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EPRI Comments on the BioInitiative 2012 Report

Executive Summary

- BioInitiative 2012 has been issued as a follow-up to the BioInitiative Working Group's (BWG) 2007 report (updated in 2010). It consists of individual chapters on electromagnetic field effects on various health outcomes and summary chapters written primarily by Ms. Cindy Sage, who was the principal organizer of this effort; much of the nearly 1,500-page 2012 BWG report includes the 2007 BWG report. It concludes that exposures of people to electromagnetic fields from power frequency through radiofrequency (RF) produce a variety of adverse health effects ranging from neurological, genetic and immune outcomes to cancer.
- The report calls for exposure limits of 1 milligauss (mG) for power frequencies (50-60 Hz) and 0.3 nanowatts per square centimeter (nW/cm^2) for RF. These are factors of 2,000 and 9,000 below the limits recommended, respectively, by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute for Electrical and Electronic Engineers (IEEE) for power frequencies, and, for RF, are (depending on frequency) at least 667,000 times lower than the limits recommended by ICNIRP, IEEE, and the Federal Communications Commission (FCC).
- An EPRI Comments document (EPRI 1016233) following the 2007 BWG report indicated that (1) its content referenced only selective portions of the scientific literature on health effects associated with electromagnetic fields, rather than focusing on the full weight of evidence; and (2) the BWG report's conclusions were inconsistent with those of many expert scientific panels constituted by government and health agencies. Collectively, these agencies had concluded that the research data were either too limited or insufficient to recommend limits below those specified by guideline-setting organizations such as ICNIRP and IEEE. The latter limits are based on established mechanisms, namely electrostimulation from power frequency exposures and tissue heating from RF exposures.
- The same general points from the 2007 EPRI Comments apply to the 2012 BWG report. Expert scientific panels have continued to monitor the literature in the intervening years, with the preponderance concluding that evidence supporting health effects from low-level electromagnetic fields across the spectrum from 0 Hertz (Hz) to 300 gigahertz (300 billion Hz) remains limited in some cases and insufficient to inadequate in most.
- Not only are the BWG's recommendations for exposure limits many times lower than currently published guidelines by ICNIRP and IEEE, but they do not mention the fact that EMF is ubiquitous in our environment and the levels recommended are often much lower than virtually all the fields present in every inhabited space in modern society for over the past half century or more.
- If RF from cellular phones was a true significant risk factor for brain cancer, then given the widespread use of cell phones, corresponding shifts in population-wide brain cancer incidence trends would be anticipated for most analyses conducted to date. However, most analyses conducted thus far report no apparent trends suggestive of risk.

Background

In 2007, the BioInitiative Working Group (BWG) issued a report that evaluated the research literature concerned with potential health effects from exposure to electromagnetic (EM) fields from power frequency (50-60 Hertz, Hz) electric and magnetic fields (EMF) to radiofrequency (RF) fields. The report entitled, "BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)," implicated EM fields from across the non-ionizing spectrum as posing excess risks for a variety of health outcomes, and called for a significant reduction in exposure limits, such as those published by International Commission on Non-Ionizing Radiation Protection (ICNIRP, 0 to 300 Gigahertz, GHz),[1,2] the Institute for Electrical and Electronic Engineers (IEEE, 0 to 300 GHz),[3,4] and the Federal Communications Commission (FCC, 0.3 to 100,000 Megahertz, MHz).[5] These limits aim to protect individuals

against all scientifically established adverse effects, which include electrostimulation (stimulation of nerve tissue) at frequencies up to 100,000 Hz (100 kHz, ICNIRP and IEEE), and against excessive tissue heating for all higher RF frequencies (ICNIRP, IEEE and FCC).

EPRI posted a commentary [6] shortly after the BWG 2007 report was released (EPRI 1016233 at www.epri.com) that indicated, among other points, that the report's authors were selective in the literature reviewed failing to account for the full weight of scientific evidence, and that the BWG's conclusions were at significant variance with other major reviews by expert scientific panels commissioned by government and health agencies in the U.S. and abroad.

