

Epidemiological Studies: Cancer

Dode AC, Leão MM, Tejo Fde A, Gomes AC, Dode DC, Dode MC, Moreira CW, Condessa VA, Albinatti C, Caiaffa WT. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ.* 2011 Sep 1;409(19):3649-65. Epub 2011 Jul 13.

The results show that approximately 856 BSs were installed through December 2006. Most (39.60%) of the BSs were located in the "Centro-Sul" ('Central-Southern') region of the municipality. Between 1996 and 2006, 7191 deaths by neoplasia occurred and within an area of 500 m from the BS, the mortality rate was 34.76 per 10,000 inhabitants. Outside of this area, a decrease in the number of deaths by neoplasia occurred. The greatest accumulated incidence was 5.83 per 1000 in the Central-Southern region and the lowest incidence was 2.05 per 1000 in the Barreiro region. During the environmental monitoring, the largest accumulated electric field measured was 12.4 V/m and the smallest was 0.4 V/m. The largest density power was 40.78 $\mu\text{W}/\text{cm}^2$, and the smallest was 0.04 $\mu\text{W}/\text{cm}^2$.

Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliott P. Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter. *Am J Epidemiol.* 1997 Jan 1;145(1):1-9.

The study area was defined as a 10 km radius circle around the transmitter, within which 10 bands of increasing distance from the transmitter were defined as a basis for testing for a decline in risk with distance, and an inner area was arbitrarily defined for descriptive purposes as a 2 km radius circle. The risk of adult leukemia within 2 km was 1.83 (95% confidence interval 1.22-2.74), and there was a significant decline in risk with distance from the transmitter ($p = 0.001$). These findings appeared to be consistent over the periods 1974-1980, 1981-1986, and were probably largely independent of the initially reported cluster, which appeared to concern mainly a later period. In the context of variability of leukemia risk across census wards in the West Midlands as a whole, the Sutton Coldfield findings were unusual. A significant decline in risk with distance was also found for skin cancer, possibly related to residual socioeconomic confounding, and for bladder cancer.

Eger H, Hagen KU, Lucas B, Vogel P, Voit H. The influence of being physically near to a cell phone transmission mast on the incidence of cancer]. *Umwelt-Medizin-Gesellschaft.* 2004;17:326-332. <http://blog.cat/gallery/17983/17983-97698.pdf>

The result of the study shows that the proportion of newly developing cancer cases was significantly higher among those patients who had lived during the past ten years at a distance of up to 400 metres from the cellular transmitter site, which has been in operation since 1993, compared to those patients living further away, and that the patients fell ill on average 8 years earlier. In the years 1999-2004, i.e. after five years' operation of the transmitting installation, the relative risk of getting cancer had trebled for the residents of the area in the proximity of the installation compared to the inhabitant of Naila outside the area.

Goldoni J, Durek M, Koren Z. Health status of personnel occupationally exposed to radiowaves. *Arh Hig Rada Toksikol.* 1993 Sep;44(3):223-8.

The findings of medical examinations performed in two groups of persons occupationally exposed to microwaves and radiofrequency radiation are presented in comparison with control findings. A group of 49 radar operators from the Zagreb Air Traffic Control was examined twice within a period of 18 months. The other group comprised 46 workers employed in radio relay stations. The control group were 46 workers from the Zagreb Airport. A follow-up study showed significant changes in haematological and biochemical parameters, in electrical brain activity and in capillaroscopic and ophthalmological findings in the group of radar operators within the followed period. For that group a cross-sectional study of the differences in general health status also showed the highest rate of changes. The results indicate that long-term occupational exposure to microwaves and radiofrequencies may damage sensitive organic systems.

Ha M, Im H, Lee M, Kim HJ, Kim BC, Gimm YM, Pack JK. Radiofrequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer. *Am J Epidemiol.* 2007 Aug 1;166(3):270-9. Epub 2007 Jun 7.

Leukemia and brain cancer patients under age 15 years, along with controls with respiratory illnesses who were matched to cases on age, sex, and year of diagnosis (1993-1999), were selected from 14 South Korean hospitals using the South Korean Medical Insurance Data System. Diagnoses were confirmed through the South Korean National Cancer Registry. Residential addresses were obtained from medical records. A newly developed prediction program incorporating a geographic information system that was modified by the results of actual measurements was used to estimate radio-frequency radiation (RFR) exposure from 31 amplitude modulation (AM) radio transmitters with a power of 20 kW or more. A total of 1,928 leukemia patients, 956 brain cancer patients, and 3,082 controls were analyzed. Cancer risks were estimated using conditional logistic regression adjusted for residential area, socioeconomic status, and community population density. The odds ratio for all types of leukemia was 2.15 (95% confidence interval (CI): 1.00, 4.67) among children who resided within 2 km of the nearest AM radio transmitter as compared with those resided more than 20 km from it. For total RFR exposure from all transmitters, odds ratios for lymphocytic leukemia were 1.39 (95% CI: 1.04, 1.86) and 1.59 (95% CI: 1.19, 2.11) for children in the second and third quartiles, respectively, versus the lowest quartile. Brain cancer and infantile cancer were not associated with AM RFR.

