

RADIATION EXPOSURE OF CELL PHONES & ITS IMPACT ON HUMAN HEALTH – A CASE STUDY IN SOUTH ASIA (BANGLADESH) AND SOME RECOMMENDATIONS

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ABSTRACT

This paper goes for a simple but elaborate measurement of the sensitivity of human health due to the radiation of mobile phone while using it. The possible risks by radio frequency electromagnetic field exposure of the human body are a major concern for the society. If exposure is sufficiently intense, it can cause biological effects. The increasing use of mobile phone in our environment it is one of the reasons why many scientists believe some disease rates are on the rise. It is scientifically proved that the radiations produced by the mobile phones affect especially the brain of human being and it will give them the difficulty to cope up with their systematized daily course of action and soon cause health injury. In this paper, it has been shown that there lies a tangible congruence of the result of statistical analysis based on an extensive survey all over Bangladesh on different level of mobile users with the hazards.

Keywords: *Radiation, Cell Phones, Biological Effects, Health, Statistical Analysis.*

1. INTRODUCTION

The telecommunication industry is experiencing a robust growth on a global scale and the cell phones are becoming an essential tool in the global modern society as they allow people to maintain constant and continuous communication without hampering their freedom of movement. Since the introduction of cell phones in the mid - 1980's, there has been significant increase in the number of cell phone users and installations of base stations. As of 2005, statistics shows that there are 1.6 billion cell phone subscribers worldwide and day-by-day it is increasing rapidly. Though phone manufacturers, regulatory agencies and service providers assure that cell phones are safe, the global debates and controversy over the health effects of these products continue. Several studies on health effects present irrefutable evidence confirming that increased occurrences of some symptoms and diseases are directly related to the exposure of cell phone operating frequencies and output power levels. It is therefore a great demand for studying in the laboratory about biological effects that can lead to health impairment. The renewal knowledge can be used as a foundation for new exposure limits that take into account of thermal and non-thermal biological effects of microwave

radiations from cellular phones and base stations. Motivated by the activities of cell phone concerning with human body we tried to pick up our best assumptions by case study in this article and finally we have suggested some suggestions.

2. LIFE CYCLE ASSESSMENT (LCA)

According to ISO 14040, Life Cycle Assessment (LCA) is a method for assessing the environmental aspects & potential impacts associated with a good or a service delivered by:

- 1) Compiling an inventory of relevant input & output of a product system (LCI).
- 2) Evaluating the potential environmental aspects associated with those inputs & outputs (LCIA).

The new Life Cycle Impact Assessment (LCIA) methodology IMPACT 2002+ proposes a feasible implementation of a combined midpoint/damage approach, linking all types of Life Cycle Inventory (LCI) results via 14 midpoint categories to 4 damage categories.

The basic idea of a Life Cycle Impact Assessment is to couple a Life Cycle Inventory of different consumption and pollutants emitted during the considered process with a LCIA methodology,

i.e. to multiply the amount consumed/emitted from the different elementary flows with the characterization factors for these respective flows for the respective impact. An elementary flow can have an impact on different midpoint categories within same or different damage categories^[1].

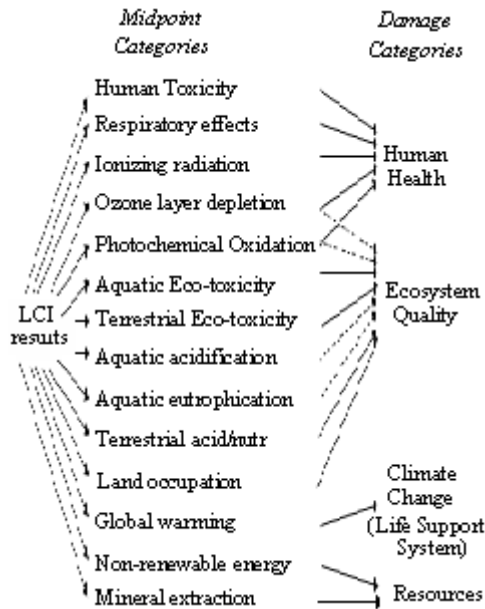


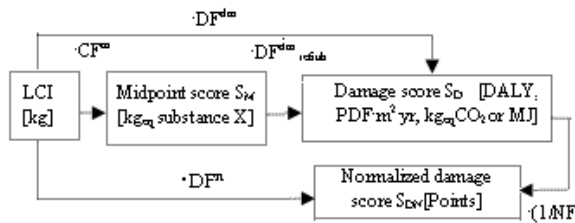
Figure 1: Overall scheme of the IMPACT 2002+ framework, linking LCI results via the midpoint to damage categories.

