exposure in studies showing dose-response effects, RR = 2.0 (1.33-2.99).

Preston-Martin et al. (191) found no in utero association from electric blanket use and brain cancer. From childhood waterbed use there was a small elevation level, OR = 1.2 (0.7-2.0). Preston-Martin et al. (192) found weak dose-response increases of childhood brain cancer in Los Angeles from the mean child room 24hr magnetic field measurements, peaking for  $>3$  mG with OR = 1.7 (0.6-5.0) for data from 1984-1991. From other rooms the highest mean exposures resulted in OR = 2.4 (0.8-7.8).

Gurney et al. (193) used a Western Washington cancer registry to investigate whether exposures to electric appliances raised the incidence of childhood brain tumors. They found OR = 1.5 (0.8-2.9) when pregnant mothers used electric heaters in their bedroom. Brain cancer rates were also elevated when children were exposed to a range of field types from appliances. For example, Portable B&W TV, OR = 1.6 (0.6-3.9); Portable Colored TV, OR = 1.3 (0.4-4.0); TV video games, OR = 1.2 (0.6-2.1); bedside dial clock, OR = 1.3 (0.6-2.7); bedside digital clock, OR = 1.8 (0.9-3.3); having been in an incubator as a baby, OR = 1.5 (0.8-3.1); and being close to a baby monitor, OR = 1.6 (0.8-3.1).

A Finland study, Valjus (194), found that children exposed to electromagnetic fields had elevated CNS tumors. For mean field  $\geq 0.2\mu\text{T}$ , SIR = 2.3 (0.75-5.4). For cumulative exposure  $\geq 0.4\mu\text{T}$ -yrs, OR = 2.3 (0.94-4.8). A similar result for Childhood Brain Tumors was found in Norway by Tynes and Haldorsen (195), but with lower mean field levels. For 0.05- $<0.14\mu\text{T}$ , OR = 2.6 (0.5-12),  $n=3$ , and for  $\geq 0.14\mu\text{T}$ , OR = 2.3 (0.8-6.6),  $n=7$ , trend  $p = 0.07$ .

Li, Theriault and Lin (196) studied the adult cancers in Taiwan associated to residential magnetic field exposures. Sub-types of brain cancer showed the highest effect for Glioblastoma, OR = 1.3 (0.5-2.9) and for Oligodendroglioma, OR = 2.8 (0.8-10.4) for exposures in the range 0.1-0.2 $\mu\text{T}$ . Ranking to the 99 percentile exposure, for all brain

tumours OR = 6.4 (0.8-53.5). A Swedish study, Feychting, Foressen and Floderus (197) compared occupational and residential exposures and cancer rates, using a job-exposure matrix assessment. The CNS tumor type was highest for Astrocytoma III-IV, RR = 1.3 (0.8-2.3) for occupational exposures 0.13-0.19 $\mu$ T. When adjusted for sex and age RR = 1.6 (1.0-2.5). When combined with residential exposures RR = 1.8 (0.9-3.6). For all CNS tumors these three situations were RR = 1.0 (0.7-1.6), RR = 1.2 (0.8-1.7) and RR = 1.4 (0.7-2.5). The highest CNS cancer type rate was for Astrocytoma III-IV from both residential and occupational exposure, RR = 2.2 (0.6-8.5), n=3.

A child sleeping in a waterbed in New Zealand produced an adjusted CNS Tumors OR = 5.5 (0.4-85.4), n=2. Using a curling tong, OR = 2.1 (0.1-64.1), n=2, electric blanket switched on while in bed, OR = 1.6 (0.4-7.1), n=8, and electric heating in the child's dayroom for 2 years, OR = 4.2 (1.0-17.3), n=20, Dockerty et al. (198). Wrensch et al. (88) studied the relation of Adult Glioma and measured residential magnetic fields in the San Francisco Bay area. The highest front door measurement is associated with OR = 1.7 (0.8-3.6).