The BWG recently posted BioInitiative 2012[1], an update to the previous report (an update had also been posted in 2010). The report is nearly 1,500 pages in length and includes the 2007 report with several chapters updated and/or added from an expanded group of authors. Like its predecessor, the report implicated exposures across the spectrum as causal factors in numerous health outcomes with a call for lower exposure standards. An illustrative passage states:

> Several thousand scientific studies over four decades point to serious biological effects and health harm from EMF and RFR [radiofrequency radiation]. These studies report genotoxicity, single- and double-strand DNA damage, chromatin condensation, loss of DNA repair capacity in human stem cells, reduction in free-radical scavengers (particularly melatonin), abnormal gene transcription, neurotoxicity, carcinogenicity, damage to sperm morphology and function, effects on behavior, and effects on brain development in the fetus of human mothers that use cell phones during pregnancy. Cell phone exposure has been linked to altered fetal brain development and ADHD-like behavior in the offspring of pregnant mice.

The report recommended an exposure limit of 1 milligauss (mG) at power frequency, the same value as in 2007, and 0.3 nanowatts per square centimeter (nW/cm^2) for RF, a 333-fold reduction from the 2007 recommendation of 0.1 microwatts per square centimeter (μW/cm^2). The power frequency recommendation is a factor of 2,000 and 9,000 lower, respectively, than the ICNIRP and IEEE limits. For RF, ICNIRP, IEEE and FCC limits are frequency dependent, with all three organizations specifying a minimum exposure limit for the general public of 0.2 milliwatts per square centimeter (mW/cm^2).[2] Thus, the BWG recommendation for RF exposure is at least 667,000 times lower than the existing limits.

The comments that follow focus on (1) evaluations of power frequency and RF fields conducted by other organizations in the intervening five years, and (2) the practical implications of BWG's recommendations for exposure limits to our society's infrastructure.

Evaluations by other organizations

The five-year period between the two BWG postings saw a greater amount of attention paid to RF research in comparison to power frequency studies. To briefly recap the preceding period, in 2002 the International Agency for Research on Cancer (IARC) - the organization within World Health Organization (WHO) that assesses cancer risks from environmental agents – classified power frequency magnetic fields in Group 2B or *Possibly carcinogenic to humans*, a determination based on "limited" epidemiologic evidence and inadequate evidence from animal studies. [7] The epidemiologic evidence was based specifically on a positive association of childhood leukemia with magnetic fields, despite the lack of confirmatory evidence from rodent bioassays and the absence of a biophysical mechanism to explain interactions of the fields with tissue. Power frequency electric fields, on the other hand, were classified in Group 3, *Not classifiable as to its carcinogenicity to humans*, based on inadequate epidemiologic and animal evidence. Appendix I briefly describes IARC's classification system.

World Health Organization (WHO)

In 2007, WHO reviewed the scientific evidence concerned with potential risk from power frequency fields for all health outcomes. [8] The resulting Environmental Health Criteria report sustained IARC's determination based on childhood leukemia concluding:

> A number of other diseases [aside from childhood leukemia] have been investigated for possible association with ELF magnetic field exposure. These

[1] BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at www.bioinitiative.org, December 31, 2012.

[2] ICNIRP's minimum value spans 10 MHz to 400 MHz, IEEE from 30 to 400 MHz, and FCC from 30 MHz to 300 MHz.

include cancers in both children and adults, depression, suicide, reproductive dysfunction, developmental disorders, immunological modifications and neurological disease. The scientific evidence supporting a linkage between ELF magnetic fields and any of these diseases is much weaker than for childhood leukaemia and in some cases (for example, for cardiovascular disease or breast cancer) the evidence is sufficient to give confidence that magnetic fields do not cause the disease.

International Agency for Research on Cancer (IARC)

In May 2011, scientists from 14 countries formed an IARC "Working Group" to review the scientific evidence concerning the potential carcinogenicity of exposure to RF fields.[9] Much of the epidemiologic and animal studies available for review dealt with RF exposures from cell phones and their potential link with brain cancer. In the final evaluation, the Working Group did not find any convincing evidence that RF could cause cancer in humans. For most cancer types, the group found that the epidemiologic evidence was inadequate, but identified uncertainties with respect to two types of brain tumor potentially related to cell phones. Also, though almost all of the 40 whole animal studies reviewed reported no effect of RF on cancer, the group identified uncertainties based on a small number of studies. Consequently, the evidence for both the epidemiologic and whole animal literature was classified as "limited", leading to an overall classification of RF in Group 2B or *Possibly carcinogenic to humans*.

For both the IARC classification of power frequency magnetic fields and RF fields the Group 2B designation can be interpreted to reflect the IARC's panels' conclusions that, despite the weight of evidence against classifying these exposures as human carcinogens or probable human carcinogens, uncertainties remain.

