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February 4, 2013

I have researched the health effects of electromagnetic radiation (EMR) since mid-2008. Since October 2009, after the publication of a quantitative review of the literature on mobile phone use and tumor risk by my colleagues and myself in the *Journal of Clinical Oncology* (Myung et al, 2009a), I have translated the research and its implications for public health policy for journalists, policy makers, and the general public.

I would like to enter into the record the contents of my **Electromagnetic Radiation Safety** web site, <http://saferemr.blogspot.com>, which contains important commentary, news releases, and media coverage about this issue.

Also see my comments (attached) on the recent GAO Report, "*Exposure and Testing Requirements for Mobile Phones Should Be Reassessed.*" I prepared these remarks at the request of legislative staff for Representatives Waxman, Markey, and Eshoo, the three members of Congress who requested this report from the GAO.

In my professional opinion, the FCC should request the EPA to empanel a Working Group composed of health experts who have no conflicts of interest with industry to review the scientific literature on EMR. The Group should recommend biologically-based EMR standards that ensure adequate protection for the general public and occupational health based upon the precautionary principle. Finally, the FCC should adopt the standards, testing procedures, and appropriate precautionary warning language recommended by the Working Group.

The FCC should not take any actions that may increase exposure of the population to EMR from cell phones, base stations, Wi-Fi, Smart Meters and other RF- or ELF-emitting devices. The FCC must especially protect vulnerable groups in the population including children and teenagers, pregnant women, men of reproductive age, individuals with compromised immune systems, seniors, and workers.

Sincerely,

A handwritten signature in black ink that reads "Joel M. Moskowitz".

Joel M. Moskowitz, Ph.D.

**Comments on the 2012 GAO Report:
“Exposure and Testing Requirements for Mobile Phones Should Be Reassessed”**

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August 15, 2012 (Aug. 24 revision)

U.S. General Accountability Office (GAO). *Exposure and Testing Requirements for Mobile Phones Should Be Reassessed*. GAO-12-771. Washington, DC: General Accountability Office. <http://www.gao.gov/products/GAO-12-771> (accessed August 7, 2012)

Overview and General Comments

The GAO Report selectively reviewed scientific literature that supports the FCC’s claim that cell phones which comply with the federal standards are safe. The GAO did not consider the methodologic limitations of this research or the alternative interpretations of the results from these studies. The GAO Report did not review the scientific evidence that strongly suggests the FCC standards which control only for thermal effects do not adequately protect the public from harm due to non-thermal effects of long-term exposure to cell phone radiation.

Although we do not have conclusive proof that cell phone radiation is harmful to humans, the FCC certainly cannot prove its claim that cell phones that comply with current federal standards are safe. The claim relies on many assumptions about the science. A critical review of the science—as opposed to simply “weighting the evidence”—reveals that these assumptions have dubious validity.

Evidence of harm from cell phone radiation

The opening statement of the GAO Report is factually incorrect:

"Scientific research has not demonstrated adverse human health effects of exposure to radio-frequency (RF) energy from mobile phone use, but research is ongoing that may increase understanding of any possible effects." (GAO Report, p. 1)

Numerous studies have demonstrated adverse health effects on humans associated with mobile phone use. Case-control research has found evidence for brain tumors (i.e., glioma, meningioma, and acoustic neuroma), and tumors of the parotid gland (Myung et al. 2009; Khurana et al., 2009). Considerable evidence exists for sperm damage caused by exposure to cell phone radiation, and increased male infertility associated with cell phone use (La Vignera et al, 2012). Preliminary evidence exists for reproductive health effects in children following *in utero* exposure to mobile phone radiation (Divan et al., 2008, 2012).

Many researchers with conflicts of interest reject this peer-reviewed research. They even dismiss their own data when the results provide evidence of adverse effects on human health. These researchers often argue that the trends in brain tumor incidence over time have been flat therefore the evidence of harm in these studies must be artifactual. However, many countries are witnessing increased incidence of specific tumors in population subgroups, if not in the overall population, associated with increased exposure over time to microwave radiation from cordless phones in addition to cell phones.

Alternatively, researchers with conflicts of interest typically argue there is no possible biologic mechanism; thus, the adverse health effects observed in their data should be dismissed. This ignores the fact that science commonly discovers causal effects before underlying mechanisms are understood. Nonetheless, numerous experimental studies have demonstrated potential mechanisms in animal models and cellular studies caused by acute, non-thermal exposures to microwave radiation. The evidence includes penetration of the blood-brain barrier, generation of free radicals and heat shock proteins, single- and double-strand DNA damage, as well as sperm damage. Multiple peer-reviewed laboratory studies demonstrate each of these adverse effects (e.g.,

Behari, 2010). Recently, Volkow et al. (2011) demonstrated increased glucose metabolism in human brains after a brief (non-thermal) exposure to cell phone radiation.