In addition to the studies cited above, there are many others supporting and confirming that residential ELF/RF/MW exposures, at very low mean chronic exposures levels, elevate, significantly elevate and dose-response increase childhood and adult Brain/CNS Cancer, (199-207)

A large number of residential studies found non-significant elevated brain cancer rates in the OR/RR range of 1.2 to 6.4 for adults, and 1.2 to 7.8 for children. Most of the case sample sizes were very small, resulting in low significance. Some studies found significant elevation of brain cancer in residential exposures when moderate case numbers were used, e.g. OR = 4.2 (1.0-17.3), n=20, for childhood CNS cancer (198). A distinct difference between the studies of the 1990's and those of the 1980's is the later studies find it more and more difficult to detect elevated cancer rates. Using leukaemia as a bio-indicator the early childhood cancer incidence rate has risen from around 0.7 per 100,000 p-yrs in 1900 to over 4 per 100,000 p-yrs by 2000, an increase by a factor of 5.7.

### **The Ubiquitous Genotoxic Carcinogen Effect:**

Electromagnetic fields in homes and along streets where electric power supply is available, are exposing every person to a continuous, low level, genotoxic carcinogen. This contributes to the general population cancer rate. Milham and Ossiander (208) used the specific cancer of Acute Lymphoblastic Leukaemia (ALL) in 2-4 year olds, as a bio-indicator of the affluent, modern technology usage of electric power. They tracked the geographic and temporal evolution and progressive development of the early childhood peak of ALL and that it only matches the installation and development of electric power supplies country-by-country, and state-by-state. In parallel with early childhood ALL, leukaemia, lymphoma, brain cancer and all cancer rates have risen by similar amounts over the past century associated with the widespread introduction and use of electric and electronic appliances and technology. This discovery is confirmed by all residential epidemiological studies showing ELF and RF/MW fields elevate cancer rates. It is specifically confirmed by Kraut et al (209) who found that childhood cancer rates in Canada rose in proportion to the level of electrification of the provinces. The strongest correlation was a significant trend for Brain Cancer.

Hatch et al. (210) 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 confirms the early initiation during pregnancy and the advancement with EMF/EMR exposures after birth.

This was independently confirmed by Green et al. (211) who found a dose-response for All Leukaemia and for ALL for children in Ontario with measured average residential magnetic fields. The All Leukaemia rate was doubled from 0.5mG average fields compared with <0.3 mG, OR = 2.0 (0.6-6.8). Using a 1mG cutoff level showed a significantly 4-times higher rate, OR = 4.0 (1.1-14.4).

These studies, together with the residential studies cited above, supported by occupational studies, confirm that the higher the domestic EMF fields the higher the ALL and all Leukaemia, Lymphoma, Brain cancer and All Cancer incidence rates become. This has progressively raised the background cancer rates in adults and children by a factor of 3 to 5 over the past century. This makes it more and more difficult to detect cancers in occupational and residential studies because of the ubiquitous nature of the fields. It is almost impossible to obtain a no-exposed reference group. If we reduce the reference rate by a factor of 3 to 5 in all of the occupational and residential studies cited above, almost every rate would be significantly elevated.

For example, using factors of 2 and 3, if Brain Cancer from exposure of a child to a microwave oven is initially found from 40 cases and 90 controls to be RR = 0.9 (0.65-1.2). If the control group was reduced to 45 or 30 then RR = 1.53 (1.05-2.23),  $p=0.029$  and RR = 2.17 (1.41-3.33),  $p=0.00033$ .

Occupational studies, especially when the Healthy Worker Effect (HWE) is dealt with, and the ubiquitous genotoxic carcinogen effect (UGCE) is accounted for in occupational and residential studies, there is strong and robust evidence that across the spectrum from ELF to RF/MW exposures is causally related to Brain Cancer. This conclusion is independent of the HWE and the UGCE using the classical Bradford Hill assessment approach (97). The addition of the effect bias factors strengthens the results and confirms the conclusions.

