Reproductive effects from EMF/EMR exposure

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Abstract:

Epidemiology is fundamental science and the strongest evidence for the assessment of human health effects of disease agents. Many epidemiological studies have shown elevated reproductive problems from exposure to electromagnetic fields and radiation. There are well-established plausible biological mechanisms including genotoxic effects, altered calcium-ions and reduced melatonin. Animal experiments show many reproductive health effects from acute and chronic RF/MW exposures, confirming that there is a non-thermal mechanism, consistent with a genotoxic substance. Reproductive effects identified by epidemiology include miscarriage, congestive malformation, stillbirths, sudden infant death syndrome, reduced sperm counts, infertility and passing on cancer to the children. The observed effects are all consistent with the identified biological mechanisms. Taken together there is very strong evidence that acute and chronic exposure to electromagnetic fields and radiation enhances the risks of reproductive health problems and therefore exposures should be significantly reduced to reduce the risk.

Introduction:

Human Health Effects Assessment Principles:

Principles behind assessing human health effects are set out by Sir Austin Bradford Hill (1965). Exposure has to take place before the possible disease agent can be associated with health effects. The biological plausibility is not necessary but it can be helpful, especially if the agent is genotoxic. Then it is known to enhance the rates of cancer, mutation and cell death. The factors of consistency and specificity can be helpful. The strongest direct evidence of a causal relationship there's a strong relationship with a highly elevated relative risk than the end of all a highly significant relationship, and/or dose-response relationship without any known confounders. A dose-response relationship, and/or strong relationships, in the context of a plausible genotoxic mechanism, with consistently elevated relative risks has strong classical evidence of a causal relationship.

Human Exposure Assessment:

A key historical exposure question is whether the effects from radio frequency and microwave exposures are only thermal or are there non-thermal interactive mechanisms? The early assumption was at all the effects were thermal. In this area of animal experiments involving chronic on-thermal exposure over lifetimes and

multigenerational periods show conclusively that there are many interactions that are non-thermal. Most of these interactions also occurred at high rates at thermal levels even though that long-term or mechanisms. They are shown to be non-thermal mechanisms when they occurred below the thermal threshold, particularly and live animals who have a metabolic temperature control system.

A vital epidemiological exposure assessment involves identifying an exposed group to compare their disease rate with that of a non-exposed group. Carefully ranking levels of exposure is necessary to obtain fitness response relationship to. It is important to note, however, in developed countries and most other areas there is no group that is not exposed to shortwave radiation, microwaves and satellites, local radio, TV, radar and mobile phone base-stations. The power frequency fields most people are living in homes and in all other buildings with electric power, with many appliances, and with powerlines along the roads above or below the ground. For most populations the exposure is ubiquitous.

Some people are exposed to more than average daily exposure levels by using computers, sleeping in electric blanket warmed beds, daily using two-way radios, cellphones, cordless phones, etc…. some occupations they exposed to the area much higher than average fields, for example here electric motors on sewing machines, welders, electric tram, train and bus drivers and conductors. Some military personnel are frequently exposed to radio and radar signals as users or repairers.

Physiotherapists have used shortwave radio and microwaves to heat their patients' tissues before the therapists give their therapy. The therapists have been regularly exposed shortly to relatively low exposures, usually for less than a minute per patient. The time is very short usually because they set up the system, make sure the patient's comfortable, set the heating time on the instrument clock, explain that they are going to be a way for the 15 to 20 minutes of heating process and the patient can press a button to call them if they have any problems. They then turn the instrument on, pause for 10 to 20 seconds, ask if you are OK and then leave the room. I have seen this several times as a patient.

Ouellet-Hellstrom and Stewart (1993) report that Physiotherapists can be exposed to microwaves, primarily from leakage from diathermy equipment. Measurements at waist level found close to the patient was in the range 80 - 1200μW/cm^2. At 15 cm from the source the highest reading was 15mW/cm^2. The therapist needs to be leaning over the patient during the therapy to receive this dose. This is highly unlikely to happen most times when the machine is turned on. Even so, this is not sufficient to cause a surface heating of the skin in the few minutes it is likely to involve. Hocking and Joyner (1995) show that microwaves produce very small SARs in the uterus, Figure 1.

In their table 2 Hocking and Joyner (1995) show maximum SARs in the uterus for the conditions in Figure 1 for short-wave (27.12 MHz) of 0.209 W/kg, for microwave (915 MHz) of 0.023 W/kg and for microwave (2.45 GHz) of 0.000027 W/kg.

Gandhi (1990) gives the relationship between SAR and temperature increase. The heating rate given is 0.0045 x SAR °C/min. With a maximum exposure time per treatment of 5 minutes, and an external field intensity of 1,200 μW/cm^2, the heating of

the fetus will be 0.0055°C , 0.00062°C and 0.00000073 °C, respectively. Not even at 15 mW/cm^2 does the short-wave exposure can produce a detectable heating effect in the uterus environment (0.071°C).

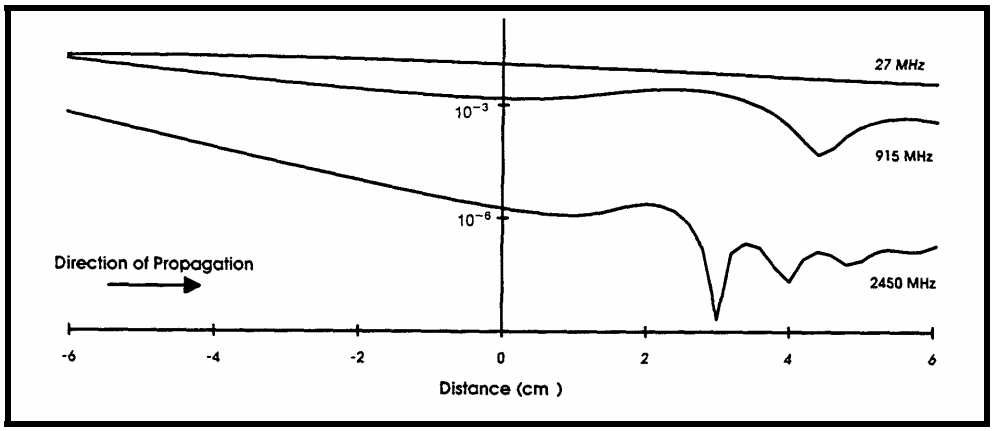

Figure 1: Specific absorption rate (SAR) profile across the uterus for a small woman exposed to 1 mW/cm^2, from Hocking and Joyner (1995). The zero distance is the wall of the uterus.

Since an acute thermal mechanism can be ruled out it is appropriate to calculate and use the cumulative average dose to determine the range of the exposure regime.

It is not the habit of therapists to stand close to the patient during the diathermy. In many cases the therapist leaves the room while the 15 to 30 minute diathermy is carried out. Hence a conservatively long exposure period of 2 minutes is chosen to be associated with the exposure range of 80 - 1200μW/cm^2, average or 640μW/cm^2. The dose-response relationship is expressed in terms of treatments per month. These assumptions allow it to converted to an exposure-based dose-response relationship. One treatment per month is associated with a mean monthly exposure in the range 0.0037 to 0.056μW/cm^2, and a mean exposure per treatment of 0.03μW/cm^2.

Table 1: Estimated mean exposure ranges, from Ouellet-Hellstrom and Stewart (1993).

No. of Exposures per Month		Exposure (μW/cm^2) Mean
0	0	0.0
<5	(2.5)	0.08
5-20	(12.5)	0.38
>20	(25)	0.75

Plausible Biological mechanisms:

The most likely mechanism is accumulated chromosome aberrations and damaged cells in the placenta and fetus because biophysics shows extremely small temperature increases can be expected from even very high RF/MW exposures.

Calcium ion efflux leads to the survival of damaged cells that carry their chromosome aberrations into future generations of cells. A reduction in melatonin reduces the

elimination of free radicals which enhances the chromosome damage. Calcium ion efflux and melatonin reduction also impairs the immune system with allows a greater population of damaged cells to survive. Cells with damaged chromosomes are a known cause of spontaneous abortion.