The little research conducted on children and pregnant women suggests these two populations are at greatest risk of harm from cell phone radiation. The GAO report does not cite the work of Om Gandhi which finds that the child's brain absorbs much more microwave radiation than the adult's brain (Gandhi et al., 2012). According to Reardon (2011) "Several countries, including Russia, Germany, France, Israel, Finland, and the United Kingdom, have issued warnings against children using cell phones." Yet, the GAO Report does not discuss children's safety from cell phone radiation even though most children in the U.S. currently have cell phones.

FCC cell phone radiation standards

The history of cell phone radiation standard setting in the U.S. reveals the FCC's inability to oversee a process that ensures decision making free of conflict of interest. The FCC does not have the expertise to oversee the research needed to develop prudent standards.

In 1978, the U.S. Comptroller General (1978) issued a report to the Congress which recommended the potential need to regulate non-thermal effects of microwave radiation based upon a review of the research conducted by the FDA. However, 18 years later in 1996, when the FCC adopted the federal cell phone radiation standards, the Commission enacted standards that controlled only for the thermal effects of the microwave radiation emitted by mobile phones. The FCC adopted standards developed by two industry groups, first by IEEE in 1991 and subsequently by ANSI. These standard setting meetings were heavily dominated by engineers and physical scientists, not health scientists. At the time, the EPA was conducting research on microwave radiation and had found evidence of non-thermal effects; however, in early 1996, their funding for this research was terminated by the Congress. In 2004, the FCC issued a public request for input on some cell phone regulatory standards; however, eight years later the agency has yet to act upon this. Hence, the FCC still employs the standards developed 21 years ago when hardly anyone used cell phones even though almost all adults and most children now use this technology.

The Radiofrequency Interagency Working Group that advises the FCC on radiation-emitting consumer products including cell phones has been a failure. This arrangement diffuses responsibility which enables the participating agencies to point fingers at each other leading to inaction according to the GAO Report:

"According to senior FCC officials, the agency has not adopted any newer limit because federal health and safety agencies have not advised them to do so. FCC officials told us that they rely heavily on the guidance and recommendations of federal health and safety agencies when determining the appropriate RF energy exposure limit and that, to date, none of these agencies have advised FCC that its current RF energy limit needs to be revised. Officials from FDA and EPA told us that FCC has not formally asked either agency for an opinion on the RF energy limit. FDA officials noted, though, that if they had a concern with the current RF energy exposure limit, then they would bring it to the attention of FCC." (GAO Report, p. 18)

Given these historic failures, the FCC should not be trusted to oversee another review of the cell phone radiation standards. Most industry-funded scientists, as well as some government scientists, deny there is any risk from chronic non-thermal exposures to cell phone radiation. If the FCC oversees a review of the standards, the agency is likely to rely heavily on the IEEE once again and adopt regulations based only on thermal effects. Moreover, since 2006, the IEEE has been advocating that the U.S. adopt standards set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The GAO Report notes that more than 40 countries have adopted the weaker ICNIRP Specific Absorption Rate (SAR) standard, a measure of the amount of energy absorbed from a cell phone in a simulated head. The Report does not mention that six countries have adopted the U.S. SAR standard (Australia, Bolivia, Canada, New Zealand, South Korea, and recently, India). Nor does the Report mention that Russia, a country that has conducted much of the health effects research on exposure to non-thermal levels of microwave radiation, has more stringent cell phone emission standards than the U.S.

Although the ICNIRP maximum specific absorption rate (SAR) of 2.0 watts per kilogram averaged over 10 grams of tissue does not sound very different from the U.S. maximum SAR of 1.6 watts per kilogram averaged over 1 gram of tissue, it actually represents a substantial difference because averaging heat absorption over a larger volume of tissue averages out the "hot spots":

“A mobile phone compliant with the ICNIRP standard of 2.0 W/kg SAR in 10 g of tissue may lead to a 2.5 to 3 times excess above the FCC standard of 1.6 W/kg in 1 g of tissue (i.e., 4–5 W/kg in a cube of 1 g of tissue) (Gandhi and Kang, 2002).” (cited in Gandhi et al, 2012)

“James Lin of the University of Illinois, Chicago, who was recently appointed a member of ICNIRP, has called this proposal to increase the averaging volume from 1g to 10g ‘scientifically indefensible’ (see MWN, J/A00 and N/D00). According to Lin, a limit of 2.0 W/Kg averaged over 10g would be approximately equivalent to an SAR of 4-6 W/Kg, averaged over 1g (see MWN, S/O01 and M/J03). Or to put it more simply, ICES wants to triple the amount of radiation you could get from a cell phone.” (Slesin, 2005)

Federal government negligent in funding cell phone radiation research

Although more research is needed to determine the long-term health consequences from continued exposure to non-thermal levels of cell phone radiation, little of this research is being conducted in the U.S. Nor are we conducting the research needed to develop safer standards and safer cell phone technology.