### **Cell phone users:**

Analogue cell phones use modulated FM RF/MW signals in the UHF (MW) range. Digital cell phones are more like radar signals using pulsed microwaves. All of these signals have been shown to increase Brain Cancer rates in children and adults at home and adults at work. The early mobile phones were mainly bag-phones and car phones. These had very powerful signals. In the past few years these have been replaced by small portable phones using the digital signals for speech, text and internet connections. Using 1 year of mortality data, 1994, Rothman et al. (212) showed that the whole body exposure from the bag-phone aerial significantly increased the mortality rate compared to those using the



small portable phones, RR = 1.38 (1.07-1.79). The study shows that this was primarily from people over 55, and the longer you use the bag-phone the higher the mortality rate became, 1.08 after 2 years and 1.16 after 3 years. This result is consistent with many previous occupational and residential studies showing that RF/MW exposure enhances mortality rates.

Mobile phone radiation significantly damages DNA strands and enhances DNA repair,  $p < 0.0001$ , (54). The enhanced repair is induced by the damage. Failure to repair or mistakes in DNA repair leads to cell death or cancer. Hence mobile phone radiation is plausibly a cause of Brain Cancer.

Inskip et al. (213) carried out a short time exposure to cell phones and didn't find any increase in Brain Cancer. However they acknowledge that it doesn't evaluate the risks of long-term, heavy users and for potentially long induction periods. However they found that using a cell phone for 5 or more years increased the incidence of Acoustic Neuromas, RR = 1.9 (0.6-5.9). Muscat et al. (214) has a similar result of a non-Brain Cancer effect with elevated incidence of Neuroepitheliomatous Cancers, OR = 2.1 (0.9-4.7). A major problem occurs because this is a "case-control" study and the cases have 14.1% using cell phones while the controls had 18.0% using cell phones. After using a cell phone for a year or more the proportion of the case group with Brain Cancer was 14.4% while in the heavier cell phone using control group the proportion was 18%.

Morgan et al. (214) analyses the cancer rates of Motorola employees, including their use of cellular telephones. The overall mortality rate of RF-exposed staff was 0.66 (0.64-0.67) showing a strong Healthy Worker Effect. Produced by using overall mortality rates from 4 states, including the elderly population. For the usual use of cell phones the high vs low Brain Cancer rate was RR = 1.13 (0.49-2.31). Adjusting for the HWE  $RR_{adj} = 1.71$ .

The largest and most careful case-control cell phone usage and brain cancer studies have been carried out in Sweden, Hardell et al. (215-220). Initially small case samples (n=270) showed elevated brain cancer from using an analogue mobile phone. When the results included more cases and adjusted the results for Xray and therapy exposures, the incidence of Brain Cancer on the side of the head that was exposed was significantly elevated, OR = 2.62 (1.02-6.71). The study group was significantly expanded to include 1429 cases. Using a cell phone for longer than a year raised the risk of Brain Cancer, OR = 1.26 (1.02-1.56). For longer latency periods, > 5 years gave OR = 1.35 (1.03-1.77) and > 10 years OR = 1.77 (1.09-2.86). For the side of the head the phone exposed OR = 2.50 (1.2-4.88).

For Acoustic Neuromas among analogue phone users OR = 3.27 (1.67-6.43). The final study involved only patients with Astrocytomas (n=414). For analogue phone use OR = 1.29 (0.87-1.90) and digital phone use OR = 1.1 (0.81-1.53). When the side of the head where the phone was used was considered, for Analogue phone OR = 1.85 (1.12-3.39) for all Brain Cancers and OR = 1.95 (1.12-3.39) for Astrocytomas. For digital and cordless phones, the risk of side of head astrocytomas was OR = 1.59 (0.98-2.58) and OR = 1.70 (1.06-2.74) respectively. For astrocytomas in the temporal or occipital areas, OR = 9.00 (1.14-71.0) based on 12 cases and 5 controls (220).

A Finnish study with n=398 for Brain Tumors, Auvinen et al. (221), found Gliomas associated with cell phone usage, OR = 1.5 (1.0-2.4). The increase of incidence per year of usage of analogue phones was OR = 1.2 (1.0-1.3) for all Brain Tumors, 1.2 (1.1-1.5) for Gliomas and OR = 1.1 (0.8-1.4) for other Brain Tumours.

