SSY135 – Wireless Communications
Supplemental Material

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Electromagnetic radiation can be dangerous to humans, when exposed for extensive periods or at high power levels. It is important for communication engineers to be aware of these risks and how they can be mitigated. This document compiles recent information from the World Health Organization (WHO) and the Federal Communications Commission (FCC) addressing both these issues. Please go through these documents as they are part of the learning outcomes of the course. Your knowledge on the impact of electromagnetic radiation and the mitigation strategies will be assessed during the final exam of the course.

International Agency for Research on Cancer

World Health Organization

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Interphone study reports on mobile phone use and brain cancer risk

The Interphone Study Group today published their results[1] in the International Journal of Epidemiology (direct media link). The paper presents the results of analyses of brain tumour (glioma and meningioma) risk in relation to mobile phone use in all Interphone study centres combined. This interview-based case-control study, which included 2708 glioma and 2409 meningioma cases and matched controls was conducted in 13 countries using a common protocol. Analyses of brain tumours in relation to mobile phone use have been reported from a number of cohort and case-control studies, including several of the national components of Interphone. No studies, however, have included as many exposed cases, particularly long-term and heavy users of mobile phones, as this study.

Background

Mobile phone use has increased dramatically since its introduction in the early-to-mid 1980's. The expanding use of this technology has been accompanied by concerns about health. In the late 1990s, several expert groups critically reviewed the evidence on health effects of low-level exposure to radiofrequency (RF) electromagnetic fields, and recommended research into the possible adverse health effects of mobile telephone use.

IARC co-ordination of a multinational effort in cancer research

As a result, the International Agency for Research on Cancer (IARC) coordinated a feasibility study in 1998 and 1999, which concluded that an international study of the relationship between mobile phone use and brain tumour risk would be feasible and informative.

Scope of the Interphone study

Interphone was therefore initiated in 2000 as an international set of case-control studies in 13 countries around the world[2] focusing on four types of tumours in tissues that most absorb RF energy emitted by mobile phones: tumours of the brain (glioma[3] and meningioma[4]), of the acoustic nerve (schwannoma[5]), and of the parotid gland[6]. The objective was to determine whether mobile phone use increases the risk of these tumours. Interphone is the largest case-control study of mobile phone use and brain tumours yet and includes the largest numbers of users with at least 10 years of exposure.

Scientific direction of Interphone

The Interphone International Study Group, made up of 21 scientists[7], was responsible for the progress of the study, the choice of analyses to be conducted, and the interpretation and publication of results. All the decisions about the study were made exclusively and collectively by the Interphone International Study Group. In the course of the study, the IARC Principal Investigator, Dr Elisabeth Cardis, moved to the Centre for Research in Environmental Epidemiology (CREAL) in Barcelona, Spain, where she continues her role as Interphone Principal Investigator, although the 13-country dataset remains at IARC.

Funding of Interphone

The Interphone study was undertaken as a collaborative effort between a number of partner institutions[8], co-ordinated by IARC. To date, the overall funding assigned to the Interphone study amounts to approx. 19.2 million euros (€). Of this amount 5.5 million € were contributed by industry sources.

Of these 5.5 million €, 3.5 million € were contributed by the Mobile Manufacturers' Forum (MMF) and the GSM Association, each contributing half of that amount, through a firewall mechanism provided by the UICC (International

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[1] "Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study", the Interphone Study Group. *International Journal of Epidemiology* 2010;1–20. doi:10.1093/ije/dyq079. Plus Appendix 1; Appendix 2.
[2] Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden and the UK.
[3] A cancer of the brain that begins in glial cells (cells that surround and support nerve cells). See also Epidemiology of brain tumours.
[4] A type of slow-growing tumour that forms in the meninges (thin layers of tissue that cover and protect the brain and spinal cord). Most meningiomas are benign and usually occur in adults.
[5] A tumour of the peripheral nervous system that arises in the nerve sheath (protective covering). It is almost always benign, but rare malignant schwannomas have been reported.
[6] Tumour that forms in a parotid gland, the largest of the salivary glands, which make saliva and release it into the mouth. There are two parotid glands, one in front of and just below each ear. Most salivary gland tumours begin in parotid glands.
[7] See Annex A for list of members.
[8] See list of participating institutions in Annex B.

Union against Cancer) to guarantee the independence of the scientists. Most of the rest of the 5.5 million € came indirectly to individual centers from mobile phone operators and manufacturers, for example, through taxes and fees collected by government agencies. Only 0.5 million € (2.5%) of the overall study costs were provided directly by the industry, in Canada and France, under contracts which preserved the independence of the study.