For the past 16 years, our federal health agencies have been negligent in funding research on the health effects of exposure to microwave radiation. The U.S. has also failed to participate in major international studies (e.g., Interphone, CEFALO, MOBI-KIDS, and COSMOS). The federal government has largely relied on industry to fund and conduct the research. From 1994-1999, the CTIA, the major wireless industry association, funded the Wireless Technology Research (WTR) Program, a \$25 million research initiative. In 2000, the CTIA funded a new research initiative, CRADA that was supposed to include FDA participation but did not. The intent of this initiative was to follow up on two studies that found harmful effects from low levels of cell phone radiation in the WTR program. Little research was published in the peer-reviewed literature from either of these industry-sponsored research programs.

The largest ongoing federally-funded study of exposure to cell phone radiation examines the health effects of 2G (i.e., second generation) cell phone technologies (GSM, CDMA) on mice and rats. The findings will be obsolete soon after the study is completed in 2015 because the industry is phasing out 2G. We should be conducting research on the health effects of 3G and 4G at this time. Some research suggests that DNA damage occurs at much lower exposures to 3G radiation than 2G. No health effects research has been published on 4G to date.

“According to representatives from the Mobile Manufacturers Forum, the association has provided about \$46 million for RF energy research since 2000 and is currently providing support for epidemiological and laboratory studies.” (GAO Report, p. 16)

A major reason for the conflicting evidence about the health effects of cell phone radiation after more than two decades of research is because governments and the W.H.O. have relied on industry to fund all or part of the research. *Microwave News* has documented several incidents where industry-funded researchers lost their funding after reporting evidence of biologic activity in laboratory studies or harmful effects in humans. The corrupting influence of industry on the scientific community and on the health effects and biologic research has been chronicled for several decades by Louis Slesin in his newsletter, *Microwave News* (<http://microwavenews.com>), and was summarized by Devra Davis in her recent book, *Disconnect* (Davis, 2010).

If we hope to develop a body of high quality research that policy makers can rely upon, we must cultivate a scientific community that is independent of industry. A fee of fifty cents per year, or a penny per week, assessed on each cell phone in the U.S. could generate \$150 million annually for research and education about cell phones and other forms of electromagnetic radiation.

GAO Report recommendations

The GAO Report makes two recommendations:

“We recommend that the Chairman of the FCC take the following two actions:

- Formally reassess the current RF energy exposure limit, including its effects on human health, the costs and benefits associated with keeping the current limit, and the opinions of relevant health and safety agencies, and change the limit if determined appropriate.

- Reassess whether mobile phone testing requirements result in the identification of maximum RF energy exposure in likely usage configurations, particularly when mobile phones are held against the body, and update testing requirements as appropriate.” (GAO Report, p. 28)

The GAO Report indicates that the industry and its affiliated organizations want the FCC to weaken the current standards by adopting the more permissive ICNIRP standards. In contrast, national environmental health organizations, which the Report refers to as “consumer groups,” demand that the FCC standards be strengthened, and the testing conditions be re-designed to better simulate real-world use of cell phones to ensure public safety.

Some environmental health groups and many scientists want supplemental standards developed to control for additional characteristics of cell phone radiation besides energy absorption (as measured by the SAR). These signal characteristics (frequency, modulation, etc.) are biologically active through non-thermal mechanisms. Considerable evidence exists that these non-thermal effects cause harm to human health as well as the health of other species (Fragopoulou et al., 2010; Juutilainen et al., 2011; Gandhi et al., 2012; Blank and Goodman, 2012). Cell phone regulatory standards should be designed to minimize these deleterious effects.

Based upon the FCC’s track record over the past several decades, the Congress should seriously consider assigning these tasks to a health agency with the requisite expertise and fund that agency to oversee the research and development of safety standards that ensure the protection of population health from **non-thermal** in addition to thermal risks associated with exposure to cell phone radiation.

The GAO Report’s second recommendation addresses a major deficiency in the FCC guidelines with regard to certification of cell phone safety. The FCC has failed to enforce its guideline that requires testing of cell phones in the manner in which they are used, namely, “against the ear and against the body.” Because the FCC allows cell phones to be tested from 1.5 to 2.5 cm (5/8 – 1 inch) away from the body and most users do not keep their phones this distance from their bodies, cell phones are being used unsafely much of the time based on the FCC’s safety definition. More importantly, users increase their risk of harm from microwave radiation by not using their phones the way they were tested.