Hallberg O, Johansson O. Melanoma incidence and frequency modulation (FM) broadcasting. *Arch Environ Health.* 2002 Jan-Feb;57(1):32-40.

The incidence of melanoma has been increasing steadily in many countries since 1960, but the underlying mechanism causing this increase remains elusive. The incidence of melanoma has been linked to the distance to frequency modulation (FM) broadcasting towers. In the current study, the authors sought to determine if there was also a related link on a larger scale for entire countries. Exposure-time-specific incidence was extracted from exposure and incidence data from 4 different countries, and this was compared with reported age-specific incidence of melanoma. Geographic differences in melanoma incidence were compared with the magnitude of this environmental stress. The exposure-time-specific incidence from all 4 countries became almost identical, and they were approximately equal to the reported age-specific incidence of melanoma. A correlation between melanoma incidence and the number of locally receivable FM transmitters was found. The authors concluded that melanoma is associated with exposure to FM broadcasting.

Hocking B, Gordon IR, Grain HL, Hatfield GE, Cancer incidence and mortality and proximity to TV towers. *Med J Aust* 165(11-12):601-605, 1996. (Published erratum appears in *Med J Aust* 166(2):80, 1997.)

We found an association between increased childhood leukaemia incidence and mortality and proximity to TV towers.

Hocking B, Gordon I. Decreased survival for childhood leukemia in proximity to television towers. *Arch Environ Health*. 2003 Sep;58(9):560-4.

There was an association between residential proximity to the television towers and decreased survival among cases of childhood leukemia in North Sydney, Australia.

Hjollund NH, Bonde JP, Skotte J, Semen analysis of personnel operating military radar equipment. *Reprod Toxicol* 11(6):897, 1997.

This is a preliminary survey of semen quality among Danish military personnel operating mobile ground-to-air missile units that use several microwave emitting radar systems. The maximal mean exposure was estimated to be 0.01 mW/cm². The median sperm density of the military personnel was significantly low compared to the references. The difference is either due to chance, uncontrolled bias, or non-thermal effects of transitory microwaves.

Lalić H, Lekić A, Radosević-Stasić B. Comparison of chromosome aberrations in peripheral blood lymphocytes from people occupationally exposed to ionizing and radiofrequency radiation. *Acta Med Okayama*. 2001 Apr;55(2):117-27.

The genotoxic effects of occupational exposure to ionizing and non-ionizing radiation were investigated in 25 physicians and nurses working in hospitals and in 20 individuals working at radio-relay stations. Examination was conducted by chromosome aberration analysis of peripheral blood lymphocytes. The data showed that total number of chromosome aberrations in people exposed to ionizing and radio-frequency radiation (4.08 +/- 0.37 and 4.35 +/- 0.5 on 200 scored metaphases, respectively) were almost equally higher than those of non-irradiated subjects. The increase was in proportion to the number of individuals having more than 5-aberration/200 metaphases. Acentric fragments comprised the most frequently seen type of aberration. The average numbers in examined groups (11.8 x 10⁻³) and 14.8 x 10⁻³) per cell, respectively), were significantly higher than 4.2 x 10⁻³), which was observed in controls, unexposed individuals. Dicentric fragments were also frequent (4.8 x 10⁻³) and 6.25 x 10⁻³), respectively, vs. 0.52 x 10⁻³) in control). In contrast, the frequency of chromatid breaks increased only after ionizing radiation (3.8 x 10⁻³) vs. 0.26 x 10⁻³) in control). A positive correlation between the total number of chromosome aberrations and cumulative 6-years dosage was also found. The data emphasized the dangerous effects of prolonged exposure to both types of radiation and indicated that chromosomal aberration analysis should be obligatory for individuals working at radio-relay stations.

Maskarinec G, Cooper J, Swygert L. Investigation of increased incidence in childhood leukemia near radio towers in Hawaii: preliminary observations. *J Environ Pathol Toxicol Oncol.* 1994;13(1):33-7.

Twelve children from the Waianae Coast, Hawaii, were diagnosed with acute leukemia from 1979 to 1990. The standardized incidence ratio (SIR) of 2.09 (95% confidence interval (CI) 1.08 to 3.65) indicates a significant increase. Seven cases occurred between 1982 and 1984 and were unusual in terms of sex, age, and type of leukemia. A case-control study (12 cases, 48 matched controls) explored risk factors, including parents' occupation, X-ray exposure, domestic smoking, family and medical histories, and distance of children's residence locations to low frequency radio towers. The odds ratio (OR) for having lived within 2.6 miles of the radio towers before diagnosis was 2.0 (95% CI 0.06 to 8.3). The clustering may have been a chance event, but because of its peculiar characteristics, we feel it should be noted.