According to Sandyk et al. (1992):

> **"The causes of spontaneous abortion can be divided into two main categories: those arising from chromosomal anomalies and those arising from abnormalities in the intrauterine environment. In the following communication, we propose that deficient pineal melatonin functions in early pregnancy may be causally related to the development of spontaneous abortions in cases where chromosomal anomalies or structural abnormalities of the uterus have been excluded."**

RF/Microwaves are shown to be associated with DNA breakage in living rats brains, Lai and Singh (1995, 1996, 1997), Sarkar et al. (1994) and in brain cell lines Phillips et al. (1998), and to cause chromosome aberrations, Heller and Teixeira-Pinto (1959), Garaj-Vrhovac et al. (1990, 1991, 1992, 1993), Haider et al. (1994) and in scores of other studies. Lai and Singh (1997) show that the DNA Strand breakage is linked to melatonin reduction and free radicals.

Almost all of these experiments show DNA damage at non-thermal or isothermal exposure levels. When there is high temperature the body has to deal with the massive induction of cellular damage. Two of the mechanisms recognized in this area are heat shock proteins and the cell death mechanism necrosis. It is now known that the heat shock proteins are more accurately described as toxic shock proteins because their activity is also induced at non-thermal levels. Blackman et al. (1991) showed that induced calcium-ion efflux occurs only within the natural homeostatic temperature range. It was also discovered that calcium-ion efflux was dependent on the local geomagnetic field. This meant that different results can be obtained from different laboratories or from different places within one laboratory where there is a large metal duct altering the local magnetic field, Blackman et al. (1990a)

Just because effects were initially seen when the temperature rose, it has not been definitely shown that the temperature rise is causing the effect. Many early experiments involved high exposure resulting in significant temperature rises, were initially to determine the temperature threshold and the fatal level of temperature rise.

When it is demonstrated that the biological effect occurs in a dose-response manner, down to exposure levels that are well below the thermal threshold, then the effect is not being caused by a thermal mechanism, because it is still there when there is no thermal effect. This is supported by, or demonstrated by, multiple independent studies showing that the mechanism occurs in isothermal situations or in non-thermal exposure levels. The genotoxic effects of microwaves as shown by chromosome aberrations, micronuclei formation and DNA-strand breakage, are used to demonstrate this.

Baranski and Czerski (1976): Chapter 4A, Chromosomal Effects, Possible Genetic Effects and Influence of Microwave Radiation on Mitosis. Cellular Effects: p 132-135.

"Chromosomal aberrations and mitotic abnormalities may be induced, at least under certain conditions and in certain cell types, by exposure to microwave or radiofrequency fields. This is a well-established fact, as several reports from at least, five independent laboratories exist. A series of investigations was carried out by Heller and his coworkers at the New England Institute for Medical Research, Ridgefield, Connecticut. These authors were the first to observe such effects in 1958, and have continued their research till now, see [221] for a review. The impact of these investigations comes from the observation that radio-frequency fields 5 to 7 MHz cause the migration of motile Protozoa with the electric field lines or across the field 27 to 30 MHz."

Back in 1976 the genotoxic evidence for RF/microwaves was strong enough to be described as "a well-established fact". Heller's work was isothermal but several other laboratories used high exposures that involved elevated temperatures, leading to a general thermal effect assumption. The thermal threshold, for a temperature rise of less than 1°C from a 1hr exposure, was identified as being above 10mW/cm^2, and so this level was used as the occupational exposure standard by the US C95. standard.

Garaj-Vrhovac, Horvat and Koren (1991) exposed Chinese hamster cells to 7.7GHz microwave radiation to determine cell survival and chromosome damage. Chromosome aberrations and micronuclei are significantly higher than the controls, ($p<0.05$, $p<0.001$, $p<0.0001$), for each of the exposure intensity. They assayed chromosome aberrations and micronuclei and found that microwaves increased these in a dose-response manner, Figure 2, to levels that were highly significantly elevated ($p<0.02$ to $p<0.01$).

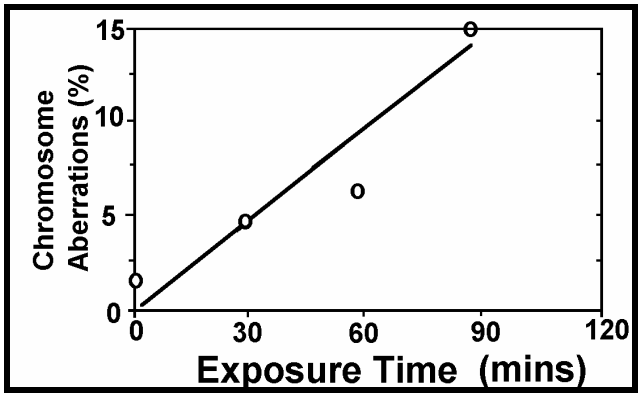

Figure 2: Chromosome aberrations in V79 Chinese hamster cells exposed to 7.7 GHz microwaves at 30mW/cm^2, Garaj-Vrhovac, Horvat and Koren (1991).

An exposure level of 30mW/cm^2 is usually able to slightly raise the temperature over an hour. This experiment was undertaken under isothermal conditions, with samples being kept within 0.4°C of 22°C. The consistency of the time exposure and the survival assay at non-thermal exposure levels, confirms that this is a non-thermal effect.

This is very strong evidence of genotoxic effects from RF/MW exposures. When chromosomes are damaged one of the primary protective measures is for the immune system natural killer cells to eliminate the damaged cells. Alternatively the cells can enter programmed cell suicide, apoptosis. Garaj-Vrhovac, Horvat and Koren (1991)

measured the cell survival rates. They found that cell survival reduced and the cell death increased in a time dependent and exposure dose response manner, Figure 3.

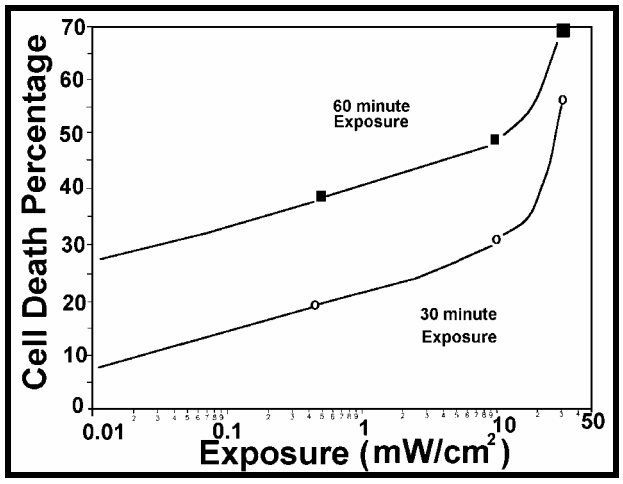

Figure 3: Cell death percentage of Chinese hamster cells exposed to 7.7GHz microwaves (CW) for 30mins and 60mins in an isothermal exposure system, Garaj-Vrhovac, Horvat and Koren (1991).

Figure 3 shows that cell death varies with time and intensity of exposure, down to very low exposure levels. An apparent 'saturation' at high levels is also becoming evident. This is probably because of the lethal effect of high intensity microwaves. Since this is an isothermal experiment it raised important questions about the reasons for the cell death as acute genetic damage which is continuously related to microwave exposure down to non-thermal levels.

Note that the general public ICNIRP guideline for microwaves above 2GHz is 1mW/cm^2, and for workers is 5 mW/cm^2. Even at 100 times below the public exposure guideline a 60 minute exposure kills 28% of the cells and 30 minutes kills 8 % of the cells. Garaj-Vrhovac et al. (1992) exposed human lymphocytes and showed that microwave radiation produced a dose response increase in chromosome aberrations, Figure 4.