The Report should also recommend to the FCC that its cell phone certification process employ artificial models, known as specific anthropomorphic mannequins, that resemble today’s cell phone users. The head of the mannequin in current use is modeled after an adult male in the 90th percentile of the military. People with smaller heads than the mannequin which includes most of the population absorb more radiation than the current test measures. Thus, most people are exposed to more microwave radiation from their cell phone than the FCC deems safe based on the current SAR standard.

The cell phone certification process should simulate who uses cell phones today including children, teenagers, pregnant women, males and females of reproductive age, seniors, and individuals with compromised immune systems and those who wear metal eyeglass frames or have metal fillings or braces on their teeth. The process should also simulate how cell phones are commonly used (e.g., directly against the head and body, in moving vehicles and in elevators).

Specific Comments

GAO Report:

“this report addresses (1) what is known about the health effects of RF energy from mobile phones and what are current research activities, (2) how FCC set the RF energy exposure limit for mobile phones, and (3) federal agency and industry actions to inform the public about health issues related to mobile phones, among other things.”

“FDA stated that while the overall body of research has not demonstrated adverse health effects, some individual studies suggest possible effects. Officials from NIH, experts we interviewed, and a working group commissioned by IARC—the World Health Organization’s agency that promotes international collaboration in cancer research—have reached similar conclusions. For example, in May 2011 IARC classified RF energy as “possibly IARC determined that the evidence from the scientific research for gliomas, a type of cancerous brain tumor, was limited—meaning that an association has been observed

between RF energy exposure and cancer for which a causal relationship is considered to be credible, but chance, bias, or confounding factors could not be ruled out with reasonable confidence.” (GAO Report, pp. 6-7)

“Studies we reviewed suggested and experts we interviewed stated that epidemiological research has not demonstrated adverse health effects from RF energy exposure from mobile phone use, but the research is not conclusive because findings from some studies have suggested a possible association with certain types of tumors, including cancerous tumors.” (GAO Report, p. 8)

Comment: Our research group published a review of the case-control research on mobile phone use and tumor risk in humans in the *Journal of Clinical Oncology* in 2009 that received worldwide attention (Myung et al, 2009a). **Our primary conclusion was that it is misleading to examine the overall weight of the evidence. Rather one must sort the studies based on research quality to see the true picture.** Case-control studies that employed high quality research methods demonstrated a significant positive association between mobile phone use and tumor risk (i.e., increased risk). This association was stronger for brain tumors among those who used cell phones for 10 or more years, especially on the side of the head where the phone was held. In contrast, low quality studies displayed a significant negative association between mobile phone use and tumor risk (i.e., reduced risk or a protective effect from using cell phones). Thus, when we combined the estimates of tumor risk from the high and low quality studies, we found no overall risk. Many scientists in academia and government have focused on the overall weight of the evidence and have ignored the quality of the research. This is how they conclude we do not have adequate evidence. We also found that low quality studies tended to be funded all or in part by industry. Even the W.H.O. Interphone Study received one-fourth of its funding from industry. In contrast, high quality studies were more likely to be funded by government health agencies. Thus, conflicts of interest may have played a key role in the conduct and reporting of the research (Myung et al., 2009b). These conclusions are reinforced by studies that were completed since our review paper was published.

“we recommend that research on the topic of mobile phone use and health should not be funded by the industry because funding sources can influence research in subtle ways, and to preserve the credibility of the research it is important to avoid even the appearance of a conflict of interest.” (Myung et al, 2009b)

GAO Report:

“findings from a nationwide cohort study conducted in Denmark that originally followed 420,095 individuals did not show an association between increased risk for certain types of tumors, including cancerous tumors, and mobile phone use. Additionally, findings from a subset of the cohort—56,648 individuals with 10 or more years since their first mobile phone subscription—did not show an increased risk for brain and nervous system tumors. Further, these findings did not change for individuals in the cohort with 13 or more years since their first mobile phone subscription. (GAO Report, pp.8-9)

Comment: In our review of the literature, we dismissed the results of the Danish Cohort study because we believed that serious methodologic problems rendered the results uninterpretable (Myung et al, 2009a). The study has been criticized because it was biased against finding increased tumor risk. Many of its results found what appeared to be reduced risk (i.e., a protective effect from using cell phones). That most of the heaviest cell phone users whose phones belonged to their businesses were classified as non-cell phone users biased the results against finding increased risk (Slesin, 2011).