Other funding was provided by the European Commission (3.74 million €) and national and local funding sources (9.9 million € in total) in participating countries.

Additional funding for the extension of the research to younger and older age groups was received directly from mobile phone operators in the UK under contracts which preserved the independence of the study.

Results

The Interphone Study Group summarized its findings as follows:

"A reduced odds ratio (OR)[9] related to ever having been a regular mobile phone user was seen for glioma [OR 0.81; 95% confidence interval (CI) 0.70-0.94] and meningioma (OR 0.79; 95% CI 0.68-0.91), possibly reflecting participation bias or other methodological limitations. No elevated OR was observed ≥ 10 years after first phone use (glioma: OR 0.98; 95% CI 0.76-1.26; meningioma: OR 0.83; 95% CI 0.61-1.14). ORs were < 1.0 for all deciles of lifetime number of phone calls and nine deciles of cumulative call time. In the tenth [highest] decile of recalled cumulative call time, ≥1640 h, the OR was 1.40 (95% CI 1.03-1.89) for glioma, and 1.15 (95% CI 0.81-1.62) for meningioma; but there are implausible values of reported use in this group. ORs for glioma tended to be greater in the temporal lobe[10] than in other lobes of the brain, but the CIs around the lobe-specific estimates were wide. ORs for glioma tended to be greater in subjects who reported usual phone use on the same side of the head as their tumour than on the opposite side."

Conclusions

The Interphone Study Group concluded with the following key message:

A reduced OR for glioma and meningioma related to ever having been a regular mobile phone user possibly reflects participation bias or other methodological limitations. No elevated OR for glioma or meningioma was observed ≥10 years after first phone use. There were suggestions of an increased risk of glioma, and much less so meningioma, in the highest decile of cumulative call time, in subjects who reported usual phone use on the same side of the head as their tumour and, for glioma, for tumours in the temporal lobe. Biases and errors limit the strength of the conclusions that can be drawn from these analyses and prevent a causal interpretation.

Change in pattern of use

The majority of subjects were not heavy mobile phone users by today's standards. The median lifetime cumulative call time was around 100 hours, with a median of 2 to 2½ hours of reported use per month. The cut-point for the heaviest 10% of users (1640 hours lifetime), spread out over 10 years, corresponds to about a half-hour per day.

Today, mobile phone use has become much more prevalent and it is not unusual for young people to use mobile phones for an hour or more a day. This increasing use is tempered, however, by the lower emissions, on average, from newer technology phones, and the increasing use of texting and hands-free operations that keep the phone away from the head.

What next?

Dr Christopher Wild, Director of IARC said: "An increased risk of brain cancer is not established from the data from Interphone. However, observations at the highest level of cumulative call time and the changing patterns of mobile phone use since the period studied by Interphone, particularly in young people, mean that further investigation of mobile phone use and brain cancer risk is merited."

Professor Elisabeth Cardis said that "the Interphone study will continue with additional analyses of mobile phone use and tumours of the acoustic nerve and parotid gland." She added:,"Because of concerns about the rapid increase in mobile phone use in young people – who were not covered by Interphone –, CREAL is co-ordinating a new project, MobiKids, funded by the European Union, to investigate the risk of brain tumours from mobile phone use in childhood and adolescence."

IARC has scheduled a comprehensive review of the carcinogenic potential of mobile phone use under the auspices of its Monographs Programme. The review, scheduled for 24-31 May 2011, will consider all published epidemiological and experimental evidence, including the new data from the Interphone study.

[9] The odds ratio (OR) is a measure of relative risk. In other terms, an OR of x is taken as meaning that people exposed have x times the risk of non-exposed people.
[10] The temporal lobe is the region of the brain located nearest the ear.

Human Exposure to Radio Frequency Fields: Guidelines for Cellular and PCS Sites

Primary antennas for transmitting wireless telephone service, including cellular and Personal Communications Service (PCS), are usually located outdoors on towers, water tanks and other elevated structures like rooftops and sides of buildings. The combination of antenna towers and associated electronic equipment is referred to as a "cellular or PCS cell site" or "base station." Cellular or PCS cell site towers are typically 50-200 feet high. Antennas are usually arranged in groups of three, with one antenna in each group used to transmit signals to mobile units, and the other two antennas used to receive signals from mobile units.