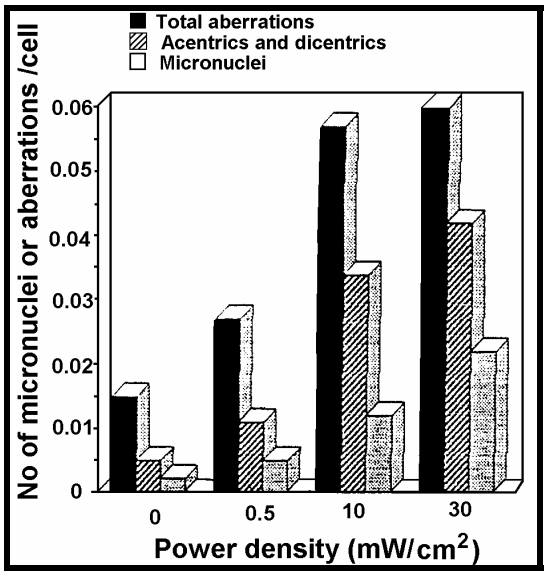

Figure 4: The relation of total chromosome aberrations. micronuclei and specific chromosome aberrations for each cell in human lymphocyte cultures

in the dose of microwave radiation in vitro, Garaj-Vrhovac et al. (1992).

Having established that microwave exposure damaged chromosomes, the Garag-Vrhovac group was asked to analyze blood samples from workers who had been exposed to pulsed microwaves generated by air traffic control radars while they were repairing them. Garag-Vrhovac and Fucic (1993) analyzed the chromosome aberration (CA) in 6 technical staff who were accidentally exposure to the radar. The initial CA percentage ranged from 3% to 33%, all being significantly higher than unexposed people.

It has now been demonstrated, using the DNA strain breakage (Comet Assay), that non-thermal exposures to radiofrequency/microwave radiation significantly enhances the rate of the DNA single and double-strand breakage, Lai and Singh (1995, 1996, 1997) and Phillips et al. (1998). Phillips et al. observed extremely significant ($p<0.0001$) DNA strand breakage from cellphone radiation at 0.0024W/kg when the thermal threshold is above 4W/kg.

Therefore it is robustly and well-established that radiofrequency microwave radiation is genotoxic through a mechanism that is definitely not thermal but is most likely to involve enhanced through radical activity. This is shown by Lai and Singh (1997) where the potent antioxidant, Melatonin, and independently, a spin-trap chemical, eliminated the RF/MW induced DNA breakage.

Animal Toxicology and Teratology:

Introduction:

In many ways animals are very similar to human beings. This is why animals are often used to test chemicals and cosmetics to see if they have biological effects or health effects that could are likely to occur in humans for the same or some other related biological mechanisms. Because it is unethical to deliberately test a pregnant woman to see if exposure to the substance causes congenital malformations or miscarriage, animal experiments are used and occupational studies can show human health effects.

The Australian ABC television investigative programme, Four Corners, claimed in a documentary on electromagnetic health effects, that in a factory which used radiofrequency heaters for sealing plastics, that of 17 women who worked at sealing machines, 14 had miscarried. Plastic sealers expose the operator to far higher levels that do physiotherapy diathermy devices. In association with the concern in Australia about the reproductive risks from plastic sealers, Brown-Woodman et al. (1989) exposed a set of rats to a repeated exposure to 27.12 MHz EM fields for 5 weeks. A reduction in fertility occurred as indicated by a reduced number of matings in exposed rats compared to sham-exposed rats, and a reduced number of conceptions after exposure. They conclude that:

> **"The data suggests that female operators could experience reduced fertility, if they remain close to the console for prolonged periods. This has particular significance for the physiotherapy profession."**

Detailed Animal Experiments:

Prausnitz and Susskind (1962) exposed male Swiss albino mice to 9.27 GHz microwaves, pulsed with a 2 μs pulse at 500 Hz, 4.5mins/day, 5 days per week for 59 weeks with an exposure level of 100 mW/cm^2. This is a thermal exposure load which produced a temperature rise of about 3.3°C. This is well below the 50% Lethal temperature (LD_{50}) of 6.7°C. This amounts to a mean weekly exposure of 22.3μW/cm^2. The short term temperature rise had no effect on the longevity of the mice.

Detailed autopsies were carried out on 60 irradiated and 40 control mice who died during the experiment. Two adverse effects were more severe in the exposed compared to the control animals.

(1) Testicular degeneration (atrophy with no sperm) occurred in 29.8% (39/124) of the exposed animals and 7.1 % (4/56) of the control animals, RR = 4.2.

(2) Cancer of the white cells or leukosis was seen in 26.5% (39/147) of the exposed animals compared to 13.0% (9/69) of the controls, RR= 2.04. This condition was described as monocytic or lymphatic leucosis, lymphatic or myeloid leukaemia in the circulating blood. Leucosis is defined as a non-circulating neoplasm of white cells, whereas leukaemia is a circulating leucosis.

In these mice significant and severe (4.2-fold) testicular damage and a 2-fold increase in the initiation of leukaemia occurred is association with a weekly mean exposure of 22.3μW/cm^2.

Giarola, Krueger and Woodall (1971) observed the reduction of adrenal gland weight and feed consumption of incrossbred male chicks, and reduction of body weight and spleen weight of laboratory rats exposed to lower level (24 or 14μW/cm^2) continuous UHF radiation at 880 MHz through 23 days of age (for chicks) and 47 days of age (for rats).

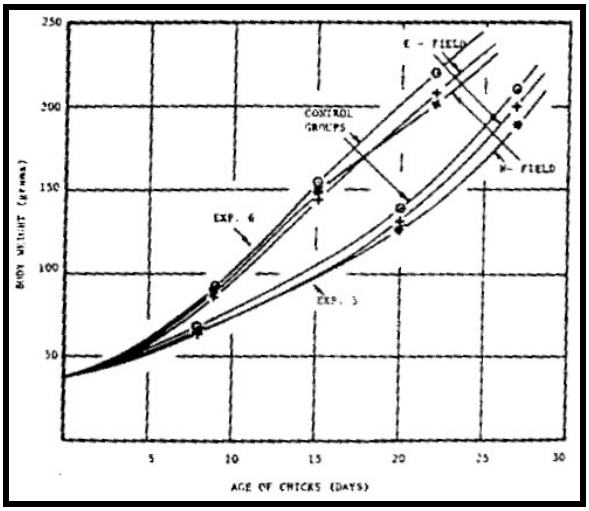

Figure 5: Reduced body weight of male baby chicks exposed to “low level” magnetic and electric fields, 1.2G and 3600V/m at 60Hz for experiment 5 and 1.4G an 3600V/m at 45Hz for experiment 6, Giarola, Krueger and Neff (1973)

Giarola, Krueger and Neff (1973) extended their previous experiments on rats and chicks have found that magnetic fields have a stronger event of reducing the body weight than electric fields. They also found that a higher frequency UHF signal (880 MHz) had a higher effect than a VHF signal (260MHz).

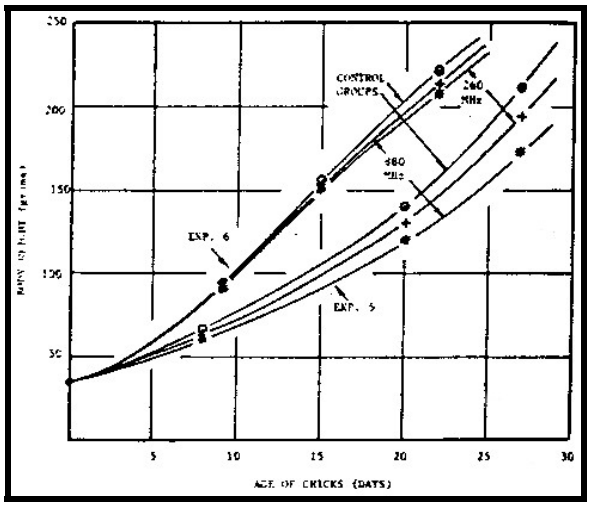

Figure 6: Reduced body weight of male baby chicks exposed to 33μW/cm^2 of 260MHz (VHF) and 880MHz UHF radiofrequency radiation, Giarola, Krueger and Neff (1973)

Olsen (1977) found the both electric and magnetic field components of continuous GHz microwaves caused teratogenesis in the pupae of the darkling beetles with the loss of rear limbs.