German Commission on Radiological Protection (SSK)

To address the possible ambiguities in interpreting IARC's classifications, the German Commission on Radiological Protection (SSK) adopted an alternative classification methodology to address the strength of scientific evidence and data quality when the latter are determined to be inadequate.[10,11] The evidence classifications and their correspondence to IARC classifications together with the data quality classifications are shown in Appendix II. The SSK applied this scheme across the electromagnetic spectrum from static fields to ionizing radiation. SSK assigned an E1 classification (weak evidence) to low-frequency magnetic fields (>0 Hz to 30 kHz) for childhood leukemia, consistent with IARC, and all other cancers in children and adults were classified E0 (lack of or insufficient evidence). The SSK stated, "Epidemiological studies offer incomplete evidence for a link between exposure to ELF [extremely low frequency] magnetic fields and the risk of developing childhood leukaemia, but this is not supported by action models or other investigative approaches." Low-frequency electric fields were classified E0 for all cancers.

The SSK divided broadcast and telecommunications into two frequency ranges, "radio-frequency electromagnetic waves" (30 kHz to 300 MHz) and "microwaves" (300 MHz to 300 GHz). SSK assigned E0 to microwaves stating, "The assessment of the evidence for a link between exposure to microwaves and cancer is based primarily on studies on radio frequency radiation from mobile telephony. Also including multinational studies, there is still no evidence for any link between mobile phone use and cancer." This classification, which was inconsistent with IARC's conclusion nonetheless accounted for the Interphone study, which the IARC evaluation used as evidence supporting its 2B classification. Radio-frequency electromagnetic waves were also classified E0 by SSK stating, "Overall, there is no evidence for a link between RF electromagnetic waves and cancer (including leukaemia)." SSK also found no basis for carcinogenesis across both frequency ranges (i.e., 30 kHz to 300 GHz) based on animal studies and biophysical and biological mechanisms.

Health Protection Agency (HPA)

In 2012, the Advisory Group on Non-ionising Radiation – a multidisciplinary expert group of scientists - updated its previous report from 2003 producing an extensive, detailed report for HPA on RF health effects, considering all health outcomes.[12,13] The executive summary in the report offered the following conclusion:

> The quantity, and in general quality, of research published on the potential health effects of RF field exposure has increased substantially since AGNIR last reviewed this subject. Population exposure to RF fields has become more widespread and heterogeneous. There are still limitations to the published research that preclude a definitive judgement, but the evidence considered overall has not demonstrated any adverse health effects of RF

field exposure below internationally accepted guideline levels. There are possible effects on EEG patterns, but these have not been conclusively established, and it is unclear whether such effects would have any health consequences. There is increasing evidence that RF field exposure below guideline levels does not cause symptoms and cannot be detected by people, even by those who consider themselves sensitive to RF fields. The limited available data on other non-cancer outcomes show no effects of RF field exposure. The accumulating evidence on cancer risks, notably in relation to mobile phone use, is not definitive, but overall is increasingly in the direction of no material effect of exposure. There are few data, however, on risks beyond 15 years from first exposure.

In summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN)

The European Commission funded EFHRAN with the "specific aim of establishing a wide-ranging network of recognised experts in relevant disciplines that interact and cooperate to perform a health risk assessment of exposure to EMF across the frequency spectrum."[14] EFHRAN released a report in 2012 that reviewed a full range of health outcomes across the spectrum. The group published a chart, reproduced in Figure 1, summarizing their conclusions. EFHRAN's two instances of "limited evidence" (orange, low frequency and childhood leukemia; high frequency and adult brain tumors) are essentially aligned, respectively, with IARC's 2002 (power frequency) and 2011 (RF) classifications. For low frequencies (<300 Hz), EFHRAN states for outcomes shown in Figure 1 aside from childhood leukemia that:

> There is inadequate evidence for Alzheimer's disease, childhood brain tumours, and amyotrophic lateral sclerosis…further studies on these outcomes would be useful. For all other cancers, other neurodegenerative diseases and for non-specific symptoms, evidence is also inadequate, but there appears to be no justification to conduct further studies. There is evidence suggesting a lack of effect for breast cancer, cardiovascular disease and for EHS [electromagnetic hypersensitivity].

For intermediate frequencies (300 Hz – 100 kHz), all evidence is considered "inadequate," but EFHRAN points out concerns "for pregnant shop assistants to work throughout the day in close proximity to anti-theft devices." For high frequencies (100 kHz – 300 GHz), the group states for the outcomes listed in the figure aside from adult brain tumors: "For none of these diseases is there sufficient evidence for a causal association between exposure and the risk of the disease, and this includes all childhood cancers."