“The Danish study has another, perhaps even more potentially fatal source of bias. The user population includes only those who had a cell phone in 1995—that was about 20% of the population. The Danish Cancer Society treats everyone who took up cell phones after 1995 as if they had never used one. They too are in the control group. That's hard to believe but true. Here's a direct quote from the BMJ paper: ‘individuals with a subscription in 1996 or later were classified as non-users.’” (Slesin, 2011).

GAO Report:

“Also, the CEFALO study—an international case-control study that compared children aged 7 to 19 diagnosed with certain types of brain tumors, including brain cancers, to similar children who were not diagnosed with brain tumors—found no relationship between mobile phone use and risk for brain tumors.” (GAO Report, p. 9)

Comment: Contrary to the study authors' conclusions and the GAO's summary, the CEFALO study reported significantly increased brain tumor risk among children who used cell phones in several analyses despite small amounts of cell phone use and short duration of use. See the Soderqvist et al (2011) for a full critique of this study and alternative interpretations of the results.

GAO Report:

"Findings from another study, which was conducted by NIH and examined trends in brain cancer incidence rates in the United States using national cancer registry data collected from 1992 to 2006, did not find an increase in new cases of brain cancer, despite a dramatic increase in mobile phone use during this time period." (GAO Report, p. 9)

Comment:

Although this study did not find an overall increase in brain cancer incidence, it did report an increase for young adults 20-29 years of age (Inskip et al., 2010). Young adults are likely to be more vulnerable to microwave radiation because their brains are not fully developed. The authors of the study dismissed this result because the tumors were located in the frontal lobe, and because the increased cancer incidence in men started before cell phones were popular in the U.S. However, absorption of microwave radiation is substantial in this lobe, and frontal lobe tumors have been associated with mobile phone use in case-control studies. Also, cordless phones which were popular before cell phones emit microwave radiation so these phones may have contributed to the increased tumor incidence observed in young adults.

GAO Report:

"Studies we reviewed suggested and experts we interviewed stated that laboratory research has not demonstrated adverse human health effects from RF energy exposure from mobile phone use, but the research is not conclusive because findings from some studies have observed effects on test subjects.... According to some studies we reviewed, while some of these studies have observed changes in behavior and cognitive function, overall, these studies have not consistently found adverse effects from RF energy levels emitted from mobile phones." (GAO Report, p. 10)

Comment: Just as we found evidence for conflict of interest affecting the epidemiologic research, Dr. Henry Lai has reported possible evidence of conflict of interest with the toxicology research:

"Henry Lai, a research professor in the bioengineering department at the University of Washington, began laboratory radiation studies in 1980 and found that rats exposed to radiofrequency radiation had damaged brain DNA. He maintains a database that holds 400 scientific papers on possible biological effects of radiation from wireless communication. He found that 28 percent of studies with cellphone industry funding showed some sort of effect, while 67 percent of studies without such funding did so. "That's not trivial," he said." (Randall Stross. Should you be snuggling with your cellphone? New York Times, Nov 13, 2010. URL: <http://www.nytimes.com/2010/11/14/business/14digi.html>)

An in-depth discussion of conflict of interest associated with research funding from the mobile phone industry and the U.S. Air Force can be found in Microwave News (Slesin, 2006).

GAO Report:

"Studies we reviewed and experts we interviewed identified key areas for additional epidemiological and laboratory studies, and according to experts, additional research may increase understanding of any possible effects. For example, additional epidemiological studies, particularly large long-term prospective cohort studies and case-control studies on children, could increase knowledge on potential risks of cancer from mobile phone use." (GAO Report, p. 12)

Comment: In our review paper, we recommended long-term prospective cohort studies as this research could yield stronger empirical evidence than case-control study research (Myung et al., 2009a). However, we no longer recommend this for the following reasons: (1) Given the widespread adoption and use of cell phones it would be difficult to recruit enough individuals for the cohort who are not exposed to cell phone, cordless phone or Wi-Fi radiation, and variation over time in microwave radiation exposure levels are necessary to detect effects on tumor risk; (2) the research would be very costly and difficult to conduct as extremely large samples of participants would be needed due to the low incidence of brain tumors; and (3) the results would not be available for 20-30 years since the latency between exposure to cell phone radiation and tumor detection can be up to four decades; meanwhile, cell phone technology keeps changing so the results may have limited value when they are published.