Berman, Carter and House (1982) also found reduced weight in mice offspring after in utero exposure to 2450-MHz (CW) microwaves using an exposure level of 28mW/cm^2. They were exposed to for 100 minutes daily from the 6th through 17th day of gestation. This gives a mean exposure during that period of 1.9 mW/cm^2. These data demonstrate that the decreased fetal weight seen in microwave-irradiated mice (-10 %) detected in utero and is retained at least 7 days after birth. Evidence from other published studies is presented to show that the retarded growth is persistent and might be interpreted as permanent stunting.

Berman et al. (1982) introduce their paper by stating:

“It has been repeatedly shown that microwaves have teratogenic potential. Rats and mice have been used almost exclusively in these studies.”

Berman et al. (1982) were extending the studies to hamsters. They investigated the teratogenic potential of microwaves on Syrian hamsters, using 2.45GHz at power densities of 30mW/cm^2 for 100 mins daily This caused a temperature rise of 0.8°C and significant fetal resporptions or death ($p = 0.0012$), decreased fetal body weight ($p=0.0001$) and decreased skeletal maturity. Averaging this over a whole day the

mean exposure is 2.08mW/cm^2. Maternal toxicity was not observed, only fetal damage and death. They conclude by comparing hamsters with mice.

> **"In mice, SAR's of 16 or 22 mW/g caused fetal changes. Comparing these two species, we see that 16 mW/g and above can cause decreased body weight and skeletal immaturity in mice, while only 9 mW/g in the hamster causes similar changes. Additionally, this lower SAR causes a significant increase in hamster fetal death (resporptions). The Hamster fetus appears to be more susceptible to microwave radiation than the mouse, exhibiting fetotoxic changes at lower SAR values."**

Chazan et al. (1983) investigated the development of murine embryos and fetuses after irradiation with 2450 MHz microwaves at 40mW/cm^2. They found indications of retardation of development in the early period of gestation in mice exposed to thermal MW fields. During the second half of pregnancy an increase in the number of resorptions, stillbirths and internal hemorrhages was noted. The living fetuses had lowered body mass compared to the offsprings of sham-irradiated mice.

In order to evaluate the reproductive function of staff exposed to radio-frequency fields from a short-wave diathermy device an experiment was carried out on mice exposed similar signals, Brown-Woodman et al. (1989). "Following repeated exposure for five weeks, a reduction in fertility occurred as indicated by a reduced number of matings in exposed rats. Compared to sham-irradiated rats and a reduction in number of rats are conceived after mating. The data are suggests that female operators could experience reduced fertility, if they remained close to the console for prolonged periods. This has particular significance for the physiotherapy profession."

This is now confirmed by multiple independent epidemiological studies.

Berman et al. (1990) summarize results of six independent international experiments conducted at the same protocol, on the development of checking embryos in a pulsed magnetic field. The field was a unipolar, pulsed magnetic field (500μ-s pulse duration, 100 pulses per second, 1μT of peak density and 2μs rise and fall time). The field was applied during 48hrs of incubation of 10 eggs, with 10 eggs also sham exposed, in each laboratory. In 5 of the 6 laboratories, more exposed embryos exhibited structural anomalies than did controls, although punitively significant differences were observed in only two laboratories (2-tailed Ps of 0.03 and 0.001) and the significance of the difference in the third laboratory is only marginal ($p=0.08$). When the data of all six laboratories are pooled the difference and incidence of abnormalities in PMF exposed embryos was significantly less, $p<0.001$, than controls.

Ray and Behari (1990) chronically exposed young albino rats to a modulated 7.5GHz microwave for 3hrs/day with a mean power density of 0.6mW/cm^2. It was found that the animals exposed to microwaves tended to eat and drink less and thus showed a smaller gain in body weight. Some of the haematological parameters and organ weights were also significantly different. They proposed that a non-specific stress response due to microwave exposure and mediated through the central nervous system is responsible for the observed physiological changes. The actual significant blood changes were an increase in the total leukocyte count and the Eosinophil count. They note that their results are in agreement with 3 previously published papers on

the effects of microwaves on animals. The non-thermal microwave exposed animals had many lower organ weights. They were significantly smaller for the spleen, kidney, brain and ovary.

A 1991 Japanese study involved exposure of developing check embryos for 428 MHz radiofrequency radiation at a power density of 5.5 mW/cm^2 for more than 28 days resulted in embryolethal and/or teratogenic effects and delaying hatching. These biological effects were not due to any thermal effect of the RF radiation. They concluded that they had demonstrated teratogenicity in the chick embryo as a result of protracted low-dose RF irradiation. They note that their non-thermal results are confirmed by several other published studies, Saito, Suzuki and Motoyoshi (1991).

Suvorov et al. (1994) studied the biological action of physical factors in the critical periods of embryogenesis. The critical period in a chicken embryonic development (the 10-13 days of incubation) is revealed under total electromagnetic radiation. EMR is a physiologically active irritant which can influence functional state of the brain. The increased absorption of electromagnetic energy takes place in this incubation period. Its dynamics within 20 days of embryonic development has phasic, up and down character.

Electromagnetic exposure (4 hours a day) in the above mentioned period evokes a delay in embryo adaptive motor behavior (biofeedback learning). Morphological investigation shows significant pathological changes, specifically, destruction of share brain synapses. The delay in embryo hatching for a day is also detected. Radiation exposure within other periods of incubation (3-6th or 12-15th days) was not effective with respect to formation of normal motor pattern in biofeedback experiment. Unfortunately this paper is in Russian and no exposure levels are quoted in the English translation of the abstract.

Ubeda et al. (1994) observe that several reports have shown that weak, extremely low-frequency (ELF), pulsed magnetic fields (PMFs) can adversely affect the early embryonic development of the chick. They state that their study involved freshly fertilized chicken eggs, exposed during the first 48h postlaying incubation to PMFs with 100 Hz repetition rate, 1μT peak-to-peak amplitude, and 500μs pulse duration. Two pulse regimes were used. PMF-A an 85μs rise and fall situation and PMF-B used 2μs. PMF-A resulted in an elevated but not significant ($p=0.173$) excess of anomalies in the embryos, while PMF-B showed a significant ($p=0.007$) increase in the early embryonic death rate. They concluded that pulsed magnetic fields can induce irreversible developmental alterations and confirm that the pulse waveform can be a determinant factor the embryonic response to ELF magnetic fields. They also conclude that similarities between the present results and previous data, obtained at the end of the 48h of field exposure, support the validity of published estimations of teratogenic incidents of MF's performed at day 2 of development.

Farrell et al. (1997) show that ELF exposures of 4μT, sinusoidal 60Hz fields, significantly enhances Ornithine Decarboxylase (ODC) activity during gastrulation and diminishes ODC activity during neurulation of chick embyos. They then identified abnormalities in older chick embryos. They found compared with normal embryos, a much lower ODC activity in the abnormal embryos. They speculate on MF-induced ODC alterations during neurulation may be related to the occurrence of MF-induced

neural tube abnormalities at later stages of development. Their conclusions include the statement “This work has demonstrated that the biochemistry of developing chicken embryos can be altered by the imposition of a weak 60 Hz magnetic field.” Since ODC there’s a key enzyme or processes of growth and development of fact that magnetic fields alter ODC activity means that they can alter the development of embryos.

Magras and Xenos (1997) responded to health concerns among residents living in the vicinity of an RF transmission tower in Greece, by placing groups of mice at various locations in relation to the tower. The mice fertility was monitored over several generations and related to the RF exposure. Figure 7 shows the fertility rate of the two exposed groups. Where group A the “Low” exposure group (0.168 $\mu W/cm^2$) became infertile after 5 generations and B the “High” exposure group 1.053 $\mu W/cm^2$, became infertile after only 3 generations. This is a highly significant result because so few multi-generation studies have been done and the effects of this study occur at extremely low levels and the effect is total infertility.

The Greek study confirms the Australian study, but shows that over several generations the infertility is complete at very low levels of mean RF/MW exposure, Figure 7.