The scores can be calculated as,

$$\text{Midpoint score (SM)} = \sum(\text{emissions} \cdot \text{CF}^{\text{mi}})$$

$$\text{Damage score (SD)} = \sum(\text{emissions} \cdot \text{DF}^{\text{dmi}})$$

$$\text{Normalized damage score (SDN)} = \sum(\text{emissions} \cdot \text{DF}^{\text{ni}})$$



[CF^{mi} = Midpoint characterization factor, DF^{dmi} = Damage factor for the considered midpoint categories, $\text{DF}^{\text{dmi}}_{\text{refsub}}$ = Damage factor for the considered reference substance, DF^{ni} = Normalized damage factor, NF^{d} = Normalization factor for the considered damage category.]

Figure 2: Basic structure for impact evaluation.

3. RADIATION EXPOSURE

The cellular phone has to emit radio frequency energy at levels high enough to reach base stations (antenna towers). Since the energy is emitted as a microwave in the direct vicinity of the users head there are concerns about the safety of this technology. There are reports from cell studies as well as animal studies that there may be a significant risk of developing cancer tumors, foremost brain tumors in the user of cellular phones. Depending on the level of exposure, radiation can adversely affect individuals directly and their descendants indirectly. Radiation can affect cells of the body, increasing the risk of cancer or harmful genetic mutations that can be passed on to future generations; or, if the dosage is large enough to cause massive tissue damage, it may lead to death within a few weeks of exposure [2][3][4].

4. SPECIFIC ABSORPTION RATIO (SAR)

SAR is a measure of the amount of radio frequency (RF) energy that is absorbed by the tissue in the human body that is measured in watts per kilogram. This measurement is used to determine whether a cell phone complies with the safety guidelines. The exposure limit takes in consideration with the body's ability to remove heat from the tissues that absorb energy from the cell phone & is set well below levels known to show biological effects. The U. S. Federal Communications Commission (FCC) & International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommend the localized SAR in the head is to be limited to 1.6 – to - 2 Watts per kilogram averages over any 10g mass of tissues in the head [5][6].

5. HEALTH RISK

With reference to the handsets, the effect of radio waves emitted by the cell phone communication, especially with specific reference to human health, can be categorized as, thermal, non thermal and genotoxic. Thermal effect is one whereby the electromagnetic field of radio waves induces polar molecules that generates dielectric heat letting the live tissues die. For instance some part of head, while receiving the message through radio waves if it happens to experience increased temperature can have damaged nerve fibers. Next to the thermal effect is non-thermal effect, in which keeping the temperature generated by radio waves constant (only the electric current) passes through the cell

membrane, while transceiving messages^{[7][8]}, and finally the genotoxic effect, which includes damage to chromosomes, alterations in the activity of certain genes and a boosted rate of cell division^[9]. Table-1 shows various reported symptoms and diseases reported by various scientists of different countries.

Table 1: Reported Symptoms and Diseases

Bibliography Source	Reported symptoms & diseases
[10]	Headaches, warmth to the ear and burning sensations on the facial skin.
[11][17] [19]	Memory loss, brain cancers and tumors and Alzheimer's disease.
[12][19]	Decline in the level of acetylcholine, a brain chemical crucial for memory and learning.
[13]	Intra-epithelial tumors, neuro-cognitive symptoms, nerve sheath tumors (including acoustic neuromas) and sleep disorders.
[14]	Blood pressure, kidney damage, Leukemia and other blood cancers, lymphoma and melatonin reduction.
[15][18]	Anxiety, birth defects, calcium ion changes, chronic fatigue, crohns disease, depression and heart disease.
[16][18]	Diabetes, disorientation, epilepsy, facial rashes and swelling, genetic damage, fibromyalgia.

6. RISK REDUCTION MEASURES & REGULATIONS

- ◆ Regulations of the field strength and power density.
- ◆ Regulations involving the specific absorption ratio (SAR).
- ◆ RF-shields between the cell phone and the user.

ICNIRP and FCC established exposure limits to RF frequency from 3 KHz to 300 MHz range for both occupationally exposed workers and general public. These organizations also set the limit for whole body exposure for occupationally exposed workers to 0.4 W/kg and general public to 0.08 W/kg in the frequency range of 10 MHz to 10 GHz. Radio-communication equipments should be tested and monitored for non-ionizing

electromagnetic radiation in accordance with guidelines established by ICNIRP and FCC^{[22][23]}.