Swedish Council for Working Life and Social Research

In 2012, the Swedish Council for Working Life and Social Research released a report updating ten years of RF health research with a focus on electromagnetic hypersensitivity (EHS) and brain cancer.[15] With respect to EHS, the authors stated, "Despite considerable research efforts during the last 10 years, no association between radiofrequency fields and wellbeing has been established. Radiofrequency fields have not been shown to trigger symptoms in subjects who perceive themselves as hypersensitive to RF fields and this group has not displayed any better ability to detect exposure to electromagnetic fields than reference groups that do not report this type of sensitivity." With respect to brain tumors, they stated, "The majority of epidemiological studies have found no evidence that mobile phone use is associated with an increased risk of glioma, meningioma, acoustic neuroma or other tumors. The few increased risk estimates observed were found in studies prone to recall bias, and the magnitude of the reported risk increases are such that they would definitely have resulted in a detectable increase in the brain tumor incidence rates if they were real." The report concludes that, "Extensive research for more than a decade has not detected anything new regarding interaction mechanisms between radiofrequency fields and the human body and has found no evidence for health risks below current exposure guidelines [i.e, exposure limits set by ICNIRP and IEEE]."

Practical Considerations with Respect to BWG 2012 Recommendations

BWG's recommendations for exposure limits – 1 mG for power frequency and 0.3 nW/cm2 for RF – are based on their conclusions that thresholds for adverse health effects from EMF exposures are within the range of power-frequency and RF fields that have been encountered on a routine, if not constant, basis in modern society for 75 years

or more. This section of the commentary presents a quantitative perspective comparing the BWG recommendations to levels of power-frequency and RF fields in our ambient environments.

Using data from EPRI's "1,000-Home Study"[16] and "Long-Term Wire Code" (LTWC)[17] and the "1,000-Person Study" (under US federal RAPID Program),[18] one can acquire a perspective on how often ambient residential magnetic fields and exposures to such fields exceed 1 mG. The 1,000-Home Study was a study of residential magnetic field sources conducted in nearly 1,000 (actually 996) residences from 25 electric utility service regions across the United States. In 22.8% of the residences, a half or more of the rooms measured had spot measurements greater than 1 mG. In the LTWC study, which included personal exposures within residences, residents of 218 homes in eight US geographic regions were sampled, each up to four times over an approximate 18 month period for each residence. For half the population 1 mG was exceeded in 28.6% of the measurements, and for one-quarter of the population 1 mG was exceeded in 63.8% of the measurements. In the 1,000-Person Study, which included measurements in and away from the residence (e.g., work, travel), 43.6% of the population was reported with 24-hour average exposures above 1 mG. Thus, it is quite clear that low-level magnetic fields are a constituent common to virtually all environments people inhabit. In fact, in the epidemiologic pooled analyses that were the major influences to IARC's classification of power frequency magnetic fields as a Group 2B carcinogen (and a follow-up analysis[19]),[20,21] 1 mG defined the upper limit of the exposure in the reference group to which all other groups of children with higher exposures were compared.

A final note with regard to low frequencies (0 to 100 kHz) was ICNIRP's decision in 2010 to increase the magnetic field limits for both occupational groups and the general public.[2] Previously the general public limit was 1 gauss at 50 Hz and 833 mG (0.833 G) at 60 Hz.[1] The new ICNIRP guideline calls for an increase to 2 Gauss across that frequency range, with the aim of protecting people against electrostimulation, as indicated in the Background section above. With respect to potential health effects at lower levels, ICNIRP stated, "The epidemiological and biological data concerning chronic conditions were carefully reviewed and it was concluded that there is no compelling evidence that they are causally related to low-frequency EMF exposure."