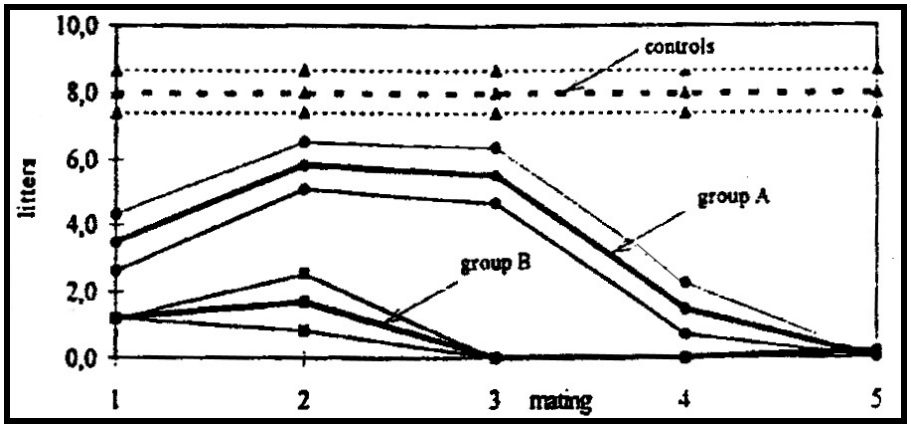

Figure 7: Multigenerational exposure of mice to low level RF, showing comparison of the mean values and ± standard deviation of number of newborns per dam and mating from all experimental groups. Group A, 0.168$\mu W/cm^2$ and Group B, 1.053$\mu W/cm^2$, Magras and Xenos (1997).

Summary and conclusions about teratological animal studies:

The animal Toxicology and Teratology experiments show a wide range of complex reproductive effects, but they are all consistent with and confirm the evidence that radiofrequency/ microwave radiation is genotoxic through a non-thermal mechanism. The animal evidence also confirms at electromagnetic fields have stronger effects than electric fields alone, and the EMR Spectrum Principle that the higher the carrier frequency the higher are the biological and health effects.

Developing sperm, embryos and fetuses are very vulnerable to damage from toxins. At critical *in utero* development times certain organs are vulnerable to damage. With sufficient fetal or placenta damage a spontaneous abortion is initiated. At other exposure levels and timing of damage a still birth can result. High levels of microwave

exposure has produced retardation of development if exposure is in early pregnancy, and resorptions, with exposure in the second half of the pregnancy, still births and hemorrhages occur.

A much lower microwave dose was associated with significant reduction in birth weight and permanent stunting and slowing of bone hardening. Changes in chicken embryo growth and biofeedback processes was observed and testicular atrophy was observed with a mean exposure to a radar-like signal averaging 22.3$\mu W/cm^2$ over a week. This is the same level that a continuous chronic exposure caused significant body weight reduction and over 15 times higher than total fertility is caused. This demonstrates that a short-term daily high exposure has a similar impact to that of the chronic low level similar mean exposure. It is consistent with a set of non-thermal mechanisms working in both situations, in a slightly different manner. Total infertility occurred in mice after 4 generations of exposure to 0.17$\mu W/cm^2$. Chronic multigenerational exposure to extremely low intensity RF radiation leaves to total infertility.

Thus 1997 it is been shown that chronic mean low level microwave exposure of animals leads to very significant adverse reproductive effects in males and females. The effects were still significant at exposures 0.17$\mu W/cm^2$. These are close to the level of the lowest published results for calcium ion efflux, 0.00015 W/kg (0.08$\mu W/cm^2$) Schwartz et al. (1990), and a genotoxic substance has no safe threshold level.

Animal experiments show that RF/MW radiation is genotoxic, teratogenic and fetotoxic in multiple, independent experiments. Hence it causes significant birth and reproductive damage in exposed animals down to very low short-term and extremely low long-term average exposure levels. This predicts that all these effects are likely to be found in similarly exposed human populations.

There is repeated evidence of RF/MW induced infertility in rodents strongly showing that RF/MW have genetically damaged the cells of the animals. This suggests that there could be reproductive and genetic damage in RF/MW exposed humans. The epidemiological studies below confirm that there is, and at very low mean levels of exposure comparable to the exposure of the mice in Greece.

Epidemiological study results:

This review now considers with a serious reproductive health effects seen in animals acutely and chronic exponents to electromagnetic fields and radiation are also found in human populations exposed to electromagnetic fields and radiation.

Miscarriage:

Vaughan et al. (1984), studying U.S. workers, found significantly increased risk of fetal death for last pregnancy for therapists, RR=2.0, CI: 1.5-2.5, n=169, for flight attendants RR = 1.8, 95%CI: 1.3-2.4, n=136, and for electronic technicians, RR= 1.5, CI: 1.2-2.0, n=202. Physiotherapists and flight attendants have higher than average electromagnetic radiation exposures.

Wertheimer and Leeper (1986) found a seasonal pattern of developmental delay and spontaneous abortion which significantly correlated with the use of times when electrically heated beds were used and higher domestic electromagnetic field from winter heat loads exist. They were not able to correlate the reproductive outcomes directly with electric field exposure. Subsequent studies have found this, confirming this result could well be EMR related.

Taskinen et al. (1990) in Finland, with 204 cases, found increased spontaneous abortion with short-wave and microwave use: Note that the statistical a significance is limited by the small sample sizes.

Electric therapies >5/week	OR= 2.0, CI: 1.0-3.9, n=17
Shortwaves ≥5h/week,	OR= 1.6, CI: 0.9-2.7, n= 30
Microwaves,	OR= 1.8, CI: 0.8-4.1, n=13),

Stronger associations were observed with ultrasound and heavy lifting:

Ultrasound>=20/week, OR= 3.4, CI: 1.2-9.0, n=9
Heavy lifting, > 10 kg or patient transfers >=50 times/week,
OR=3.5, IC: 1.1-9.0, n=11

Odds ratios increased for pregnancies > 10 weeks:

Electric therapies	OR=2.2
Shortwaves	OR=2.5
Microwaves	OR=2.4
Ultrasound	OR=3.4
Heavy lifting	OR=6.7 .

Taskinen et al. conclude “Physical exertion during early pregnancy seems to be a risk factor for spontaneous abortion. The findings raise suspicion of potential harmful effect of shortwaves and ultrasound on the pregnancy, but no firm conclusion can be drawn on the bases of these results alone.”

However, this study, in the context of all the other studies, is consistent and adds considerable weight to the conclusion that there are adverse health effects from RF/MW exposure. Taskinen at al. also found statistically significant increases in congenital malformations in the children of mothers using shortwave therapy. This confirms the results of Kallen et al, and Larsen et al.

Taskinen et al. (1990) was the only Scandanavian study to have a large enough sample to investigate the effects of miscarriage with microwaves. The sample was quite small (13), limiting the significance of the result. The Odds Ratio was (OR= 1.8, 95% CI 0.8-4.1). Exposure to ultrasound and short-wave showed significant increases in odds ratio for abortion after the 10th week of gestation, (OR = 3.4, $p<0.01$ and OR = 2.5, $p<0.03$, respectively). Taskinen et al. concluded: “The effect of shortwaves and ultrasound on the ‘late’ spontaneous abortions was significant and increased in a dose-response manner.”

Larsen et al. (1991), identified 54 cases with birth problems and 146 spontaneous abortion cases from Denmark. They found a significant increase in malformations, still birth, low birth weight, cot death and prematurely when working with short-wave diathermy. They found that only 17% of the “highly exposed” newborn infants were boys, the ratio of 1:6 vs the normal 1:2.

A great deal of concern has been expressed for many years about the risks of miscarriage with the exposures to a wide range of frequencies of EMR from visual display units (VDUs) on computers. With the very low monthly mean microwave exposures causing miscarriage for physiotherapists it is not surprising that many workplace stories were published about clusters of miscarriages in association with VDU or VDT uses. These were dismissed by computer manufacturers and employers as anecdotal and unlikely to be actually associated with VDT exposure that was so much lower than standards allowed.