At a cell site, the total radio frequency (RF) power that can be transmitted from each transmitting antenna depends on the number of radio channels (transmitters) that have been authorized by the Federal Communications Commission (FCC) and the power of each transmitter. Although the FCC permits an effective radiated power (ERP) of up to 500 watts per channel (depending on the tower height), the majority of cellular or PCS cell sites in urban and suburban areas operate at an ERP of 100 watts per channel or less.

An ERP of 100 watts corresponds to an actual radiated power of 5-10 watts, depending on the type of antenna used. In urban areas, cell sites commonly emit an ERP of 10 watts per channel or less. For PCS cell sites, even lower ERPs are typical. As with all forms of electromagnetic energy, the power density from a cellular or PCS transmitter rapidly decreases as distance from the antenna increases.

Consequently, normal ground-level exposure is much less than the exposure that might be encountered if one were very close to the antenna and in its main transmitted beam. Measurements made near typical cellular and PCS cell sites have shown that ground-level power densities are well below the exposure limits recommended by RF/microwave safety standards used by the FCC.

Guidelines

In 1996, the FCC adopted updated guidelines for evaluating human exposure to RF fields from fixed transmitting antennas such as those used for cellular and PCS cell sites. The FCC's guidelines are identical to those recommended by the National Council on Radiation Protection and Measurements (NCRP), a non-profit corporation chartered by Congress to develop information and recommendations concerning radiation protection. The FCC's guidelines also resemble the 1992 guidelines recommended by the Institute of Electrical and Electronics Engineers (IEEE), a non-profit technical and professional engineering society, and endorsed by the American National Standards Institute (ANSI), a nonprofit, privately-funded membership organization that coordinates development of voluntary national standards in the United States.

In the case of cellular and PCS cell site transmitters, the FCC's RF exposure guidelines recommend a maximum permissible exposure level to the general public of approximately 580 microwatts per square centimeter. This limit is many times greater than RF levels typically found near the base of cellular or PCS cell site towers or in the vicinity of other, lower-powered cell site transmitters. Calculations corresponding to a "worst-case" situation (all transmitters operating simultaneously and continuously at

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the maximum licensed power) show that, in order to be exposed to RF levels near the FCC's guidelines, an individual would essentially have to remain in the main transmitting beam and within a few feet of the antenna for several minutes or longer. Thus, the possibility that a member of the general public could be exposed to RF levels in excess of the FCC guidelines is extremely remote.

When cellular and PCS antennas are mounted on rooftops, RF emissions could exceed higher than desirable guideline levels on the rooftop itself, even though rooftop antennas usually operate at lower power levels than free-standing power antennas. Such levels might become an issue for maintenance or other personnel working on the rooftop. Exposures exceeding the guidelines levels, however, are only likely to be encountered very close to, and directly in front of, the antennas. In such cases, precautions such as time limits can avoid exposure in excess of the guidelines. Individuals living or working within the building are not at risk.

Consumer Help Center

For more information on consumer issues, visit the FCC's Consumer Help Center at https://consumercomplaints.fcc.gov.

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Human Exposure to Radio Frequency (RF) Fields from Mobile (Vehicle-Mounted) Antennas

Vehicle-mounted antennas used for wireless communications normally operate at a power level of three watts or less. These wireless antennas are typically mounted on the roof, trunk or rear window of a car or truck.

Results of Studies

Studies show that, in order to be exposed to RF levels that approach the safety limits adopted by the FCC, it would be necessary to remain very close to a vehicle-mounted wireless antenna for a significant amount of time. Studies have also shown that the metal body of the vehicle can effectively shield occupants. Proper installation of a vehicle-mounted antenna to maximize this shielding effect is a good way to minimize exposure. Some companies recommend that antennas be installed either in the center of the roof or center of the trunk of a vehicle. In response to concerns expressed over the commonly used rear-window mounted wireless antennas, a minimum separation distance of 1-2 feet has been suggested as a way to minimize exposure to vehicle occupants.

Conclusions/Recommendations

From data gathered to date, properly-installed, vehicle-mounted, personal wireless antennas using up to three watts of power result in maximum exposure levels in or near the vehicle that are typically well below the FCC's safety limits, assuming that the transmitting antenna is 6 inches or more from vehicle occupants.

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Wireless Devices and Health Concerns

Current Exposure Limits

While there is no federally developed national standard for safe levels of exposure to radiofrequency (RF) energy, many federal agencies have addressed this important issue. In addition to the Federal Communications Commission, federal health and safety agencies such as the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have been actively involved in monitoring and investigating issues related to RF exposure. For example, the FDA has issued guidelines for safe RF emission levels from microwave ovens, and it continues to monitor exposure issues related to the use of certain RF devices such as cellular telephones. NIOSH conducts investigations and health hazard assessments related to occupational RF exposure.