Turning to BWG's recommendation for RF, it is instructive to examine the fields from broadcast sources that have existed for 75 years or more. In 1980, Tell and Mantiply, then at the US Environmental Protection Agency, conducted an exhaustive evaluation of ambient RF in 15 metropolitan areas.[22] Figure 2, which breaks down the data from the study in terms of sources, reveals that FM broadcast was the dominant source of ambient fields. The median exposure across all sites was 4.8 nW/cm^2, and it was estimated that about 80% of the population experienced ambient fields above 2 nW/cm^2. A recent EPRI survey of four metro areas, all smaller than those in the 1980 study, indicates that fields from FM sources are on the same order of magnitude as they were over 30 years ago.[23] Another important factor for focusing on FM is that RF fields within the FM frequency range (88 – 108 MHz) couple more strongly to the human body compared to fields in other frequency bands in the RF spectrum. With regard to the wideband RF spectrum in general, several studies in Europe have measured exposure levels in both indoor and outdoor environments.[16] The results indicated that exposure levels were in the range of 10 to 100 nW/cm^2, on the order of 30 to 300 times the BWG recommendation. BWG's recommendation for RF exposure is below, often well below, the levels present continuously in our environments both now and in the past. The BWG is thus indicating that virtually every venue of human activity has power frequency and RF fields that are above its recommended exposure limits by a wide margin. However, as indicated in the previous section, this position is not held by expert scientific panels that have been convened by government and international health agencies. Rather, the panels have indicated that the available science justifies the exposure limits published by ICNIRP, IEEE and the FCC.

Discussion

The summary chapters and recommendations of the BWG 2012 report were written primarily by one of its two signatories, Ms. Cindy Sage, who has had a long-term involvement with the EMF issue. Ms. Sage suggests that the proliferation of electromagnetic field sources related to both the electric power system and telecommunications would be accompanied by, "[c]hronic exposure to low-intensity RFR [radiofrequency radiation] and to ELF-modulated RFR at today's environmental levels in many cities will exceed thresholds for increased risk of many diseases and causes of death…… [e]xposures now common in home and school environments are likely to be physiologically addictive and the effects are particularly

serious in the young." These and other statements such as - "Windows of critical development mean that risk factors once laid down in the cells, or in epigenetic changes in the genome may have grave and life-long consequences for health or illness for every individual" - seem to imply that EMF/RF impacts would manifest in overall population morbidity (disease incidence) and mortality (death).

Several analyses have, in fact, already addressed whether the expansion of telecommunications technology has been accompanied by an increased incidence of brain cancer, and whether increased risks reported in some epidemiology studies are consistent with population statistics of brain cancer incidence (brain cancer, as described, has been the health outcome of greatest interest with respect to RF). Inskip et al. of the U.S. National Cancer Institute (NCI) tracked temporal trends of brain cancer against mobile phone subscriptions in the U.S., which at the time had risen to about 225 million. They reported no relationship of rising phone subscriptions with brain cancer, whose incidence remained essentially flat.[24] In a follow-up analysis by NCI investigators, Little et al.[25] compared the observed rates of glioma incidence recorded in the U.S. from 1997 to 2008 to what one would project the rates should have been under an assumption that the relative risks for glioma associated with cell phone use reported in two studies[26,27] were, in fact, valid estimates of risk. They concluded, "Raised risks of glioma with mobile phone use, as reported by one (Swedish) study forming the basis of the IARC's re-evaluation of mobile phone exposure, are not consistent with observed incidence trends in US population data, although the US data could be consistent with the modest excess risks in the Interphone study." The latter qualification is based on the fact that, given the period of time in which cell phones have been in widespread use, the observation period is not sufficiently long to account for the full brain cancer latency period, which may be 20 years or more.

Along a similar line of thinking, a group of European investigators representing Denmark, Finland, Norway, and Sweden, as well as IARC published a study in 2012 that addressed whether the results of studies reporting increased brain cancer risks associated with mobile phone use were consistent with temporal trends in brain cancer incidence in the four countries represented.[28] These investigators concluded, "Our simulations show that many increased or decreased risks reported in case-control studies are implausible, implying that biases and errors in the self-reported use of mobile phone have likely distorted the findings." In other words, if the risks associated with mobile phone use reported in some studies were true,[27,29] given the extensive penetration of cell phones into the population, the effect would have shown itself in overall rates of brain cancer; however, this has not been the case.

In a recent meta-analysis, Lehrer et al.[30] reported a positive correlation of brain cancer and cell phone subscription rates across 19 states within the U.S. However, little detail is available in this brief paper and interpretation would require a broader investigation. In another meta-analysis, de Vocht et al.[31] collected brain cancer incidence data from 2008 and population statistics on numerous environmental risk factors from 165 countries, reporting a higher incidence of brain cancer associated with number of mobile/cellular telecommunications subscriptions for each country. However, the effort was disadvantaged by the fact that, "…in 2006 only about 21% of the world population was actually covered by population-based cancer registries, and only about 8% of the world population by 'good quality' registries." Further, the analyses indicated, "…a relatively small risk, explaining only about 1% of the variation in incidence rates between countries…" Finally, the authors cautioned that ecological studies such as this one "should not be used to infer causality." Neither of these two meta-analyses attempted to reconcile population statistics with the data from epidemiology studies that had reported risks associated with cell phones, as described above. In fact, the first author (de Vocht) of the study just described had conducted such an exercise for mobile phone use from 1985 to 2003 and brain cancer incidence from 1998 to 2007 in England.[32] That study concluded, "…the increased and widespread use of mobile phones…has not led to a noticeable increase in the incidence of brain cancer in England between 1998 and 2007. Therefore, it is very unlikely that we are 'at the forefront of a cancer epidemic' related to mobile phone use."