In 1992 the American Journal of Epidemiology published a paper by Lindbohm et al. (1992) that observed a dose-response increase in miscarriage as a function of magnetic fields strength of exposure from VDTs, Figure 8. Their data follows, including measured VDT ELF emissions:

Exposure Range	Mean	RR	95%CI
<0.13μT	0.09	1.0	Reference
0.13-0.3 μT	0.21	1.9	0.9-3.9
>0.3 μT	0.35	3.4	1.4-8.6

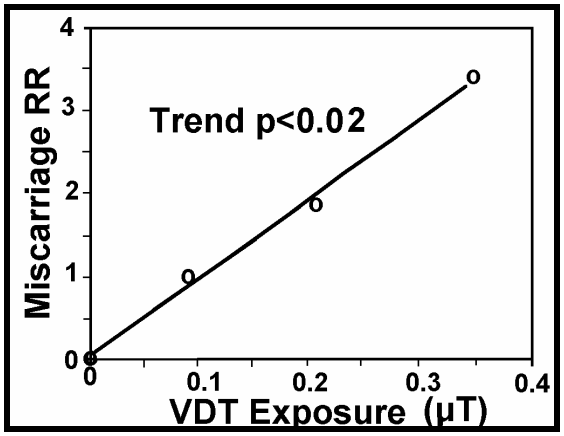

Figure 8: ELF/RF/MW exposure from VDT usage increases miscarriage in a dose-response manner, Lindbohm et al. (1992).

VDTs also emit RF radiation, ICNIRP (1998). There is no “Non-Exposed” group. Applying an adjustment for this could well lift the line in Figure 3 to go through RR = 1 at exposure = 0, with the other RRs elevated in proportion.

Physiotherapists have been exposed to microwaves and shortwave radiation in the course of diathermy of patients. From a very large survey group 6,684 female Physiotherapists from the United States, reported using microwave or shortwave radiation at some time during their work history. A total of 1753 pregnancies involving first trimester miscarriage were matched to 1753 control pregnancies. This revealed a

7%, but non-significant rise in miscarriage associated with shortwave exposure and a highly significant 28% increase in first trimester miscarriage for those exposed to microwaves, including a highly significant ($p<0.005$) dose-response relationship, Figure 9, Ouellet-Hellstrom and Stewart (1993).

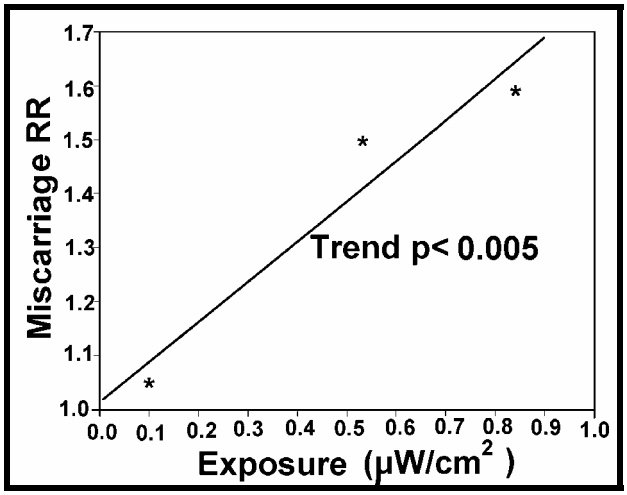

Figure 9: Microwave exposure associated miscarriage for pregnant physiotherapists, Ouellet-Hellstrom and Stewart (1993).

Exposure levels were based on 3 minutes exposure per treatment to 600μW/cm^2, a peak exposure level near the middle of the reported range. This gives 0.042μW/cm^2 per treatment per month, to give a monthly mean dose-response based on treatments per month.

The overall odds ratio was a la = 1.28 (1.02 – 1.59). For all physiotherapists with no prior foetal loss the overall odds ratio was OR = 1.26 (1.00- 1.59). There was a highly significant dose-response trend, $p < 0.01$.

Magnetic Resonance Workers are exposed to quite strong ELF and RF fields. Evans et al. (1993) compared reproductive outcomes between Magnetic Resonance Workers and other groups. MRI workers had elevated outcomes compared with other workers but compared with homemakers they were highly elevated:

Outcome	RR	95%CI	
Miscarriage	3.22	1.74-5.97	(p=0.0001)
Early Delivery	1.71	0.87-3.38	
Low Birth Weight	1.52	0.52-4.41	

Juutilainen et al. (1993) observed a significant early pregnancy loss associated with "high" residential 50 Hz exposures ($\geq$ 0,63μT ($\geq$6.3mG) at the front door), OR = 5.1 (1.0-25).

Hence up to 1993, seven published human studies confirm the results of animal studies that microwave exposure at extremely low mean exposure levels causes early pregnancy miscarriage and RF exposure is more associated with late pregnancy miscarriage, still birth, SIDS and congenital malformation. With consistently elevated, significantly elevated and multiple dose-response elevation of miscarriage, backed by animal experiments and genotoxic evidence, this is sufficient

for concluding a causal relationship between RF/MW exposure and miscarriage. The mechanisms are the same and the evidence is consistent about congenital malformations, and other serious reproductive problems resulting for a range of complex exposure situations and a wide variety of immune system health levels.

More Recent Studies:

Belanger et al. (1997) conducted a prospective study (N= 2967) to evaluate the relation between spontaneous abortion and the use of electrically heated beds. Electric blanket use was associated with increased spontaneous abortion, OR = 1.84, 95%CI: 1.08-3.13 for unadjusted data, and when the data is adjusted for other risk factors such as alcohol, smoking, age and caffeine intake, OR = 1.74, 95%CI: 0.96-3.15.

Although the evidence as strong and consistent, it has been criticised by some people who claim that there is weakness because of the lack of appropriate exposure assessments. Therefore it has been recommended that a careful prospective study be carried out. This was agreed to happen in California and the results of the prospective study are now available.

Lee et al. (2000) conducted a prospective cohort study in California to evaluate the relation of spontaneous abortion and electric bed heater use during the first trimester of pregnancy. They found that 20 women who used electric blankets at a high setting for 1 hour or less had an adjusted odds ratio of 3.0 (95% CI = 1.1-8.3), but they found no spontaneous abortions among the few women (N = 13) who used a high setting for 2 or more hours.

Li et al. (2002) studied the effect of magnetic fields on the risk of miscarriage, they conducted a population-based prospective cohort study among pregnant women within a large health maintenance organization. All women with a positive pregnancy test at less than 10 weeks of gestation and residing in the San Francisco area were contacted for participation in the study. They conducted in-person interviews to obtain information on risk factors for miscarriage and other potential confounders. All participants were also asked to wear a magnetic field-measuring meter for 24 hours and to keep a diary of their activities.

Pregnancy outcomes were obtained for all participants by searching the health maintenance organization's databases, reviewing medical charts, and telephone follow-up. They used the Cox proportional hazard model for examining the magnetic field-miscarriage association. A total of 969 subjects were included in the final analyses. Although they did not observe an association between miscarriage risk and the average magnetic field level, miscarriage risk increased with an increasing level of maximum magnetic field exposure with a threshold around 16mG.

The rate ratio (RR) associated with magnetic field exposure > or = 16 mG (vs <16 mG) was 1.8 (1.2-2.7). The risk remained elevated for levels (in tertiles) of maximum magnetic field exposure > or = 16 mG. The association was stronger for early miscarriages (<10 weeks of gestation), RR = 2.2 (1.2-4.0) and among "susceptible" women with multiple prior fetal losses or subfertility, RR = 3.1 (1.3-7.7). After excluding women who indicated that their daily activity pattern during the measurements did not

represent their typical daily activity during pregnancy, the association was strengthened; RR = 2.9 (1.6-5.3) for maximum magnetic field exposure > or = 16 mG, RR = 5.7 (2.1-15.7) for early miscarriage, and RR = 4.0 (1.4-11.5) among the susceptible women.

They concluded that their findings provide strong prospective evidence that prenatal maximum magnetic field exposure above a certain level (possibly around 16 mG) may be associated with miscarriage risk. This observed association is unlikely to be due to uncontrolled biases or unmeasured confounders.

The second follow-up prospective study, Lee et al. (2002), was a nested case-control study (177 cases, 550 controls) to assess the relation between retrospective magnetic field measures and clinical miscarriage among members of the northern California Kaiser Permanente medical care system.

