

A REVIEW OF SOME RF EPIDEMIOLOGICAL STUDIES

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Introduction:

The rapid growth of the use of cell phones to include more than a hundred million people world wide has lead to an increased interest in the possibility of adverse health effects as a result of exposures to radio waves. Several possible health effects have been raised as issues for public concern including possibility of causing or promoting cancers, a reduction in memory and an increase in reaction time. Three of the major concerns with respect to cancer are brain tumors, breast cancers and leukemia. These concerns have been raised as result of both by the occurrence of a few cases of brain tumors on the side of heavy cell phone use and some animal studies that indicate reduced memory for exposed animals.

In this paper we will review approximately 15 of the more than 40 epidemiological studies. Approximately seven of these studies report possible negative health effects. However, all these studies have weaknesses that make difficult to separate possible effects of the RF from other causes. These weaknesses typically include only a small number of cases or poor data on the exposures of the cases and controls. Additionally at least part of the problem is that there does not exist a good model for biological effects at levels below those that give rise to thermally driven biological changes. At this time there is no generally accepted theoretical model to help the epidemiologists design their studies so as to separate the exposed from unexposed populations. For example it is not known whether the peak fields, the average fields or the values above some threshold for periods greater than a time, t , are the important parameters for a biologically significant change.

In reviewing these studies some it is worthwhile to point out some of the authors biases. First we are electrical engineers who have been involved in animal studies, simulations and one epidemiological study at ELF. This leads to the following beliefs:

1. Biological systems are extremely nonlinear.
2. High levels of RF exposure lead to biological effects.
3. The level at which biological changes are observed will decrease over time as our understanding improves and our measurements get better.
4. Long-term low levels of exposure may lead to results that are not seen with short high-level s of exposure.

5. Competing processes with different time constants may lead to both positive and negative health effects.
6. There are likely to be thresholds below which no effects are observed.

After reviewing these studies in roughly chronological order, we will make recommendations on some characteristics that should be considered for future epidemiological studies.

Some Early Studies.

The following are very brief summaries of the studies we reviewed.

1. R.P. Gallagher et al. *Journal of Occupational Medicine* Vol.33 No.9 Sept. 1991 This letter shows an elevated proportional mortality rate from brain cancers for electrical engineers, radio and TV announcers, technicians, and projectionists. The data is from British Columbia on male deaths from 1950 -1984 for 320,493 cases. 5 deaths for EE's and not statistically significant. Social Economic Status may be a factor. [?]
2. Slevin, S. "Distance and Risk Measures for the Analysis of Spatial Data: A Study of Childhood Cancers Epidemiology" *Soc. Sci Med* (1992) 34(7): 769-777 This study of children under 21 near a microwave tower in San Francisco showed no correlations with distance from the tower out to 3.5 Km on tumor incidence. (1973-1988)[?]
3. G. Maskarinec, et al. "Investigation of Increased Incidence in Childhood Leukemia near Radio Towers in Hawaii: Preliminary Observations" *Journal of Environmental Pathology, Toxicology and Oncology* 13(1): 33-37 (1994)
This study shows a not statistically significant increase in acute childhood leukemia for children (under 15) within 2.6 miles of radio towers (23.4 kHz) (OR) = 2 (95 % CI 0.06- 8.3) period 1979-1990. This was a case control study with 12 Cases. The geographical distribution of these cases indicates the possibility of a cluster that makes cause and effect hard to assess. [?]
4. Kolodynski 93 "Motor and Psychological functions of School Children Living in the Area of the Skrunda Radio Locations Station in Latvia" *The Science of the Environment* 180(1996) 87- 93 This study shows statistically significant difference between the exposed and control groups. Exposed children show less developed memory and attention spans. Reaction times for the exposed children were slower and their endurance was decreased. [?]
5. Szmigielski, S. "Cancer Morbidity in Subjects Occupationally Exposed to High Frequency (radio frequency and microwave) Electromagnetic Radiation" *The Science of the Total Environment* 180(1996) 9-17
This study shows an increased cancer morbidity in the Polish military for the period 1971-1985 for personal whose assignments were believed to lead to significant occupational exposures. The overall observed to expected ratio (OER) =2.07 with $P < 0.05$ and myelocytic leukemia (OER=13.9) and myeloblastic leukemia (OER =8.2) [?]
6. Hocking, B et al. "Cancer Incidence and Mortality and Proximity to TV Towers" *Medical Journal of Australia* 1996;165:601

