Chapter 7

Risk of brain tumors from wireless phone

7.1. Introduction

The debate regarding the health effects of low-intensity electromagnetic radiation from sources such as power lines, base stations and cell phones has recently been rekindled. The wireless communication has dramatically influenced our lifestyle; its impact on human health has not been completely assessed. Widespread concern continues in the community about the deleterious effects of radiofrequency radiations on human tissues and the subsequent potential threat of carcinogenesis. Exposure to low frequency electromagnetic field has been linked to a variety of adverse health outcomes. We have surveyed the results of early cell phone studies, where exposure duration was too short to expect tumor genesis, as well as two sets of more recent studies with longer exposure duration: the Interphone studies and the Swedish studies led by Hardell [128].

Health hazards due to the extensive use of cell phones among ever growing schemes of society are a matter of concern. Effect of radio frequency radiation (RFR) on the human giving rise to brain tumor is being extensively studied all over the world. Investigations suggest that the use of mobile phone for ten or more years can dramatically increase the risk of developing a tumor [129-130].
Mobile phones use electromagnetic radiation in the microwave range and this may be harmful to the human health. Some national radiation advisory authorities have recommended measures to minimize the exposure of their citizens to other digital wireless systems, such as data communication networks [152-154]. The studies by cell phone industries show [131-133] that the cell signal is absorbed deeply into the brains of children and up to 2 inches into an adult skull. Fig. 7.1 (Courtesy from ref. [134]) shows an estimate of the absorption of radio frequency radiation into the brain based on age. Salford et al., document serious neuronal damage in rat brains following an exposure to a microwave radiation from a cell phone, at levels comparable to what people would experience during the normal use. Damage to nerve cells was observed in several places within the brain, including the cortex, hippocampus and basal ganglia [135]. Currently there is an international effort underway to develop and conduct long-term toxicology studies on the potential health effects associated with cellular phone RFR emissions.

Independent research by a number of investigations has suggested a link between brain tumors and cell phone use [136-137]. Cell phones radiate microwaves, as do microwave ovens. An overwhelming majority of the European Parliament has voted for a set of changes based on health concerns associated with electromagnetic fields. Cell phone radiation damages DNA, an undisputed cause of cancer. Cell phone radiation has been shown to cause the blood-brain barrier to leak. The leakage of Blood-Brain Barrier (BBB) resulting from cell phone use, increases the possibility of brain tumors. A study discovered remarkable differences between the independent research and the industry funded research in favor of industry interests. By falsifying the evidence...
the latter showed that the radiation could protect against tumors. The protective effect study is illustrated in Fig. 7.2 (Courtesy from ref. [138]).

![Figure 7.2: A study of industry bias in brain tumor research.](image)

**7.2. Cellular Technology**

Cell phone technology consists of base stations called transmission tower antennae and cell phone hand-held units. The latest system currently is based on adaptations of CDMA (code division multiple access) and TDMA (time division multiple access) (800 and 1900 MHz). Radio waves emitted by modern GSM (global system of mobile) handsets have a peak power of 1 to 2 W, whereas other digital cellular technologies have power outputs of below 1 W, level generally regarded as being safe by international regulatory authorities. The output power of the phone is generally set to the highest level during handovers between network base stations as a user moves from one geographic area to another or when signal interference is greatest. In rural areas, base station power output is much higher because of the vast areas requiring coverage between sparsely distributed base stations and cell phones rurally are more often at their maximum power output during use in order to maintain good communication [139-140].
7.2.1. Electromagnetic radiation (EMR)

An EMF is composed of an electric field generated by differences in voltage and a magnetic field generated by the flow of current. The field propagates at the speed of light in waves of a certain length that oscillate at a certain frequency. Electromagnetic radiation is often described by its frequency—the number of oscillations of the perpendicular electric and magnetic fields per second and is expressed in hertz. Cell phones operate by the bidirectional transmission of radio waves of ultra-high frequency. The Global System of Mobile (GSM) communication cell phones operate at a frequency of 900 or 1800 MHz. The interaction of cell phones with the base station via radio frequency radiation (RFR) occurs even when the phone is not in use. The frequency at which cell phones operate is in the same spectrum as that utilized by televisions and radios, thus identified as RFR [141-142]. RFR in this range is non-ionizing radiation. It does not carry enough energy to completely move an electron none from an atom or molecule. Instead, the energy is sufficient only for excitation, the movement of an electron to a higher energy state. Therefore, RFR emitted by cell phones does not cause damage to tissues via thermal means of radiation damage [187]. RF energy, on the other hand, produces heating of tissue. Although there is a small amount of experimental evidence that suggests RF energy can impact DNA in rats, this data has been contradicted by several other animal studies and is not well substantiated. The investigation into cell phone safety must look for non-thermal means of cancer promotion.