A very large group cohort study of cell phone users in Denmark, Johansen et al. (222), used a general population control group to calculate the SIRs. This reduces the rates significantly by using a high reference cancer rate. This produces many SIRs in the range 0.6-0.7. It suggests a HWE of 0.6. For Glioma SIR = 0.94 (0.72-1.20). Adjusting the expected rate for Glioma from 70.2 to 42 gives SIR = 1.59 (1.08-2.34). For the Frontal Lobe Glioma, SIR = 1.85, Occipital Lobe (back of head), SIR = 2.98 and Cerebellum, SIR = 2.78. Using a similar approach the rates for Brain/CNS tumors for the time use of digital phones <1 yr, 1-2yrs and ≥3 yrs are given as SIR = 0.7, 0.9 and 1.2. Adjusting by 0.7 gives, 1.0, 1.29 and 1.71, a serious dose-response effect from using digital cell phones.

Laboratory evidence shows DNA damage from exposure to microwaves and cell phone radiation. Multiple studies showing increased Acoustic Neuromas Cancer, significantly increased Eye Cancer, OR = 4.2 (1.2-14.5), (223) and Brain Cancer. Therefore the evidence shows that cell phones will raise the cancer rates of the phone usage population, especially for the very young and the heavy users.

### **Occupational Risk for Dedicated Public Servants**

Police and Fire Officers, along with security guards in public buildings, are heavy users of hand-held radios with high exposures to their heads and other body organs. Police Officers are also heavy users of speed radars in some job situations, such as State Troopers in the United States. Hand-held traffic speed radar guns had been shown, like all other forms of RF/MW radiation including radar, to cause serious increases in Testicular Cancer, O/E = 6.9, p<0.001, Davis and Mostofi (223). Radar guns causes cancer. RF/MW radiation causes Brain Cancer. Therefore, chronic exposure of an officer's head to a speed radar installed behind him/her in the patrol car, will significantly increase the daily DNA damage rate in their brains and highly significantly increase his/her risk of developing a Brain Cancer.

### **Summary and Conclusions:**

This review is citing a large amount published epidemiological studies showing that EMF and EMR enhances the Brain Cancer incidence and mortality and a large body of laboratory evidence that across the spectrum EMF and EMR signals damage DNA. This evidence is much more sufficient to conclude that there is a causal relationship between residential and occupational exposures to the electromagnetic spectrum signals and childhood and adult Brain/CNS Cancer. This is substantial and robust evidence that the EM signals are a Ubiquitous Genotoxic Carcinogen. Therefore there is no non-exposure group to use as a control or reference group. There is very strong evidence that the EM signals, primary from electric energy sources wiring has been a major contributor to the massive and continuing rise in cancer over the past century. In the past decade or two RF/MW appliances and telecommunication technology for radio, TV and cordless and mobile telephone technology are continuing to increase the general public exposure levels.

By wide-authority ignorance of the genotoxic and epidemiological evidence, standards for ELF and RF/MW are set very high exposure allowed levels and do not protect public nor for workers from chronic carcinogen Brain/CNS Cancer increased risks. There is also a widespread non-use and non-application of the Healthy Worker Effect and the Ubiquitous Genotoxic Carcinogen Effect in epidemiological studies. Hence almost every epidemiological study cited above grossly under-estimates the health effects.

Radio and TV signals can be delivered in fiber optic cables using channeled light rather than using EMR radiating through the air and exposing all people to genotoxic radiation. Using simple physics principles, cell phones can be made 20 to 100 times safer with hand-sets in built-in shields, narrow directional radiation aerials sending the signal away from the user, and with fiber optic hands-free kits. Base stations can be located away from residences, schools and work places, with side-lobe protection to reduce the local ground level exposures. High voltage power lines can be required to be built in purchased corridors with at least 50m to 100m on either side depending on the voltage. Houses designed to use solar passive heating can reduce the imported energy by at least 80%, along with other retrospective domestic energy efficiency improvement. This reduces the electric energy and current requirements, costs and EM field levels. Many other appliances can be designed and made much safer with lower EMF/EMR field strengths.

Accepting and applying the evidence provided here the EMF/EMR signals are Ubiquitous Universal Genotoxic Carcinogens, can lead to very strong improvement of public health and reduction of personal and family stress and grief, by setting appropriate protective standards. It can also lead to development of new safer, competitive and efficient technology to stimulate the economy.

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