GAO Report:

“additional studies on laboratory animals as well as human and animal cells examining the possible toxic or harmful effects of RF energy exposure could increase knowledge on potential biological and health effects of RF energy. Further, additional laboratory studies on human and animal cells to examine non-thermal effects of RF energy could increase knowledge of how, if at all, RF energy interacts with biological systems. However, some experts we spoke to noted that, absent clear evidence for adverse health effects, it is difficult to justify investing significant resources in research examining non-thermal effects of RF energy from mobile phone use.” (GAO Report, p. 12)

Comment: Although results are not consistent, numerous peer-reviewed toxicology studies demonstrate evidence for non-thermal effects of RF energy from mobile phone use, especially for GSM and UMTS mobile phone carrier systems (Juutilainen et al., 2011; Wolchover, 2011). Fewer studies have been conducted on CDMA and W-CDMA mobile carrier systems, and there is less evidence for biologic activity for these technologies. The lack of research on CDMA and W-CDMA can be explained by two factors: (1) Most research on the health effects of cell phone radiation has been conducted outside of the U.S. because our federal government has neglected to fund this research with minor exceptions; and (2) few countries other than the U.S. employ CDMA and W-CDMA (currently used by half of the U.S. population who have Verizon and Sprint as their cell phone providers); hence, few countries fund research on these two technologies.

The U.S. has one major study in progress that contrasts the effects of GSM and CDMA in mice and rats conducted by the National Toxicology Program. Results from this study should be available by 2015. However, these 2G (second generation) technologies are likely to be obsolete in the U.S. by 2016. We need a major research funding initiative now to evaluate the effects of 3G (UMTS, W-CDMA) and 4G (LTE, WiMax) technologies and to enable us to set appropriate regulatory standards for these forms of microwave radiation to protect population health.

GAO Report:

“The Danish National Birth Cohort consists of over 100,000 Danish children who were born from 1996 to 2002. Data on lifestyle factors, dietary habits, and environmental exposures have been collected on these children, and data on current mobile phone use by children have been collected since these children reached the age of seven.” (GAO Report, Footnote b, p. 14)

Comment: The only mention of this study in the Report appears in a footnote even though Dr. Leeka Kheifets at UCLA was one of the experts the GAO consulted. Moreover, her study is one of a few cell phone radiation health effect studies that the federal government has funded. Dr. Kheifets has published two peer-reviewed papers that reported behavioral problems in children exposed *in utero* to cell phone radiation (Divan et al., 2008, 2012). These children were more likely to display symptoms that resemble attention deficit disorder. If these reproductive health effects are replicable, they have profound implications for public health. Recently, Dr. Hugh Taylor at Yale replicated these behavioral effects in an experimental study conducted with rats exposed to cell phone radiation *in utero* (Aldad et al., 2012).

GAO Report:

"In 1996, FCC adopted the RF energy exposure limit for mobile phones of 1.6 watts per kilogram, averaged over one gram of tissue, a measurement of the amount of RF energy absorbed into the body.²⁸ FCC developed its limit based on input from federal health and safety agencies as well as the 1991 recommendation by the Institute of Electrical and Electronics Engineers (IEEE) that was subsequently approved and issued in 1992 by the American National Standards Institute (ANSI). This recommended limit was based on evidence related to the thermal effects—the only proven health effects of RF energy exposure—and was set at a level well below the threshold for such effects. FCC noted that the limit provided a proper balance between protecting the public from exposure to potentially harmful RF energy and allowing industry to provide telecommunications services to the public in the most efficient and practical manner possible." (GAO Report, pp. 16-17)

Comment: In 1996, the FCC based its cell phone radiation standard on a set of recommendations made by two industry groups composed largely of engineers. The exposure limit protects the user from the acute effects from heating of body tissue but not from the non-thermal effects of microwave radiation. The FCC claimed that the SAR limit it adopted was based on input from federal health and safety agencies yet it ignored the EPA's recommendation at the time that the SAR be limited to 1.0 watts per kilogram instead of 1.6 watts per kilogram. Instead, the FCC traded public safety for the industry's recommendation to achieve what it considered "a proper balance."

"The EPA and NIOSH, two health agencies that have studied the RF/MW health data for decades, have each advocated pegging the threshold to 1 W/Kg for the public and to 2 W/Kg for workers, respectively." (Slesin, 19966)

GAO Report:

"FCC has implemented standardized testing procedures requiring mobile phones to be tested for compliance with the RF energy exposure limit when in use against the ear and against the body while in body-worn accessories, such as holsters, but these requirements may not identify the maximum exposure under other conditions. The specific minimum separation distance from the body is determined by the manufacturer (never to exceed 2.5 centimeters), based on the way in which the mobile phone is designed to be used. FCC has not reassessed its testing requirements to ensure that testing identifies the maximum RF energy exposure for the other usage conditions a user could experience when mobile phones are in use without body-worn accessories or as advised by the manufacturer's instructions, rather than the head." (GAO Report, pp. 22-23)

Comment: The FCC should not have allowed manufacturers the latitude to decide whether to test the phone from 1.5 to 2.5 centimeters from the body in the "against the body" test. Because these distances are in the "near-field" of the antenna each additional millimeter corresponds to a 15% reduction in emissions. A phone tested at 2.5 cm can produce up to 5 times the microwave radiation as a phone tested at 1.5 cm and still be legal. Furthermore, the "against the body" SARs are not comparable for two phones tested at different distances from the body.