They also conducted a prospective substudy of 219 participants of the same parent cohort to determine whether 12-week and 30-week exposure assessments were similar. They evaluated wire codes, area measures, and three personal meter metrics: (1) the average difference between consecutive levels (a rate-of-change metric), (2) the maximum level, and (3) the time-weighted average. For wire codes and area measures they found little association. For the personal metrics (30 weeks after last menstrual period), they found positive associations. Each exposure was divided into quartiles, with the lowest quartile as referent. Starting with the highest quartile, adjusted odds ratios and 95% confidence intervals were 3.1 (1.6-6.0), 2.3 (1.2-4.4), and 1.5 (= 0.8-3.1) for the rate-of-change metric; 2.3 (1.2-4.4), 1.9 (1.0-3.5), and 1.4 (0.7-2.8) for the maximum value; and 1.7 (0.9-3.3), 1.7 (0.9-3.3), and 1.7 (0.9-3.3) for the time-weighted average. The odds ratio conveyed by being above a 24-hour time-weighted average of 2 mG was 1.0 (0.5-2.1).

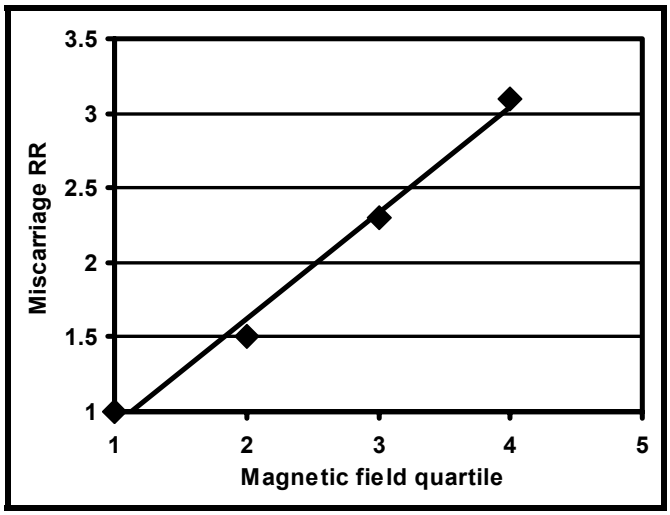

Figure 10: The miscarriage RR for the rate-of-change metric of the measure magnetic field exposure, p<0.001, Lee et al. (2002)

Exposure assessment measurements at 12 weeks were poorly correlated with those taken at 30 weeks. Nonetheless, the prospective substudy results regarding miscarriage risk were consistent with the nested study results.

These very recent epidemiological studies confirm that residential and occupational exposure is extremely low-frequency electronic fields is strongly associated with increased rates of miscarriage from a pro perspective to study involving actual otters monitored fields and appropriately dealing with all possible confounders with the authors' conclusion: "This observed association is unlikely to be due to uncontrolled biases or unmeasured confounders."

Sperm count:

One of the early descriptions of the symptoms that workers got when exposed to microwaves and radiofrequency signals was the "radiofrequency syndrome" or the "microwave syndrome" are summarized and described by Baranski and Czerski (1976). They distinguish between a syndrome of acute microwave exposure and a syndrome of chronic microwave overexposure. Acute reactions were typically complaints of headaches, nausea, vertigo, and sleep disturbances (sleeplessness). Objectively, hypertonia, changes in cardiac rhythm, and a skin rash may be encountered. EEG examination may show a decrease in amplitude of alpha waves.

The chronic-overexposure syndrome is characterized by subjective complaints consisting of headaches, irritability, sleep disturbances, weakness, decrease of sexual activity (libido), pains in the chest, and general ill-defined feelings of ill-being. On physical examination tremor of fingers and extended arms, acrocyanosis, hyperhydrosis, red or white dermographism, and hypotonia have been observed. This raises the question about subjectivity or reality of physiological effects and microwave exposures. The following studies show that they are measured effects confirming real changes.

Lancranjan et al. (1975) investigated and found significantly the altered a gonadic function in workmen with long-term exposure to 3.6-10GHz microwaves in 10s to 100s of $\mu W/cm^2$. They found a high frequency of libido decrease and sexual dynamic disturbance in the framework of the asthenic syndrome in 70% of the subjects as well as various alterations to the spermatogenesis's and 74% of the subjects. Sperm counts were extremely reduced ($p<0.001$).

Kowalczuk, Saunders and Stapleton (1983) exposed the lower half of the bodies of mice to 2.45GHz microwaves at 44W/kg for 30mins per day. They found that microwave effects are strong on spermatids and spermatocytes. Male fertility was significantly reduced and was correlated well with reduced pregnancy rates and microwaves clearly induced abnormally shaped sperm.

Testicular damage has also been found in men who have radar exposures. Weyandt et al. (1996) studied 30 U.S. service men who had regular radar exposures. **"The group of men with potential microwave exposures demonstrated lower sperm counts/mL ($p = 0.009$) and lower sperm/ejaculate ($p= 0.027$) than the comparison group."**

At Salzburg conference in 2000 the Chinese researcher reported that in a China province the microwaves were used for birth control by exposing the man's testicles to microwaves significantly reduced sperm count.

Parental occupation passing cancer on to children:

A genotoxic carcinogen causes increased cancer rates in exposed populations. If a mother or father are exposed prior to pregnancy and their sperm or eggs are genetically altered, or the mother is exposed during her pregnancy, then it is plausible and scientifically logical that the offspring are at higher risk of getting cancer and than the offspring of parents who were not exposed to the damaging substance.

Savitz and Chen (1990), reviewed 24 published epidemiological studies relating occupational exposure of parents to childhood cancer. Several studies involved fathers in electrical and electronic occupations. They show elevated odds ratio for childhood nervous system cancers in the range of 1.6 to 1.7 in one study, and significant elevation of 2.7 and 11.8 for two other studies.

Olsen et al. (1991) found in Denmark that mothers involved in constructing of communication equipment, which involves power frequency and radiofrequency exposures, had a highly significant increase risk of leukaemia in the children, OR = 14.5, $p<0.01$. Childhood Renal tumours were more common from fathers in Electrical contracting firms, OR = 4.7, $p<0.05$.

Kuijten et al. (1992) found in the Netherlands that the incidence of childhood Astrocytoma increased from probable EMF exposure during preconception, OR = 1.7 (0.7-4.4), during pregnancy, OR = 1.6 (0.6-4.5), and postnatal, OR = 1.3 (0.5-3.6). For electrical repairing only, in the same order were OR = 8.0 (1.1-365.1), OR = 5.0 (0.6-237.1) and OR = 2.5 (0.4-26.2).

Infante-Rivard (1995) found that in Spain, mothers who are exposed to high ELF field from working on sewing machines have a very significantly higher rate of acute Lymphoblastic leukaemia in their children <15 years, OR = 7.0 (1.59-30.79). and adjusted for mothers income from smoking, OR = 5.78 (1.27-26.25).

Wilkins and Wellage (1996) investigated male electrical occupations for the risk of electromagnetic fields passing on CNS/Brain tumors to offspring, including preconception and pregnancy, electrical workers and welders. For electrical workers any employment during preconception gave OR = 1.31 (0.58-2.98), n=11, while during pregnancy, OR = 1.03 (0.45-2.39), n=9. For welders the equivalent figures are OR = 3.83 (0.95-15.55), n=6 and 2.5 (0.67-9.31), n=5.

Colt and Blair (1998) review 9 studies showing that parental occupations past on Brain/CNS tumors to their children, with significant findings in multiple studies.

Hatch et al. (1998) found that pregnant mothers who used electric blankets or electric heating pads during their pregnancies had significantly elevated incidence of children with leukaemia (cALL), OR = 1.59, 95%CI: 1.11-2.29, and OR = 1.46, 95%CI: 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 cALL 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, 95%CI: 1.64-13.36. For video games connected to the TV for an hour or more a day, OR = 1.87, 95%CI: 1.13-3.10. This confirms the early initiation during pregnancy and the advancement with EMF/EMR exposures of the child after birth.

Olshan et al. (1999) used US data to identify parental occupations passing on Neuroblastoma to their offspring. When the odds ratios are adjusted for a number of demographic and social factors, the odds ratio for electric power installers and power plant operators was OR = 2.7 (0.9-8.1), n=5, for electricians, OR = 1.2 (0.4-3.5), n=8.