Michelozzi P, Ancona C, Fusco D, Forastiere F, Perucci CA, Risk of leukemia and residence near a radio transmitter in Italy. *Epidemiology* 9 (Suppl) 354p, 1998.

We conducted a small area study to investigate a cluster of leukemia near a high power radio-transmitter in a peripheral area of Rome. The leukemia mortality within 3.5 km (5,863 inhabitants) was higher than expected (SMR=2.5, 95% confident interval 1.07-4.83); the excess was due to a significant higher mortality among men (7 cases observed, SMR=3.5). The results of the Stone's test, after adjusting for socio-economic confounding, showed a significant decline in risk with distance from the transmitter only among men ($p=0.005$), whereas the p -value for both sexes was $p=0.07$.

Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A, Perucci CA. Adult and childhood leukemia near a high-power radio station in Rome, Italy. *Am J Epidemiol* 155(12):1096-1103, 2002.

Vatican Radio is a very powerful station located in a northern suburb of Rome, Italy. In the 10-km area around the station, with 49,656 residents (in 1991), leukemia mortality among adults (aged >14 years; 40 cases) in 1987-1998 and childhood leukemia incidence (eight cases) in 1987-1999 were evaluated. The risk of childhood leukemia was higher than expected for the distance up to 6 km from the radio station (standardized incidence rate = 2.2, 95% confidence interval: 1.0, 4.1), and there was a significant decline in risk with increasing distance both for male mortality ($p = 0.03$) and for childhood leukemia ($p = 0.036$). The study has limitations because of the small number of cases and the lack of exposure data. Although the study adds evidence of an excess of leukemia in a population living near high-power radio transmitters, no causal implication can be drawn. There is still insufficient scientific knowledge, and new epidemiologic studies are needed to clarify a possible leukemogenic effect of residential exposure to radio frequency radiation.

Michelozzi P, Kirchmayer U, Capon A, Forastiere F, Biggeri A, Barca A, Ancona C, Fusco D, Sperati A, Papini P, Pierangelini A, Rondelli R, Perucci CA. Leukemia mortality and incidence of infantile leukemia near the Vatican Radio Station of Rome.

Some recent epidemiological studies suggest an association between lymphatic and haematopoietic cancers and residential exposure to high frequency electromagnetic fields (100 kHz-300 GHz) generated by radio and television transmitters. Vatican Radio, a very powerful radio station transmitting all over the world (up to 600 kW) is located in Santa Maria di Galeria, in the northern suburbs of the city of Rome. Electric field measurements in the proximity of the radio station ranged between 1.5 and 25 V/m. In the 10 km area around the station, with 60.182 residents (1999), leukaemia mortality among adults (> 14 years, 40 cases) in the period 1987-98 and childhood leukaemia incidence in the period 1987-99 (8 cases) were evaluated. The analysis (Stone's conditional test) was performed computing observed and expected cases (reference: population of Rome) in 5 bands of increasing radius (2 km width). The risk of childhood leukaemia was higher than expected within 6 km from the station (Standardized Incidence Ratio = 217; 95% Confidence Interval 99-405). Stone's test showed a significant decrease in risk with increasing distance both for male adult mortality (p-value = 0.03) and for childhood incidence (p-value = 0.04). A Score test, showed a significant decrease in risk of childhood incidence as function of the distance. The main limitations of this study are the small number of observed cases and the use of distance as a proxy for RF exposure. Further research will require a systematic campaign of electromagnetic field measurements to allow better assessment of the population exposure.

Park SK, HaM, Im H-J. Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. *International Archives of Occupational and Environmental Health* 77(6):387-394, 2004.

We observed higher mortality rates for all cancers and leukemia in some age groups in the area near the AM radio broadcasting towers. Although these findings do not prove a causal link between cancer and RF exposure from AM radio broadcasting towers, it does suggest that further analytical studies on this topic are needed in Korea.

Richter E, Berman T, Ben-Michael E, Laster R, Westin JB. Cancer in radar technicians exposed to radiofrequency/microwave radiation: sentinel episodes. *Int J Occup Environ Health*. 2000 Jul-Sep;6(3):187-93.

Controversy exists concerning the health risks from exposures to radiofrequency/microwave irradiation (RF/MW). The authors report exposure-effect relationships in sentinel patients and their co-workers, who were technicians with high levels of exposure to RF/MW radiation. Information about exposures of patients with sentinel tumors was obtained from interviews, medical records, and technical sources. One patient was a member of a cohort of 25 workers with six tumors. The authors estimated relative risks for cancer in this group and latency periods for a larger group of self-reported individuals. Index patients with melanoma of the eye, testicular cancer, nasopharyngioma, non-Hodgkin's lymphoma, and breast cancer were in the 20-37-year age group. Information about work conditions suggested prolonged exposures to high levels of RF/MW radiation that produced risks for the entire body. Clusters involved many different types of tumors. Latency periods were extremely brief in index patients and a larger self-reported group. The findings suggest that young persons exposed to high levels of RF/MW radiation for long periods in settings where preventive measures were lax were at increased risk for cancer. Very short latency periods suggest high risks from

high-level exposures. Calculations derived from a linear model of dose-response suggest the need to prevent exposures in the range of 10-100 microw/cm(2).

Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N, Jöckel KH. The possible role of radiofrequency radiation in the development of uveal melanoma. *Epidemiology*. 2001 Jan;12(1):7-12.

There are few epidemiologic studies dealing with electromagnetic radiation and uveal melanoma. The majority of these studies are exploratory and are based on job and industry titles only. We conducted a hospital-based and population-based case-control study of uveal melanoma and occupational exposures to different sources of electromagnetic radiation, including radiofrequency radiation. We then pooled these results. We interviewed a total of 118 female and male cases with uveal melanoma and 475 controls matching on sex, age, and study regions. Exposure to radiofrequency-transmitting devices was rated as (a) no radiofrequency radiation exposure, (b) possible exposure to mobile phones, or (c) probable/certain exposure to mobile phones. Exposures were rated independently by two of the authors who did not know case or control status. We used conditional logistic regression to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs). We found an elevated risk for exposure to radiofrequency-transmitting devices (exposure to radio sets, OR = 3.0, 95% CI = 1.4-6.3; probable/certain exposure to mobile phones, OR = 4.2, 95% CI = 1.2-14.5). Other sources of electromagnetic radiation such as high-voltage lines, electrical machines, complex electrical environments, visual display terminals, or radar units were not associated with uveal melanoma. This is the first study describing an association between radiofrequency radiation exposure and uveal melanoma. Several methodologic limitations prevent our results from providing clear evidence on the hypothesized association.

Tynes T, Hannevik M, Andersen A, Vistnes AI, Haldorsen T. Incidence of breast cancer in Norwegian female radio and telegraph operators. *Cancer Causes Control*. 1996 Mar;7(2):197-204.

Exposure to electromagnetic fields may cause breast cancer in women if it increases susceptibility to sex-hormone-related cancer by diminishing the pineal gland's production of melatonin. We have studied breast cancer incidence in female radio and telegraph operators with potential exposure to light at night, radio frequency (405 kHz-25 MHz), and, to some extent, extremely low frequency fields (50 Hz). We linked the Norwegian Telecom cohort of female radio and telegraph operators working at sea to the Cancer Registry of Norway to study incident cases of breast cancer. The cohort consisted of 2,619 women who were certified to work as radio and telegraph operators between 1920 and 1980. Cancer incidence was analyzed on the basis of the standardized incidence ratio (SIR), with the Norwegian female population as the comparison group. The incidence of all cancers was close to unity (SIR = 1.2). An excess risk was seen for breast cancer (SIR = 1.5). Analysis of a nested case-control study within the cohort showed an association between breast cancer in women aged 50+ years and shift work. In a model with adjustment for age, calendar year, and year of first birth, the rate ratio for breast cancer associated with being a radio and telegraph operator--in comparison with all Norwegian women born 1935 or later--analyzed with Poisson regression, was 1.5 after adjustment for fertility factors. These results support a possible association between work as a radio and telegraph operator and breast cancer. Future epidemiologic studies on breast cancer in women aged 50 and over, should address possible disturbances of chronobiological parameters by environmental factors.

Weyandt TB, Schrader SM, Turner TW, Simon SD. Semen analysis of military personnel associated with military duty assignments *Reprod Toxicol*. 1996 Nov-Dec;10(6):521-8.

A collaborative study between the U.S. Army Biomedical Research and Development Laboratory (USABRD) and the National Institute for Occupational Safety and Health (NIOSH) was designed to assess fecundity of male artillery soldiers with potential exposures to airborne lead aerosols. Potential exposure assessment was based upon information provided in an interactive questionnaire. It became apparent from extensive questionnaire data that many soldiers in the initial control population had potentially experienced microwave exposure as radar equipment operators. As a result, a third group of soldiers without potential for lead or microwave exposures, but with similar environmental conditions, was selected as a comparison population. Blood hormone levels and semen analyses were conducted on artillerymen (n = 30), radar equipment operators (n = 20), and the comparison group (n = 31). Analysis of the questionnaire information revealed that concern about fertility problems motivated participation of some soldiers with potential artillery or microwave exposures. Although small study population size and the confounding variable of perceived infertility limit the reliability of the study, several statistically significant findings were identified. Artillerymen who perceived a possible fertility concern demonstrated lower sperm counts/ejaculate (P = 0.067) and lower sperm/mL (P = 0.014) than the comparison group. The group of men with potential microwave exposures demonstrated lower sperm counts/mL (P = 0.009) and sperm/ejaculate (P = 0.027) than the comparison group.