Phone-shielding technologies can redirect and control near field exposure of the cell phone radiation. These shielding devices would be most effective when the phone is used outdoors, far from reflecting (particularly metallic) surfaces^[23]. Though the effectiveness of shields in reducing exposures to cell phone RF fields is relatively unexplored, one may use these devices to control near field radiation effects.

7. MIGRATION TECHNIQUES

In comparison to the base stations, the effects from handsets radiation are much more complex, unpredictable and significantly stronger due to the proximities reactive near field electromagnetic conditions for the user. The transmitted power from ordinary handset is absorbed in the user's head, hand or body due to the very small distance and strong interactions. Several smart antennas shown in fig. 3 (efficient planner micro-strip antennas) such as *Planar Inverted F Antenna* (PIFA), *Dual Meandering Antenna* (DMA) are implemented in the handsets, which increase the distance of the antenna from the user's head by 2 to 3 cm and reduce the absorption by the user's head and enhance the propagation efficiency in the direction of the base stations^{[24][25]}.

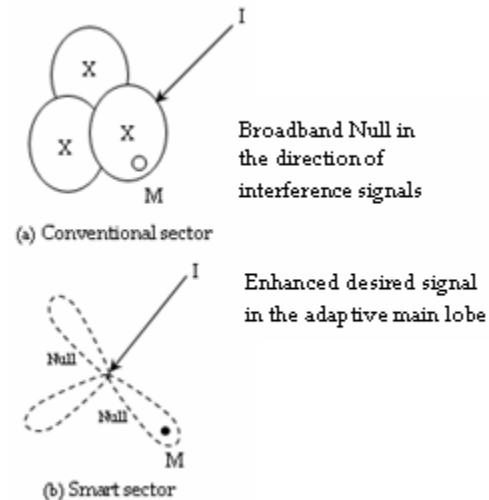


Figure 3: Comparison between conventional and smart antenna.

However the phase cancellation principle used in this technique is efficient for fixed radio systems but not for mobile handsets where the proximate distance and the coupling to the user's head are always changing. One of the most recent migration techniques suggests a compact mobile

handset apparatus using a two part fold-over mobile phone where the lower part contains all the non-radiating low frequency/power circuits and the upper part contains high frequency power amplifier, multiplexer and the monopole antenna to a distance of 8-16 cm. This technique named R95 significantly increases antenna efficiency and reduces drastically the SAR to the user's head^{[25][26][27]}.

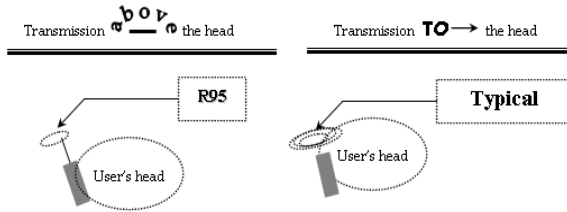


Figure 4: The R95 concept.

Recently a group of scientists from the University of Toronto, Canada used the Galerkin moment method to compute the SAR from conventional handsets to homogeneous and heterogeneous head models. The handsets radiating antennas were helical at 893 and 1881 MHz and monopole whip at 907 MHz. In their simulations and computations (Table-2) they included the handset model R95 (fig. 4) at 907 MHz which shows that the SAR of this model is about 100 times less than the conventional model using homogeneous head model and 50 times less for heterogeneous model.

Table 2: Galerkin sample to compute the SAR from conventional handsets to homogeneous and heterogeneous head models.

Antenna Type	Simulation time using Galerkin method	SAR (Galerkin sample for homogeneous head model)	SAR (Galerkin sample for heterogeneous head model)
Helical @ 893 MHz	7.6 minutes	2.1	0.65
Helical @ 1881 MHz	7.4 minutes	1.5	0.19
Monopole @ 907 MHz	6.9 minutes	1.9	1.0
Modified R95 @ 907 MHz	7 minutes	0.020	0.012

8. METHODOLOGY

It is a casual study directed toward determining the impact of cellular phone on human health. The data have been collected from primary data

by sample survey aided by a structured questionnaire. The respondents have been chosen of aged above 16 years from different cities (Dhaka, Chittagong, Sylhet, Rajshahi, Khulna and Comilla) of Bangladesh. In this research we have used Z distribution for test hypothesis. Among various distribution processes this one is more appropriate for our work as our sample size is large (7650 respondents). Besides this Z distribution contains more accurate, symmetric and easy calculations.