Though analyses of these sorts do not answer questions at a detailed level, and are not usually considered definitive, they help to define whether a widespread technology is affecting the overall health of a population.

Additionally, it is appropriate to mention that the wealth of research to date has not identified and verified a mechanism of action for both power frequency and RF fields below those currently published by ICNIRP, IEEE and FCC. The Scientific Committee on Emerging and Newly

Identified Health Risks (SCENIHR) composed of expert scientists charged with reviewing electromagnetic field health effects for the European Commission, concluded in 2009 that:[33]

> At sufficiently high intensities, RF fields cause biological effects by tissue heating, while ELF fields excite nerve and muscle cells [i.e., electrostimulation]. However, despite several decades of research into biological effects of EMF, there are still no generally accepted biological effects or interaction mechanisms that would explain human health effects below the thresholds for thermal effects and nerve stimulation. Hypothesis-driven research on plausible mechanisms is necessary for major progress in evaluation of possible health risks of weak EMF.

In 2012, Dr. Luc Verschaeve of the University of Antwerp in Belgium published a book chapter entitled, "Evaluations of International Expert Group Reports on the Biological Effects of Radiofrequency Fields" in which 33 evaluations of RF health science were reviewed for content and quality.[34] He concluded,

> "…the vast majority of the reports do not consider that radiofrequency fields at current exposure levels (especially from mobile phone base-station antennas and handsets) pose a serious health risk to humans. The only exception comes from the Bioinitiative report. All reports, except the Bionitiative report, conclude that there is so far no clear indication of adverse health effects from RF-exposure from applications for wireless communication purposes. They usually remain prudent with regard to long-term bio-effects, not because of strong indications that such effects might occur, but only because there are so far not enough data available to draw a sound conclusion."

Thus, the BWG's conclusions, as discussed in the commentary presented here and as represented by the Verschaeve review cited above, are inconsistent with the opinions of expert scientific panels that have reviewed the science concerned with potential health risks from electromagnetic fields across the spectrum from power frequency to RF. In addition, the BWG recommendations for exposure limits have not been supported by the full weight of scientific evidence, and fail to account for the presence of electric power and telecommunication infrastructure that has serviced modern societies for the past century.