Wolf R, Wolf D. Increased incidence of cancer near a cell-phone transmitter station. *International Journal Cancer Prev*. 2004; 1:123-128.
http://www.stopumts.nl/pdf/studies/wolf_2004.pdf

Relative cancer rates for females were 10.5 for area A, 0.6 for area B and 1 for the whole town of Netanya. Cancer incidence of women in area A was thus significantly higher ($p < 0.0001$) compared with that of area B and the whole city. A comparison of the relative risk revealed that there were 4.15 times more cases in area A than in the entire population. The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Yakymenko I, Sidorik E, Kyrlylenko S, Chekhun V. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. *Exp Oncol*. 2011 Jun; 33(2):62-70.
<http://exp-oncology.com.ua/wp-content/uploads/2011/11/110.pdf?upload=>

In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxy-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells.

We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical

(thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

Epidemiological Studies: Neurological Effects

Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat FEI-Batanouny M, Salem E. Neurobehavioral effects among Inhabitants around mobile phone base stations. *Neurotoxicology*. 2007;28:434-440.

<http://www.iddd.de/umtsno/emfkrebs/EgyptStudy.pdf>

Inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition. So, revision of standard guidelines for public exposure to RER from mobile phone base station antennas and using of NBTB for regular assessment and early detection of biological effects among inhabitants around the stations are recommended.

Abelin et al. Sleep Disturbances in the Vicinity of the Short-Wave Broadcast Transmitter Schwarzenburg. 2005.

http://www.avaate.org/IMG/pdf/som_11_05.pdf

In both surveys, prevalence of difficulties of falling asleep and in particular, maintaining sleep, increased with increasing radio frequency electromagnetic field exposure (RF-EMF). Sleep quality improved after interruption of exposure. A chronic change of melatonin excretion following RF-EMF exposure could not be shown, but a parallel study of salivary samples in cows showed a temporary increase after a short latency period following interruption of exposure.

The series of studies gives strong evidence of a causal relationship between operation of a short-wave radio transmitter and sleep disturbances in the surrounding population, but there is insufficient evidence to distinguish clearly between a biological and a psychological effect.

Altpeter, E. S. et al., 1995. Study on health effects of the shortwave transmitter station of Schwarzenburg, Berne, Switzerland, Study No. 55, Swiss Federal Office of Energy.

Institute for Social and Preventative Medicine. At exposure means of 0.024 and 0.24 $\mu\text{W}/\text{cm}^2$, with lowest exposure of 0.0034 $\mu\text{W}/\text{cm}^2$ and highest of 9.06 $\mu\text{W}/\text{cm}^2$, researchers found significant sleep and concentration disturbance, and general weakness/tiredness. In children there was a slow school promotion rate.

Altpeter et al. 2006. Effect of Short-Wave (6-22 MHz) Magnetic Fields on Sleep Quality and Melatonin Cycle in Humans: The Schwarzenburg Shut-Down Study. *Bioelectromagnetics* 27:142-150. Shut-Down Study. *Bioelectromagnetics* 27:142-150.

Sleep quality improved after transmitter was shut down.

Baste V *et al*, (April 2008) *Radiofrequency electromagnetic fields; male infertility and sex ratio of offspring*, *Eur J Epidemiol*. 2008 Apr 16

Infertility increased significantly along with increasing self-reported exposure to radiofrequency electromagnetic fields. In a logistic regression, odds ratio (OR) for infertility among those who had worked closer than 10 m from high-frequency aerials to a "very high" degree relative to those who reported no work near high-frequency aerials was 1.86 (95% confidence interval (CI): 1.46-2.37), adjusted for age, smoking habits, alcohol consumption and exposure to organic solvents, welding and lead. Similar adjusted OR for those exposed to a "high", "some" and "low" degree were 1.93 (95% CI: 1.55-2.40), 1.52 (95% CI: 1.25-1.84), and 1.39 (95% CI: 1.15-1.68), respectively. In all age groups there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields. However, the degree of exposure to radiofrequency radiation and the number of children were not associated. For self-reported exposure both to high-frequency aerials and communication equipment there were significant linear trends with lower ratio of boys to girls at birth when the father reported a higher degree of radiofrequency electromagnetic exposure.

Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schüz J, Berg-Beckhoff G. Mobile phone base stations and adverse health effects: Phase 1 of a population-based, cross-sectional study in Germany. *Occup Environ Med*. 2009;66:118-123.

A substantial proportion of the German population is concerned about adverse health effects caused by exposure from mobile phone base stations. The observed slightly higher prevalence of health complaints near base stations can not however be fully explained by attributions or concerns.