Federal, state and local government agencies and other organizations have generally relied on RF exposure standards developed by expert non-government organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the National Council on Radiation Protection and Measurements (NCRP). Since 1996, the FCC has required that all wireless communications devices sold in the United States meet its minimum guidelines for safe human exposure to radiofrequency (RF) energy. The FCC's guidelines and rules regarding RF exposure are based upon standards developed by IEEE and NCRP and input from other federal agencies, such as those listed above. These guidelines specify exposure limits for hand-held wireless devices in terms of the Specific Absorption Rate (SAR). The SAR is a measure of the rate that RF energy is absorbed by the body. For exposure to RF energy from wireless devices, the allowable FCC SAR limit is 1.6 watts per kilogram (W/kg), as averaged over one gram of tissue.

All wireless devices sold in the US go through a formal FCC approval process to ensure that they do not exceed the maximum allowable SAR level when operating at the device's highest possible power level. If the FCC learns that a device does not confirm with the test report upon which FCC approval is based – in essence, if the device in stores is not the device the FCC approved – the FCC can withdraw its approval and pursue enforcement action against the appropriate party.

Recent Developments

Several US government agencies and international organizations work cooperatively to monitor research on the health effects of RF exposure. According to the FDA and the World Health Organization (WHO), among other organizations, to date, the weight of scientific evidence has not effectively linked exposure to radio frequency energy from mobile devices with any known health problems.

The FDA maintains a website on RF issues at www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm. The World Health Organization (WHO), which has established an International Electromagnetic Fields Project (IEFP) to provide information on health risks, establish research needs and support efforts to harmonize RF exposure standards, provides additional information on RF exposure and mobile phone use at www.who.int/mediacentre/factsheets/fs193/en/index.html. For more information on the IEFP, go to www.who.int/peh-emf/en.

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Some health and safety interest groups have interpreted certain reports to suggest that wireless device use may be linked to cancer and other illnesses, posing potentially greater risks for children than adults. While these assertions have gained increased public attention, currently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses. Those evaluating the potential risks of using wireless devices agree that more and longer-term studies should explore whether there is a better basis for RF safety standards than is currently used. The FCC closely monitors all of these study results. However, at this time, there is no basis on which to establish a different safety threshold than our current requirements.

You can find additional useful information and links to some of the other responsible organizations on the FCC's website at www.fcc.gov/encyclopedia/radio-frequency-safety.

What You Can Do

Even though no scientific evidence currently establishes a definite link between wireless device use and cancer or other illnesses, and even though all cell phones must meet established federal standards for exposure to RF energy, some consumers are skeptical of the science and/or the analysis that underlies the FCC's RF exposure guidelines. Accordingly, some parties recommend taking measures to further reduce exposure to RF energy. **The FCC does not endorse the need for these practices,** but provides information on some simple steps that you can take to reduce your exposure to RF energy from cell phones**. For example,** wireless devices only emit RF energy when you are using them and, the closer the device is to you, the more energy you will absorb.

Some measures to reduce your RF exposure include:

- Use a speakerphone, earpiece or headset to reduce proximity to the head (and thus exposure). While wired earpieces may conduct some energy to the head and wireless earpieces also emit a small amount of RF energy, both wired and wireless earpieces remove the greatest source of RF energy (the cell phone) from proximity to the head and thus can greatly reduce total exposure to the head.

- Increase the distance between wireless devices and your body.

- Consider texting rather than talking - **but don't text while you are driving**.

Some parties recommend that you consider the reported SAR value of wireless devices. However, comparing the SAR of different devices may be misleading. First, the actual SAR varies considerably depending upon the conditions of use. The SAR value used for FCC approval does not account for the multitude of measurements taken during the testing. Moreover, cell phones constantly vary their power to operate at the minimum power necessary for communications; operation at maximum power occurs infrequently. Second, the reported highest SAR values of wireless devices do not necessarily indicate that a user is exposed to more or less RF energy from one cell phone than from another during normal use (see our guide on SAR and cell phones at www.fcc.gov/guides/specific-absorption-rate-sar-cell-phones-what-it-means-you). Third, the variation in SAR from one mobile device to the next is relatively small compared to the reduction that can be achieved by the measures described above. Consumers should remember that all wireless devices are certified to meet the FCC maximum SAR standards, which incorporate a considerable safety margin. (Information about the maximum SAR value for each phone is publicly available on the FCC website at www.fcc.gov/encyclopedia/specific-absorption-rate-sar-cellular-telephones.)