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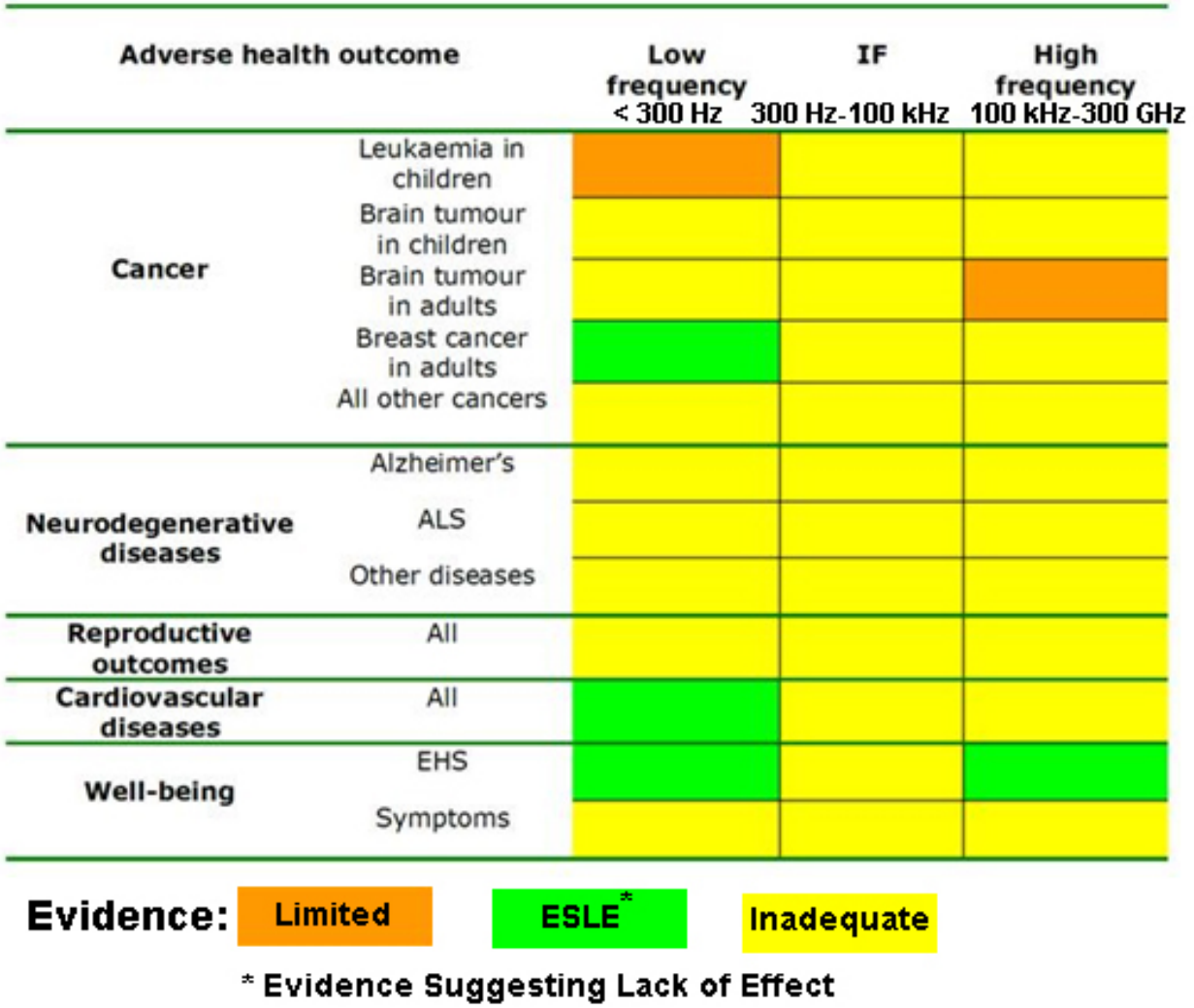