Bortkiewicz, A., Zmyslony, M., Szyjkowska, A., Gadzicka, E. (2004). Subjective symptoms reported by people living in the vicinity of cellular phone base stations. *Med. Pr.* 55:345-351

The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo

The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

Clark ML, Burch JB, Yost MG, Zhai Y, Bachand AM, Fitzpatrick CT, Ramaprasad J, Cragin LA, Reif JS. Biomonitoring of estrogen and melatonin metabolites among women residing near radio and television broadcasting transmitters.

Among premenopausal women, there were no associations between RF or 60-Hz nonionizing radiation and E1G or 6-OHMS excretion. Among postmenopausal women, increased residential RF exposures, transmitter proximity and visibility, and temporally stable 60-Hz exposures were significantly associated with increased E1G excretion. This association was strongest among postmenopausal women with low overnight 6-OHMS levels.

Divan. Et al. *Cell phone use and behavioural problems in young children*, J Epidemiol Community Health. (2010).

The findings of the previous publication were replicated in this separate group of participants demonstrating that cell phone use was associated with behavioural problems at age 7 years in children, and this association was not limited to early users of the technology. Although weaker in the new dataset, even with further control for an extended set of potential confounders, the associations remained.

Divan HA, Kheifets L, Obel C, Olsen J. Prenatal and postnatal exposure to cell phone use and behavioral problems in children. *Epidemiology*. 2008 Jul;19(4):523-9.

Exposure to cell phones prenatally-and, to a lesser degree, postnatally-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.

Duan L, Shan Y, Yu X. Observations of changes in neurobehavioral functions in workers exposed to high-frequency radiation. *Zhonghua Yu Fang Yi Xue Za Zhi*. 1998 Mar;32(2):109-11.

Four neurobehavioral functions were tested for the workers exposed to high-frequency radiation with Neurobehavioral Core Tests Battery recommended by WHO. Scores for various indicators in exposed workers were significantly lower than those in controls, and correlated to the detection of neurasthenia in the exposed workers, to certain extent.

Eger, H, Manfred, J. Specific Health Symptoms and Cell Phone Radiation in Selbitz (Bavaria, Germany) Evidence of a Dose-Response Relationship. 2010.

http://www.emrpolicy.org/science/research/docs/eger_selbitz_2009.pdf

The mean radiation exposure level of the highest exposure group in Selbitz (1.2 V/m) was substantially higher than that of the study population in the QUEBEB study (1) of the German Mobile Phone Programme (mean value 0,07 V/m). For such symptoms as sleep problems, depressions, cerebral symptoms, joint problems, infections, skin problems, cardiovascular problems as well as disorders of the visual and auditory systems and the gastrointestinal tract, a significant dose-response relationship was observed in relation to objectively determined exposure levels. The impact of microwave radiation on the human nervous system serves as an explanation.

Eskander EF, Estefan SF, Abd-Rabou AA. How does long term exposure to base stations and mobile phones affect human hormone profiles? *Clin Biochem.* 2012 Jan;45(1-2):157-61. Epub 2011 Nov 27.

This study showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels

Goldsmith, J.R. "Epidemiologic evidence relevant to radar (microwave) effects". *Environmental Health Perspectives.* 1997, 105 (Suppl 6):1579-87.

Public and occupational exposures to microwave (RF) are of two main types. The first type of exposures are those connected with military and industrial uses and, to some extent broadcast exposures. It is this type that most of the data cited in this study draw upon. The second type, cellular telephones and their associated broadcast requirements, have raised concerns about current exposures because of their increasingly widespread use. Four types of effects were originally reported in multiple studies: increased spontaneous abortion, shifts in red and white blood cell counts, increased somatic mutation rates in lymphocytes, and increased childhood, testicular, and other cancers. In addition, there is evidence of generalized increased disability rates from a variety of causes in one study and symptoms of sensitivity reactions and lenticular opacity in at least one other. These findings suggest that RF exposures are potentially carcinogenic and have other health effects. Therefore, prudent avoidance of unneeded exposures is recommended as a precautionary measure. Epidemiologic studies of occupational groups such as military users and air traffic controllers should have high priority because their exposures can be reasonably well characterized and the effects reported are suitable for epidemiologic monitoring. Additional community studies are needed.

Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med.* 2006;63:307-313.

http://www.buergerwelle.de/assets/files/base_stations_health_utter_oem_2006.pdf?cultureKey=&q=pdf/base_stations_health_utter_oem_2006.pdf

Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality.

Huber R, Graf T, Cote KA, Wittmann L, Gallmann E, Matter D, Schuderer J, Kuster N, Borbély AA, Achermann P. Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. *Neuroreport.* 2000 Oct 20;11(15):3321-5.