According to the FCC 2001 guidelines, the manufacturer can use warning labels to ensure that the user maintains a minimum distance between his body and the phone that corresponds to the distance used in the SAR test procedure. However, if the manufacturer, cannot ensure that the user will comply with this instruction, then the SAR test must be conducted "at its closest range to persons under normal operating conditions."

"When applicable, operation instructions and prominent warning labels may be used to alert the exposed persons to maintain a specified distance from the transmitter or to limit their exposure durations and usage conditions to ensure compliance. If the use of warning labels on a transmitter is not effective or desirable, the alternative of performing SAR evaluation with the device at its closest range to persons under normal operating conditions may be used." (FCC, 2001, p. 8)

GAO Report:

"Representatives from some consumer groups and experts we spoke with raised concerns that the information on federal agency websites about mobile phone health effects is not precautionary enough, among other things. In particular, these representatives and experts said that federal agencies should

include stronger precautionary information about mobile phones because of the uncertain state of scientific research on mobile phone health effects as well as the fact that current testing requirements may not identify the maximum possible RF energy exposure.” (GAO Report, p. 25)

Comment: Information on federal agency websites about mobile phones is at best confusing, and often misleading. Coverage of the health effects research has often been biased. For example, news coverage of the major Interphone Study paper reported “no evidence” of increased tumor risk on both the FDA and the NCI web sites (e.g., “No Evidence Linking Cell Phone Use to Risk of Brain Tumors,” FDA Consumer Health Information; May 17, 2010). This was completely false as a significant 40% increased glioma risk was found for the heaviest cell phone users (which corresponded to about 30 minutes per day over 10 years) (Interphone Study Group, 2010a). Appendix 2 of this paper presented results from analyses that corrected for selection bias in the study (Interphone Study Group, 2010b). In the appendix, the heaviest cell phone users had 82% increased risk of glioma as compared to those who used cell phones less than 5 hours in their lifetime. Moreover, a significant dose-response relationship for number of years of cell phone use and glioma risk was reported. Based upon the results of this study, two of the investigators including the lead investigator have called for precautionary health warnings to “reduce exposure to the brain from mobile phones...particularly among young people” (Cardis and Sadetzki, 2011).

References

- Aldad TS, Gan G, Gao X-B, Taylor HS. Fetal radiofrequency radiation exposure from 800-1900 Mhz-rated cellular telephones affects neurodevelopment and behavior in mice. *Scientific Reports*. Published online March 15, 2012. URL: <http://www.nature.com/srep/2012/120315/srep00312/full/srep00312.html>
- Behari J. Biological responses of mobile phone frequency exposure. *Indian Journal of Experimental Biology*. 2010 Oct;48(10):959-81. URL: <http://nopr.niscair.res.in/handle/123456789/10341>
- Blank M, Goodman RM. Electromagnetic fields and health: DNA-based dosimetry. *Electromagnetic Biology and Medicine*. Published online before print June 7, 2012. URL: <http://informahealthcare.com/doi/abs/10.3109/15368378.2011.624662>
- Cardis E., Sadetzki S. Indications of possible brain-tumour risk in mobile-phone studies: should we be concerned? *Occupational and Environmental Medicine* 2011. 68:169-171. URL: <http://oem.bmj.com/content/68/3/169>
- Davis D. *Disconnect: The truth about cell phone radiation, what the industry has done to hide it, and how to protect your family*. New York: Dutton. 2010.
- Divan HA, Kheifets L, Obel C, Olsen J. Prenatal and postnatal exposure to cell phone use and behavioral problems in children. *Epidemiology* 2008.19(4):523-9. URL: <http://www.ncbi.nlm.nih.gov/pubmed/18467962?dopt=Abstract>
- Divan HA, Kheifets L, Obel C, Olsen J. Cell phone use and behavioural problems in young children. *Journal of Epidemiology and Community Health*. 2012; 66:524-529. URL: <http://jech.bmj.com/content/66/6/524.long>
- Federal Communications Commission (FCC). *Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields*. OET Bulletin 65. Supplement C. Edition 01-01. Washington, DC: Office of Engineering Technology, FCC. 2001. URL: http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65c.pdf
- Fragopoulou A, Grigoriev Y, Johansson O, Margaritis LH, Morgan L, Richter E, Sage C. Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales. *Review of Environmental Health* 2010. 25(4):307-17. URL: <http://www.ncbi.nlm.nih.gov/pubmed/21268443>
- Gandhi OP, Morgan LL, de Salles AA, Han YY, Herberman RB, Davis DL. Exposure limits: the underestimation of absorbed cell phone radiation, especially in children. *Electromagnetic Biology and Medicine*. 2012. 31(1):34-51. URL: <http://www.ncbi.nlm.nih.gov/pubmed/21999884>
- Interphone Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. *International Journal of Epidemiology*. 2010a. 39(3):675-94. URL: <http://ije.oxfordjournals.org/content/39/3/675>
- Interphone Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Appendix 2. *International Journal of Epidemiology*. 2010b. 39(3):675-94. URL: http://ije.oxfordjournals.org/content/suppl/2010/05/06/dyq079.DC1/Interphone_Appendix2.pdf
- Inskip PD, Hoover RN, Devesa SS. Brain cancer incidence trends in relation to cellular telephone use in the United States. *Neuro-Oncology* 2010.12(11):1147-1151. URL: <http://neuro-oncology.oxfordjournals.org/content/12/11/1147>
- Juutilainen J, Höytö A, Kumlin T, Naarala J. Review of possible modulation-dependent biological effects of radiofrequency fields. *Bioelectromagnetics* 2011. 32(7):511-534. URL: <http://onlinelibrary.wiley.com/doi/10.1002/bem.20652/full>
- Khurana VG, Teo C, Kundi M, Hardell L, Carlberg M. Cell phones and brain tumors: a review including the long-term epidemiologic data. *Surgical Neurology* 2009. 72(3):205-14; discussion 214-5. URL: <http://www.sciencedirect.com/science/article/pii/S0090301909001451>