Other Risks

Some studies have shown that wireless devices might interfere with implanted cardiac pacemakers if used within eight inches of the pacemaker. Pacemaker users may want to avoid placing or using a wireless device this close to their pacemaker.

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SAR For Cell Phones: What It Means For You

There is considerable confusion and misunderstanding about the meaning of the maximum reported Specific Absorption Rate (SAR) values for cell phones (and other wireless devices). SAR is a measure of the rate of RF (radiofrequency) energy absorption by the body from the source being measured – in this case, a cell phone. SAR provides a straightforward means for measuring the RF exposure characteristics of cell phones to ensure that they are within the safety guidelines set by the FCC.

Many people mistakenly assume that using a cell phone with a lower reported SAR value necessarily decreases a user's exposure to RF emissions, or is somehow "safer" than using a cell phone with a high SAR value. While SAR values are an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone, a single SAR value does not provide sufficient information about the amount of RF exposure under typical usage conditions to reliably compare individual cell phone models. Rather, the SAR values collected by the FCC are intended only to ensure that the cell phone does not exceed the FCC's maximum permissible exposure levels even when operating in conditions which result in the device's highest possible - but not its typical - RF energy absorption for a user.

SAR Training

SAR testing uses standardized models of the human head and body that are filled with liquids that simulate the RF absorption characteristics of different human tissues. In order to determine compliance, each cell phone is tested while operating at its highest power level in all the frequency bands in which it operates, and in various specific positions against the dummy head and body, to simulate the way different users' typically hold a cell phone, including to each side of the head. To test cell phones for SAR compliance, the phone is precisely placed in various common positions next to the head and body, and a robotic probe takes a series of measurements of the electric field at specific pinpoint locations in a very precise, grid-like pattern within the dummy head and torso. All data for each phone placement are submitted as a part of the equipment approval test report for final authorization. However*, only the highest SAR values* for each frequency band are included in the final authorization to demonstrate compliance with the FCC's RF guidelines.

What SAR Shows

The FCC requires that cell phone manufacturers conduct their SAR testing to include the *most severe, worst-case (and highest power) operating conditions for all the frequency bands* used in the USA for that cell phone. The SAR values recorded on the FCC's authorization and in the cell phone manual to demonstrate compliance with Commission rules indicate only the highest single measurement taken for each frequency range that the particular model uses. FCC approval means that the device will never exceed the maximum levels of consumer RF exposure permitted by federal guidelines, but it does not indicate the amount of RF exposure consumers experience during normal use of the device. While only the maximum SAR values are used for FCC approval, all test reports submitted by the manufacturer are available *in full* for public inspection on the Commission's website.

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What SAR Does Not Shows

The SAR value used for FCC approval does not account for the multitude of measurements taken during the testing. Moreover, cell phones constantly vary their power to operate at the minimum power necessary for communications; operation at maximum power occurs infrequently. Consequently, cell phones cannot be reliably compared for their overall exposure characteristics on the basis of a single SAR value for several reasons (each of these examples is based on a reported SAR value for cell phone A that is higher than that for cell phone B):

- Cell phone A might have one measurement that was higher than any single measurement for cell phone B. Cell phone A would, therefore, have a higher reported SAR value than cell phone B, even if cell phone B has higher measurements than A in most other locations and/or usage configurations. In such a case, a user generally would receive more RF energy overall from cell phone B.

- Cell phone A might communicate more efficiently than cell phone B, so that it operates at lower power than cell phone B would under comparable conditions. Consequently, a user would receive more RF energy overall from cell phone B.

- The highest value from cell phone A might come from a position which the user seldom or never employs to hold a phone, whereas that user might usually hold a phone in the position that resulted in the highest value for cell phone B. Therefore, the user would receive the highest RF exposure that cell phone B delivers but would not receive the highest RF exposure that cell phone A delivers.

The Bottom Line

ALL cell phones must meet the FCC's RF exposure standard, which is set at a level well below that at which laboratory testing indicates, and medical and biological experts generally agree, adverse health effects could occur. For users who are concerned with the adequacy of this standard or who otherwise wish to further reduce their exposure, the most effective means to reduce exposure are to hold the cell phone away from the head or body and to use a speakerphone or hands-free accessory. These measures will generally have much more impact on RF energy absorption than the small difference in SAR between individual cell phones, which, in any event, is an unreliable comparison of RF exposure to consumers, given the variables of individual use.

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