The aim of the study was to investigate whether the electromagnetic field (EMF) emitted by digital radiotelephone handsets affects brain physiology. Healthy, young male subjects were exposed for 30 min to EMF (900 MHz; spatial peak specific absorption rate 1 W/kg) during the waking period preceding sleep. Compared with the control condition with sham exposure, spectral power of the EEG in non-rapid eye movement sleep was increased. The maximum rise occurred in the 9.75-11.25 Hz and 12.5-13.25 Hz band during the initial part of sleep. These changes correspond to those obtained in a previous study where EMF

was intermittently applied during sleep. Unilateral exposure induced no hemispheric asymmetry of EEG power. The present results demonstrate that exposure during waking modifies the EEG during subsequent sleep. Thus the changes of brain function induced by pulsed high-frequency EMF outlast the exposure period.

Huttunen P et al, (March 2009) *FM-radio and TV tower signals can cause spontaneous hand movements near moving RF reflector*, Pathophysiology. 2009 Mar 4

For testing human sensitivity to radio frequency (RF) standing waves a movable reflecting wall was constructed. Radio waves from the radio-TV tower reflected back and formed a standing wave near the reflector. When the reflector was moved, the position of the maximums of the standing waves changed and the electromagnetic intensity changed in the body of the standing test subject. The computer with an AD-converter registered the signals of the hand movement transducer and the RF-meter with 100MHz dipole antennas. A total of 29 adults of different ages were tested. There were 9 persons whose hand movement graphs included features like the RF-meter. Six showed responses that did not correlate with the RF-meter. There were also 14 persons who did not react at all. Sensitive persons seem to react to crossing standing waves of the FM-radio or TV broadcasting signals.

Johnson-Liakouris, A.J. "Radiofrequency (RF) Sickness in the Lilienfeld Study: an effect of modulated microwaves?". Arch. Environ. Health. 1998, 53:236-238.

There is a controversy among professionals regarding whether radiofrequency radiation sickness syndrome is a medical entity. In this study, this controversy was evaluated with a methodology adapted from case studies. The author reviewed U.S. literature, which revealed that research results are sufficiently consistent to warrant further inquiry. A review of statistically significant health effects noted in the Lilienfeld Study provided evidence that the disregarded health conditions match the cluster attributed to the radiofrequency sickness syndrome, thus establishing a possible correlation between health effects and chronic exposure to low-intensity, modulated microwave radiation. The author discusses these health effects relative to (a) exposure parameters recorded at the U.S. Embassy in Moscow and (b) the Soviet 10-microwatt safety standard for the public. Given the evidence, new research-with current knowledge and technology-is proposed.

Kundi M, Hutter HP. Mobile phone base stations - Effects on well being and health. Pathophysiol. 2009;16:123-35.

Studying effects of mobile phone base station signals on health have been discouraged by authoritative bodies like WHO International EMF Project and COST 281. WHO recommended studies around base stations in 2003 but again stated in 2006 that studies on cancer in relation to base station exposure are of low priority. As a result only few investigations of effects of base station exposure on health and wellbeing exist. Cross-sectional investigations of subjective health as a function of distance or measured field strength, despite differences in methods and robustness of study design, found indications for an effect of exposure that is likely independent of concerns and attributions. Experimental studies applying short-term exposure to base station signals gave various results, but there is weak evidence that UMTS and to a lesser degree GSM signals reduce wellbeing in persons that report to be sensitive to such exposures. Two ecological studies of cancer in the vicinity of base stations report both a strong increase of incidence within a radius of 350 and 400m respectively. Due to the limitations inherent in this design no firm conclusions can be drawn, but the results underline the urgent need for a comprehensive investigation of this issue. Animal and in vitro studies are inconclusive to date. An increased incidence of DMBA induced mammary tumors in rats at a SAR of

1.4W/kg in one experiment could not be replicated in a second trial. Indications of oxidative stress after low-level in vivo exposure of rats could not be supported by in vitro studies of human fibroblasts and glioblastoma cells. From available evidence it is impossible to delineate a threshold below which no effect occurs, however, given the fact that studies reporting low exposure were invariably negative it is suggested that power densities around 0.5-1mW/m(2) must be exceeded in order to observe an effect. The meager data base must be extended in the coming years. The difficulties of investigating long-term effects of base station exposure have been exaggerated, considering that base station and handset exposure have almost nothing in common both needs to be studied independently. It cannot be accepted that studying base stations is postponed until there is firm evidence for mobile phones.

Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M, Ahonen M. Epidemiological evidence for a health risk from mobile phone base stations. International Journal of Environmental Health. Int J Occup Environ Health. 2010 Jul-Sep; 16(3):263-7.

http://www.brain-surgery.us/Khurana_et_al_IJOEH-Base_Station_RV.pdf

We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact.

Kolodynski AA, Kolodynska VV, Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia. Sci Total Environ 180(1):87-93, 1996.

This paper presents the results of experiments on school children living in the area of the Skrunda Radio Location Station (RLS) in Latvia. Motor function, memory and attention significantly differed between the exposed and control groups. Children living in front of the RLS had less developed memory and attention, their reaction time was slower and their neuromuscular apparatus endurance was decreased.