9. EVALUATION MATRIC

Median is used to calculate the average duration and frequency of communication through cell phone which is defined as

$$Me = L + \frac{\frac{(n+1)}{2} - p.c.f}{f_m} \times l_m \quad (\text{equ}^n 1)$$

where L is the lower limit of the median class, l_m and f_m is the length and frequency of the median class respectively, $p.c.f$ is the cumulative frequency of the pre-median class and n is the sample size. [Sample size, n = 7650]

Ho: $\mu = 3$, i.e. Null Hypothesis μ is equal to 3 point. It means mobile phone may cause health hazard or not.

H1: $\mu > 3$, i.e. Alternative Hypothesis μ is greater than 3 point. It means mobile phone cause hazard on human body.

Z distribution for test hypothesis is defined as

$$Z_{c.l} = \frac{\bar{X} - \mu}{\frac{S}{\sqrt{n}}} \quad (\text{equ}^n 2)$$

where S is the Standard Deviation defined as

$$S = \sqrt{\frac{\sum(x - \bar{x})^2}{n-1}} \quad (\text{equ}^n 3)$$

10. SURVEY OUTCOME

It has been revealed from the study that people spend about an average of 57.33 minutes per day for communication purpose through cell phone (table 3) and the average frequency of communication is about 9.80 times per day (table 4). So the span of time per call for the said purpose is about 5.85 minutes (average), which is fairly large amount of duration of communication through cell phone.

Table 3: Duration of communication through cell phone per day.

Range (Per day)	Frequency (f)	Cumulative Frequency (c.f.)
Less than 10 min	1709	1709
10 – 39 min	1938	3647
40 – 59 min	1861	5508
1 – 1.5 hour	1199	6707
More than 1.5 hour	943	7650

Table 4: Frequency of communication through cell phone per day.

Range (Per day)	Frequency (f)	Cumulative Frequency (c.f.)
Less than once	229	229
1 – 3 times	1046	1275
4 – 6 times	2448	3723
7 – 9 times	2193	5916
More than 10 times	1734	7650

As a result the mobile users are affected by mobile radiation and they suffer from various diseases. Fig. 5, 6, 7 and 8 shows the subscriber versus diseases diagram of different level of users in percentage.