La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. Effects of the exposure to mobile phones on male reproduction: a review of the literature. *Journal of Andrology* 2012. 33(3):350-356. URL: <http://www.andrologyjournal.org/cgi/content/full/33/3/350>

Myung S-J, Ju W, McDonnell DD, Lee YH, Kazinets G, Cheng C-T, Moskowitz JM. Mobile phone use and risk of tumors: A meta-analysis. *Journal of Clinical Oncology* 2009a. 27(33):5565-5572. URL: <http://jco.ascopubs.org/content/27/33/5565.abstract>

Myung S-J, Ju W, McDonnell DD, Lee YH, Kazinets G, Cheng C-T, Moskowitz JM. Reply to A. Stang et al, J.T. Rowley et al, and F. Samkange-Zeeb et al. *Journal of Clinical Oncology* 2009b. 28(7):e124-e125. URL: <http://jco.ascopubs.org/content/28/7/e124.full>

Reardon, M. Cell phone radiation: A self-defense guide (FAQ). CNET. June 6, 2011. URL: http://news.cnet.com/8301-30686_3-20068419-266/cell-phone-radiation-a-self-defense-guide-faq/

Slesin L. ANSI/IEEE v. NCRP: Battle for Control of RF/MW Standards. March/April 1996. *Microwave News*. 16(2):12. URL: <http://microwavenews.com/sites/default/files/sites/default/files/backissues/m-a96issue.pdf>

Slesin L. The Danish Cohort Study: The politics and economics of bias. *Microwave News*. November 3, 2011. URL: <http://microwavenews.com/DanishCohort.html>

Slesin L. *Microwave News*. January 14, 2005. URL: <http://microwavenews.com/january-14-2005>

Slesin L. "Radiation Research" and the cult of negative results. *Microwave News*. July 2006. 26(4):1-5. URL: <http://microwavenews.com/sites/default/files/docs/mwn.7-06.RR.pdf>

Soderqvist F, Carlberg M, Mild KH, Hardell L. Childhood brain tumour risk and its association with wireless phones: a commentary. *Environmental Health* 2011.10(1):106. URL: <http://www.ehjournal.net/content/10/1/106>

U.S. Comptroller General. More protection from microwave radiation hazards needed. Report by the Comptroller General of the United States to the House Committee on Interstate and Foreign Commerce, Oversight and Investigations Subcommittee. HRD-79-7; B-164031(2). Washington, DC: Comptroller General's Office. November 30, 1978. URL: <http://www.gao.gov/assets/130/124884.pdf>

Volkow ND, Tomasi D, Wang GJ, Vaska P, Fowler JS, Telang F, Alexoff D, Logan J, Wong C. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. *Journal of the American Medical Association* 2011 Feb 23;305(8):808-13. URL:<http://jama.jamanetwork.com/article.aspx?articleid=645813>

Wolchover N. Radiation risk: Are some cellphones more dangerous than others? *Life's Little Mysteries*. June 23, 2011. URL: <http://www.lifessmallmysteries.com/1550-radiation-risk-some-cell-phones-more-dangerous-than-others.html>