Loughran et al Individual differences in the effects of mobile phone exposure on human sleep: rethinking the problem. 2012 <http://www.ncbi.nlm.nih.gov/pubmed/21812009>

These results confirm previous findings of mobile phone-like emissions affecting the EEG during non-REM sleep. Importantly, this low-level effect was also shown to be sensitive to individual variability. Furthermore, this indicates that previous negative results are not strong evidence for a lack of an effect and, given the far-reaching implications of mobile phone research, we may need to rethink the interpretation of results and the manner in which research is conducted in this field.

Oberfeld, G; Navarro, E; Portoles, M; Ceferino, M; Gomez-Perretta, C. The Microwave Syndrome – Further Aspects of a Spanish Study. (published?)

http://www.powerwatch.org.uk/pdfs/20040809_kos.pdf

The adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Navarro EA, Segura J, Portolés M, Gómez-Perretta C. The microwave syndrome: A preliminary study in Spain. *Electromag Biol Med.* 2003; 22:161–169.

http://www.stopumts.nl/pdf/studies/navarro_2003.pdf

A health survey was carried out in Murcia, Spain, in the vicinity of a Cellular Phone Base Station working in DCS-1800 MHz. This survey contained health items related to “microwave sickness” or “RF syndrome.” The microwave power density was measured at the respondents' homes. Statistical analysis showed significant correlation between the declared severity of the symptoms and the measured power density. The separation of respondents into two different exposure groups also showed an increase of the declared severity in the group with the higher exposure.

Santini et al. Symptoms Experienced by People Living in Vicinity of Mobile Phone Base Stations.: Incidences of Distance and Sex. 2002.

A survey study using questionnaire was conducted in 530 people (270 men, 260 women) living or not in vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaints frequencies (CHI-SQUARE test with Yates correction) in relation with distance from base station and sex, show significant ($p < 0.05$) increase as compared to people living > 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, discomfort, etc. 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men ($p < 0.05$) complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual perturbations. This first study on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, minimal distance of people from cellular phone base stations should not be < 300 m.

Santini, R.; Santini, P.; Danze, J.M.; Le Ruz, P.; Seigne, M.: Study of the health of people living in the vicinity of mobile phone base stations: I. Influences of distance and sex; *Pathol Biol* 2002; 50; S. 369 - 373.

A survey study using questionnaire was conducted in 530 people (270 men, 260 women) living or not in vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaints frequencies (CHI-SQUARE test with Yates correction) in relation with distance from base station and sex, show significant ($p < 0.05$) increase as compared to people living > 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, discomfort, etc. 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men ($p < 0.05$) complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual perturbations. This first study on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, minima distance of people from cellular phone base stations should not be < 300 m.

Santini, R., Santini, P., Danze, J.M., Le Ruz, P., Seigne, M. (2003). Symptoms experienced by people in vicinity of base stations: II. Incidences of age, duration of exposure, location of subjects in relation to the antennas and other electromagnetic factors. *Pathol. Biol.* 51:412-415

Our results show significant increase ($p < 0.05$) in relation with age of subjects (elder subjects are more sensitive) and also, that the facing location is the worst position for some symptoms studied, especially for distances till 100 m from base stations. No significant difference is observed in the frequency of symptoms related to the duration of exposure (from < 1 year to > 5 years), excepted for irritability significantly increased after > 5 years.

Thomas S, Heinrich S, von Kries R, Radon K. Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents. *Eur J Epidemiol.* 2010 Feb;25(2):135-41. Epub 2009 Dec 4. <http://www.ncbi.nlm.nih.gov/pubmed/19960235>

Seven percent of the children and 5% of the adolescents showed an abnormal mental behaviour. In the multiple logistic regression analyses measured exposure to RF fields in the highest quartile was associated to overall behavioural problems for adolescents (OR 2.2; 95% CI 1.1-4.5) but not for children (1.3; 0.7-2.6). These results are mainly driven by one subscale, as the results showed an association between exposure and conduct problems for adolescents (3.7; 1.6-8.4) and children (2.9; 1.4-5.9). As this is one of the first studies that investigated an association between exposure to mobile telecommunication networks and mental health behaviour more studies using personal dosimetry are warranted to confirm these findings.

Zwamborn APM, Vossen SHJA, van Leersum BJAM, Ouwens MA, Makel WN. Effects of global communication system radiofrequency fields on well being and cognitive functions of human subjects with and without subjective complaints. Organization for Applied Scientific Research (TNO), Physics and Electronics Laboratory: The Hague, Netherlands, 2003.

Found significant effects on well-being, according to a number of internationally recognized criteria (including headaches, muscle fatigue/pain, dizziness etc) from 3G mast emissions well below 'safety' levels (less than $1/25,000^{\text{th}}$ of ICNIRP guidelines)