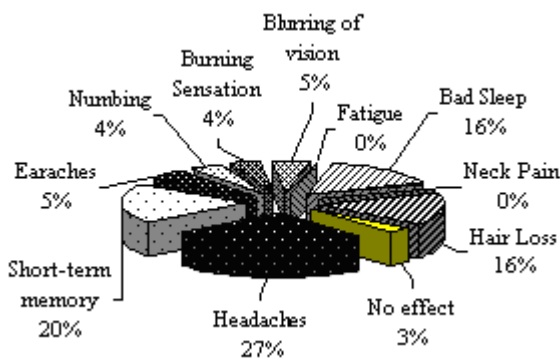


Figure 5: Subscriber (2000 students) versus diseases

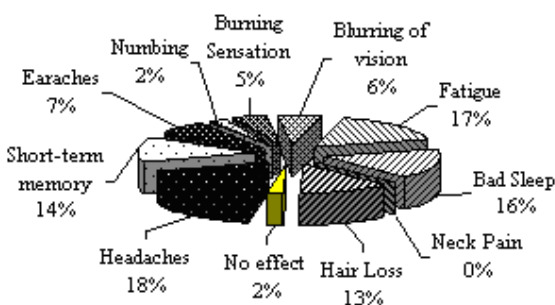


Figure 6: Subscriber (150 teachers) versus diseases

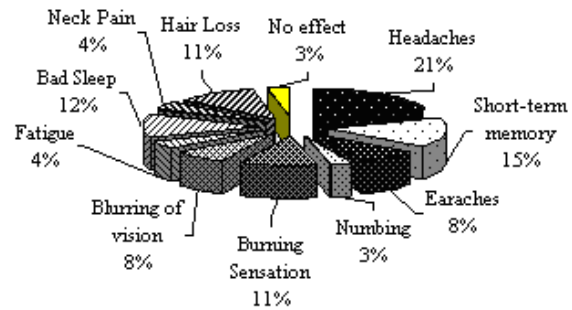


Figure 7: Subscriber (2500 service holders & businessman) versus diseases

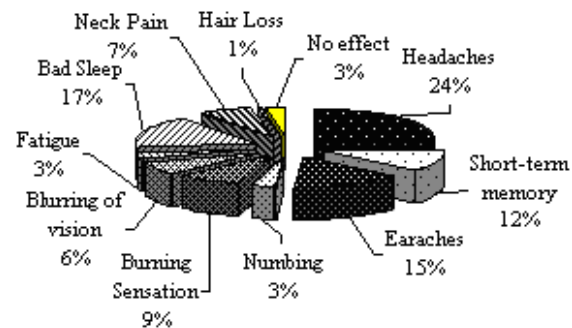


Figure 8: Subscriber (3000 general public) versus diseases

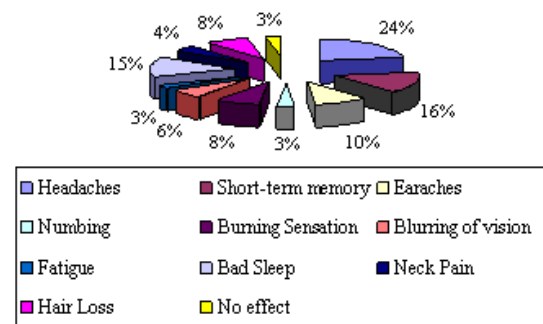


Figure 9: Overall health effects of subscriber

Fig. 9 shows the overall health effects of the cell phone users. This diagram determines that among the 7650 respondents 24% claimed on headaches, 15% on bad sleep, 10% on earaches, 16% on short-term memory loss, 8% on hair loss, 8% on burning sensation, 6% on blurring of vision and 3% claimed no effects on health.

It has been proved that SAR value of a particular mobile phone may cause damage to human health to some extent. But it is not the only reason that is responsible for hazards. There might be variety of reasons. It has been observed that a mobile having a low SAR value may cause more damage than a mobile having that of higher value. Fig. 10 shows that most of the people in

Bangladesh are using cell phones of low SAR value but they are facing various diseases.

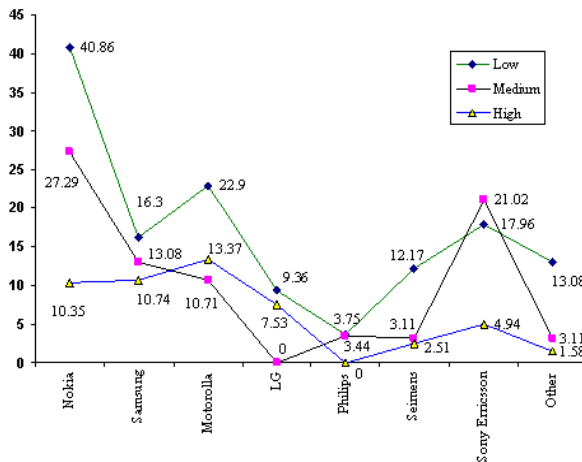


Figure 10: Use of cell phones of different SAR value

So the rate of hazards of human health due to use of mobile phone might not thus be estimated only on SAR value; rather many other factors such as long term use, large amount of duration are accrued in this regard.

11. RECOMMENDATIONS

We have reached to a cumulative decision based on extensive literature reviews (related works) and our findings from survey that hazards caused by using cell phones are real and are getting increased significantly and Bangladesh is not out of these nuisances.

We may suggest some undeniable steps due to get rescued from it:

- Using cell phone only when a conventional phone is not available.
- Using a handset to places more distant between users' head and the antenna (the main source of radiation).
- Keeping the phone off of users' lap as well.
- Governmental control/regulation for cell phone specification.
- Using cell phone with lowest output power.
- Avoid long conversations and frequent use.
- Tightening of exposure guidelines.
- Planning guidance on base station locations.
- Providing comparative information on the SAR from cell phones to the customer.

12. CONCLUSION

The use of cell phone is increasing tremendously day-by-day but most of the people of Bangladesh (who use cellular phone) have no knowledge how the cell phones impact on human health. It is almost clear from the research that the radiation from cell phone is responsible for many diseases like brain tumor, headaches, short-term memory loss, different types of heart diseases etc. In the presence of various RF sources, including cell phone handsets and broadcast antennas which contribute the overall environmental exposure has become a great concern about safety of this new technology and as well as human health. However we should contribute more efforts to transform mobile radio communication to an efficient, secure and convenient system useful for the welfare and positive advancement to Bangladesh and for the global society. And for this the Government and BRTC should take necessary steps for the mobile industry with proper regulations.

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