This is a population studies on increased cancer incidence in the vicinity of three TV towers for the period 1972-1990. The power densities in this study ranged from 8mw/cm² to 0.02 mw/cm² at 12 km and frequencies in the range 63 -215 MHz. The results showed an increase in total leukemia incidence of 1.24 times the expected value with (CI 1.09 -1.4) for the population at less than 4km.

The expected power densities in this region are greater than 0.2 mw/cm². The mortality increases by 2.74 times the expected value (CI 1.42-5.27 at 95% level) for childhood lymphatic leukemia. [?]

7. McKenzie, D. et al. "Childhood Incidence of Acute Lymphoblastic Leukemia and Exposure to Broadcast Radiation in Sydney- A Second Look" *Aust NZ J. Public Health* 1998;22:360-36. An analysis of the Hocking data shows that the increase in leukemia resulted from on highly exposed government area where as other similarly exposed areas showed not increase. [?]
8. Dolk, H., "Cancer Incidence Near Radio and Television Transmitters in Great Britain 2. All High Power Transmitters" *Am. J. Epidemiology*(1997) 145:1-9 also 10-17. This followed an earlier study indicating an excess of leukemia near the Sutton Colfield transmitter with a study of the populations near 20 transmitters. This showed no overall increase in leukemia but some evidence of a decrease with distance from the transmitters. The interpretation is still being debated.[?]
9. Cooper, D. et al. " Cancer Incidence Near Radio and Television Transmitters in Great Britain I. Sutton Coldfield Transmitter: II All High Power Transmitters" *American Journal of Epidemiology*, Vol. 153. No. 2,202-204,(2001) This study does not show a variation in the incidence of cancer with distance as implied by the first study in this region. [?]
10. Hardell, L., "Case Control Study of Malignant Brain Tumors with Reference to Work in the Electronics Industry and Exposure to Microwaves from Mobile Phones" *International J. Oncology* (1999) 15:113-116, second paper in *Med Gen Med* (2000)[internet journal] This study showed no significant increase in brain Tumors with cell phone exposure. A non-significant increase in brain tumors localized in the area of greatest RF exposure OR = 2.45 for NMT(analog) users not for GSM users. [?]
11. Muscat, J. "Cellular Telephones and the Risk of Brain Cancer" *JAMA*(2000) 284K(23);3001-3007; wtr sponsored 2 State of the Science Colloquium (Long Beach, 1999O) This data showed no correlation between malignant brain tumors or acoustic neuromas and wireless phone use. Additionally this data does not support the data by Hardell. [?]
12. Morgan, R. et al. "Radio frequency Exposure and Mortality from Cancer of the Brain and Lymphatic/Hematopoietic Systems" *Epidemiology* March 2000, Vol. 11 No. 2 118-127 This is a cohort mortality study at Motorola using job titles for classification on 195,775 workers from 1976-1996. After correction for the healthy worker affect no significant increase in mortality from cancers. [?]
13. Johanson, "Cellular Telephones and Cancer; A Nationwide Cohort Study in Denmark" *Journal of the National Cancer institute* (2001) 93:203-206 This study is a cohort study of 80,000 people for period 1982-1995, for exposure to RF fields with frequencies at 900 and 1800 MHz. No significant increase for any tumors was found. [?]
14. Vecchia P. "The Case of Vatican Radio" *BEMS News letter*. March- April 2001 This is a case where small number and politics can shape the result. One case where none was expected leads to a statement of a factor of 6 times increase over expected number of cancers. [?]
15. Inskip, P., et al. "Cellular-Telephone Use and Brain Tumors" *New England Journal of Medicine*, Vol. 344:344: 79-86 January 11, 2001 This is a case control study with 782 patients covering the period 1994-1998. The controls were other patients in the same hospitals for other reasons and had a somewhat younger age distribution. The results showed no increase in brain tumors with cell phone usage. The study is limited to relatively short term use and would not be expected to apply to very heavy users or long-term exposures. [?]