De Roos et al. (2001) investigated 537 case mothers and 503 control mothers to determine if occupational radiation exposures of pregnant mothers that are linked to their offspring children developing Neuroblastoma. From investigation of highly probable exposure, the Odds Ratios were adjusted for child's age, maternal race, maternal age and maternal education.

Exposure equipment	Cases	Adj OR	95%CI.
Cellular phone	2	2.1	0.4-11.0
X-ray machine	2	2.1	0.4-11.4
Equipment grouped by major frequency			
Radio-frequency radiation	4	2.8	0.9-8.7
Ionizing irradiation	3	1.4	0.3-6.4

Even though the samples of a small using a cellular telephone is as bad as being Xrayed and doubles the risk of your children developing Neuroblastoma. Radiofrequency radiation is twice as bad (OR=2.8) as ionizing radiation (OR = 1.4).

There are strong and multiple independent evidence that occupational exposure of mothers during pregnancy and fathers prior to conception can pass on cancer to their children if they exposed to power frequency fields at work and at home and radio frequency fields including the use of cellular telephones. This is very strong evidence that these fields are genotoxic.

Passing on malformations to children:

If a substance is genotoxic and passes on cancer to the offspring from its exposed parents, then it is logical and plausible that also it passes on other malformations and illnesses to the children. The relative risks of passing on serious, moderate or weak health effects to children are related to the level of impact of exposure and the and strengths of the parents' immune and cellular repair systems, including their natural melatonin levels.

Sigler et al, (1965), found a significant association between father's military radar exposure as a radar repairer or operator, and Down's syndrome in their off-spring, OR = 2.64, p=0.02. Sigler et al. suggested that this result, along with research which found "tissue damage in humans and laboratory animals" and "a deleterious effect of rat testis" as evidence that microwaves might be ionizing radiation, since similar effects had been identified with exposure to ionizing radiation. "The acknowledged association of Mongolism and leukaemia, and radiation and leukaemia is additional evidence consistent with the hypothesis that radiation is a etiological importance in Mongolism." We now know that chromosome aberrations do occur in microwave

exposed subjects, who have a significant increased incidence of Leukaemia, Szmigielski (1996), without the need for microwaves to be ionizing.

Kallen, Malmquist and Moritz (1982) found that female physiotherapists exposed to shortwave radiation had a higher incidence of dead or malformed infants than amongst controls.

Nordstrom, Birke and Gustavsson (1983) observed a significant decrease in "normal" pregnancies in high voltage substations in Sweden, almost exclusively as a result of congenital malformations when the father was a high voltage switchyard worker. Nordenson et al. (1988) measured a significant increase in chromosome aberrations in similar workers.

Sanjose et al. (1991) investigated the incidence of low birth weight and preterm delivery in Scotland, 1981-84, in relation to parent's occupation. They found statistically significant ($p<0.05$) increases in low birth weight (RR = 1.4) and preterm delivery (RR = 1.8) for mothers who work in the electrical industry. People who work in "electrical industries" are recognized as being exposed to a wide range of EMR giving them more than average EMR exposures.

Larsen (1991) found a non-significant elevation in congenital malformations in a small (n=54) group of RF exposed Danish physiotherapists, OR = 1.7, 95%CI: 0.6-4.3. Evans et al. (1993) compared reproductive outcomes between Magnetic Resonance Workers and other groups and found for MR exposures, Low Birth Weight, OR = 1.52 (0.52-4.41). Larsen et al. (1991) showed a 3-fold reduction in the number of boys born from highly RF exposed mothers.

Lipscomb et al. (1991) found highly significantly calibrated incidents of low birth weight infants from women working on for the electronics production and assembly industry of where they are about average exposures are solvents and electromagnetic fields. The odds ratios, after adjustment for maternal low weight gain and smoking were:

For electronic production OR = 3.99, 95%CI 1.09-14.66, n=3
For electronic assembly OR = 5.38, 95%CI: 1.42-20.46, n=3

Another possible consequence of being exposed to a genetically damaging substance is the incidence of twins. Flaherty (1994) carried out a study of Australian air force personnel, "The effect of non-ionizing electromagnetic radiation on RAAF personnel during World War II". He found in a group of 302 surviving veterans, men had a ratio of single to twin births of 41:1, women 38:1 and overall the ratio was 40:1. This contrasts with the ratio in the normal Australian population of 85:1. The Relative Ratio of twins of radar exposed people vs the average population rate was RR =2.125 for all people, RR = 2.073 for men and RR = 2.237 for women. Hence radar exposed veterans had over twice the expected number of twins, a very significant result.

Schnitzer, Olsham and Erickson (1995) found that several occupations, including electrical and electronic workers, have children with a higher rate of birth defects.

	Electricians electrical workers, N = 229			Electronic equipment operators,N = 123		
	N	OR	95%CI	N	OR	95%CI
Anencephalus	7	1.3	0.6-2.8	4	1.6	0.5-4.8
Spina Bifida	10	1.2	0.6-2.5	6	1.9	0.7-4.7
Atrial septal defect				4	2.6	0.9-7.9
Cleft Palate				3	2.1	0.6-7.3
Cleft lip and palate				4	1.7	0.6-5.4
Coarctation of aorta	6	3.0	1.2-7.5			
Pyloric stenosis				7	1.7	0.7-3.9
Rectum, anus atresia/stenosis	4	1.7	0.6-5.0			
Reduction defects upper limb				4	4.2	1.3-13.7

Savitz, Olsham and Gallagher (1996) studied the relationships between maternal occupations and pregnancy outcomes. For electrical in equipment operators the risk of preterm delivery at any time during pregnancy, after adjustment for an other stage, race car education, first quarter, prenatal care onset, cigarette smoking and alcohol use, was OR = 1.8 (0.9-3.3), n=57. Up to the fifth month of pregnancy the equivalent result was, OR = 1.8 (0.9-3.5), n=46.

For very low birth weight the equivalent results were OR = 1.5 (0.9-2.3), n=36, and OR =1.2 (0.7-2.1), n=24.

Summary, Conclusions and Recommendations:

There is direct evidence that electromagnetic fields and radiation are genotoxic. The animal experiments are consistent with this observation and the EMR Spectrum Principle. They show at non-thermal exposures, fetal resorptions, reduced sperm counts, altered sperm shape, limb loss, reduced body weight, foetal loss, and infertility.

When all the studies are taken together, they form a comprehensive and compelling body of research to show that RF/MW exposed human subjects have reduced sperm counts, induced miscarriages in early trimesters from microwave exposure and later miscarriage and more congenital malformed babies, still birth, premature birth, SIDS, more twins and low birth weight babies with shortwave or lower intensities or microwave and power frequency exposures. The surviving offspring of parents who have been occupationally exposed electromagnetic fields and radiation, have an elevated risk rate of a wide range of abnormalities and cancers. All of these observed health effects are consistent with electromagnetic fields and radiation being genotoxic and cause reduced Melatonin.

The strongest evidence in multiple studies is for miscarriage was elevated, significantly elevated and three significant dose-response relationships for both RF/MW and ELF occupational and residential exposures. The evidence is sufficient to conclude that there are as a causal relationship. It is sobering to also note that for

women who miscarry in the first trimester, the breast cancer risk is over 4 times higher RR = 4.1, 95% CI: 1.5-11.3, Hadjimichael et al, (1986).

It has been widely observed that reduced sperm count could well be associated with the rising the levels of radiofrequency/microwave radiation which is exposing the whole population to levels that have been shown to cause multiple generation infertility in mice below 0.1μW/cm^2. Radio-frequency radiation in the Schwarzenburg project was shown to be associated with reduced Melatonin and sleep disturbance down to 0.4nW/cm^2.

Public health protection exposure standards should be set to significantly reduce the very serious reproductive health effects identified in this review, with the dose-response relationships and the genotoxic mechanism indicating that has no safe threshold.

Therefore it has recommended that chronic mean exposure levels should be *de minimus*, and be aimed to be lower than 10nW/cm^2.

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