Figure 1
EFHRAN 2012 Summary

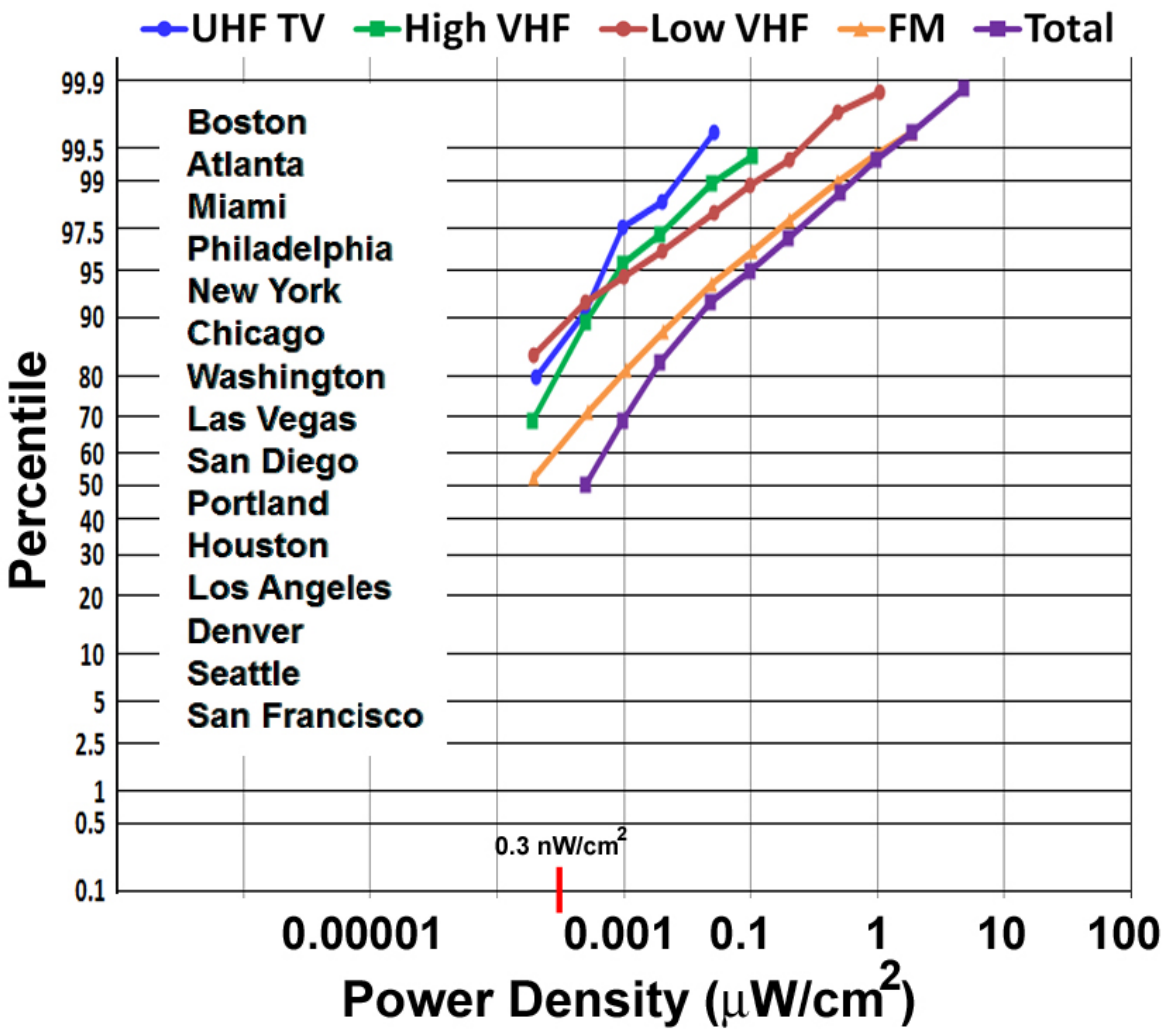

Figure 2
Environmental RF Fields (Adapted from: Tell & Mantiply, 1980)

Appendix I: IARC Classification Scheme

The International Agency for Research on Cancer or IARC was established in 1965 in Lyon France as a part of the World Health Organization to "…provide governments with expert, independent, scientific opinion on environmental carcinogenesis." To date, IARC has issued carcinogen classifications for nearly one thousand exposures. The classifications are given group numbers, as shown in Appendix I, Table 1.

Table 1
IARC Classifications

Group	Conclusion
1	Carcinogenic to humans • Sufficient epidemiologic evidence • Evidence from animal studies can be inadequate
2A	Probably carcinogenic to humans • Sufficient evidence from animal studies • Epidemiologic evidence can be limited
2B	Possibly carcinogenic to humans • Limited epidemiologic evidence • Evidence from animal studies can be limited or inadequate
3	Not classifiable as to its carcinogenicity to humans • Inadequate epidemiologic evidence • Inadequate evidence from animal studies
4	Probably not carcinogenic to humans • Evidence suggesting lack of carcinogenicity in humans and experimental animals

Table 2
Examples of IARC Classifications

Group 1, Carcinogenic to Humans (107)	Group 2B, Possible Carcinogen (267)
Asbestos	Chloroform
Benzo[a]pyrene (upgraded from 2A)	DDT
1,3-Butadiene (rubber industry)	**ELF magnetic fields**
Estrogen	Engine exhaust, gasoline
Hepatitis B virus	Pickled vegetables
X- and Gamma Radiation	**RF electromagnetic fields**
Group 2A, Probable Carcinogen (59)	**Group 3, Not Classifiable (508)**
Cisplatin (chemotherapy agent) (upgraded from 2B)	Ampicillin
Engine exhaust, diesel	Caffeine
Occupation as hairdresser or barber	Diazepam (Valium)
5-Methoxypsoralen (in sunscreen) (upgraded from 2B)	**ELF Electric fields**
Shiftwork that involves circadian disruption	Polystyrene (used in plastics)
Tetrachloroethylene (dry cleaning fluid)	Saccharin (downgraded from 2B)
Group 4, Probably Not Carcinogenic (1)	
Caprolactam	

Appendix II: German Commission on Radiological Protection Classification Scheme

SSK classification		IARC classification	
E3	Convincing evidence (scientific proof)	1	Carcinogenic to humans
E2	Incomplete evidence (justified scientific suspicion)	2A	Probably carcinogenic to humans
E1	Weak evidence (scientific indication)	2B	Possibly carcinogenic to humans
E0	Lack of or insufficient evidence for causality/non-causality	4	Probably not carcinogenic to humans
EN	Evidence for non-causality		
D2	Inconsistent data	3	Not classifiable
D1	Unreliable data		
D0	Lack of or insufficient data		

Source: SSK, 2011

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