16. John O. de Lorge and Clayton S. Ezell, "Observing-Responses of Rats Exposed to 1.28- and 5.62-GHz microwaves", *Bioelectromagnetics* 1:183-198 (1980) This study shows the observing-response rate of rats was affected by above 3.75W/kg at 1.28 GHz and 4.94W/kg at 5.62GHz. John M. Osepchuk* mentioned that this result of the disruption of food-motivate learned behavior had affected the safety standard of ANSI/IEEE (C95 series). In ANSI/IEEE standard C95.1, the safety level of SAR is 0.4W/kg for controlled environments, which is about 10 times below than the result of this paper. John M. Osepchuk, Ronald C. Petersen, "Safety Standards", *IEEE microwave*, June 2001, pp57-69 [?]
17. Gabriele Freude, et. al., "Effects of Microwaves Emitted by Cellular Phones on Human Slow Brain potentials", *Bioelectromagnetics* 19:384-387 (1998) The frequency of applied field was 916.2 MHz pulsed with 217Hz and a pulse width of 577ms. The radiated power is 2.8W of peak value and 0.35W of average. The average SAR was 1.4W/kg over 10g tissue. The subjects were healthy men. During subjects were doing visual monitoring task (VMT), the magnitude of mean Slow Brain Potentials (SP, up to 20mV) slightly decreased. [?]
18. Mika Koivisto, et. al., "Effects of 902MHz electromagnetic field emitted by cellular telephones on response times in humans", *Neuroreport* 11:413-415 A 902MHz pulsed with 217Hz field of 0.25W mean power exposed to 24 men and 24 women for 1 hour during response tests. The simple reaction time (SRT) and vigilance tasks and the cognitive time was speeded up. [?]

Conclusions:

We believe the study by A. Kolodynski should be followed up with additional studies. We have not seen similar studies that would either support or contradict this study. Additionally there are some animal studies that indicate reduced memory for exposed animals. Most of the other studies reviewed here either do not show any effects or have weakness such as a small number of cases, short exposure times, or poor measurement data on the exposure that make them less than convincing to these authors. This is especially true in those cases where follow up studies failed to confirm the initial results. See Table 1 for a very condensed summary of the reviewed studies.

The high variability of the exposure with location as a result of scattering and the absorption by objects such as trees and buildings make exposure estimates based on distance from a transmitter subject to large errors. This is especially true at shorter wavelengths and if we are looking for long- term exposure where a significant part of the exposure is expected to occur inside a building. An unpublished comparison of measurements and calculations made by students of one of the authors, (Barnes), showed that computer programs for predicting the fields in rough terrain were almost useless.

Unfortunately a convincing epidemiological study of possible health effects of exposure to low levels of RF fields is going to require good exposure data and a long period of time. With growth of the use of cell phones by a larger and larger fraction of the population it is going to be increasingly difficult to find an unexposed control group that does not differ from the exposed population in many other ways that increase the probability of confounders. Thus the sooner a study of this type is initiated the more likely it is to succeed.

I'm using dvips(k) 5.86, kpathsea version 3.3.1 on an ordinary Linux system and I would like to produce a document containing some landscape pages and some portrait pages. Therefore I use the LaTeX portland

package. But I didn't find any possibility to inform dvips to switch the page geometry in the inner of my document (at the beginning it works fine).