Fig. 3: Energy radiations.

The intensity of EMR varies with the distance from the source according to the inverse square law. The specific absorption rate (SAR) measures the rate at which radiation is absorbed by the human body and is therefore relevant to exposure. For the head, the Federal Communications
Commission (FCC) has set an acceptable SAR of 1.6 W/kg. In cellular telephony, the SAR
depends on several factors, including the antenna type and position, head morphology, the
distance between the phone and the head and the power output of the phone that can vary.
Exposure of the brain depends on the type of phone and position of the antenna but tends to be
highest in the temporal lobe and insular region and overlying skull, scalp and parotid gland
tissues. Irrespective of the type of phone, exposure is highest on the side of the head against
which the cell phone is held and appears to be even higher in children owing to thinner scalps
and skulls, increased water content of their brain and lower brain volume [139-140, 143-145].

7.3. Major Study and Analysis

This review covers all case-control studies on the risk of brain tumors from cell phone use
published up to 2009 including epidemiological studies on the risk of brain tumors from
exposure to other sources of electromagnetic fields (EMFs). There are only 11 published studies
examining long-term cell phone use (i.e., use for 10 years) and the risk of developing a brain
tumor [146-151]. Since each set uses a common protocol, each can be considered a single study.
The two sets are the industry-funded Interphone studies and the independently funded Swedish
studies reported by Hardell team. The Hardell studies are comprehensive case-control studies
looking at data exclusively from Sweden acquired between 1997 and 2003, whereas the
Interphone study is a multinational collective of several comprehensive case-control studies
looking at data acquired between 1999 and 2004.

7.3.1. The INTERPHONE Study

The objective of this 13 nations study was to assess whether radiofrequency radiation
exposure from cell phones is associated with tumor risk, specifically, risk of glioma,
meningioma, acoustic neuroma and parotid gland tumors. This non-blinded, interview-based,
substantially wireless industry-funded case-control study was designed to have enough statistical
power to detect an increase in risk over the period of 5 to 10 years from the commencement of
cell phone use. The salient fact of these early studies is the short duration of cell phone use.
There were following several flaws which were not investigated by Interphone studied.
(i) Cell phones radiating higher power levels in rural areas are not investigated.
(ii) Exposure to other transmitting sources are not considered.
(iii) Exclusion of brain tumor cases because of death or too ill to respond.
(iv) Tumors outside the cell phones radiation plume are treated as exposed.

The radiation plume's volume is a small proportion of the brain's volume. Treating tumors outside the radiation plume as exposed tumors, results in an overestimation of risk. The adult brain absorbs the cell phones radiation almost entirely on the side of the head where the cell phone is held (ipsilateral); almost no radiation is deposited on the opposite side of the head (contralateral). In adults the ipsilateral temporal lobe absorbs 50–60% of the total radiation and is ~15% of the brain's volume. The ipsilateral cerebellum absorbs 12–25% of the total radiation and is ~5% of the brain's volume.

7.3.2. The Hardell Studies

These studies had no industry funding and are entirely independently funded Swedish studies led by Dr. Hardell. The Interphone studies have handled more cases than the Hardell studies. However, the Hardell studies have more cases that used a cell phone for 10 or more years. The Hardell team concludes that the higher the cumulative hours of use, / higher the radiated power, / higher the number of years since first use, / higher the exposure and younger the user then higher the risk of brain tumor [129, 136, 139, 140, 147-148]. Hardell et al., have performed six case-control studies in the area of cellular and cordless phones and tumors. Three of the studies concerned brain tumors; one, salivary gland tumors; one, NHL; and one, testicular cancer. In brief, significantly elevated risks of developing an ipsilateral astrocytoma and acoustic neuroma were found in analogue and digital cell phone and cordless phone users. This study also has only three flaws i.e., tumors outside the cell phones radiation plume are treated as exposed, tumors outside the cell phones radiation plume are treated as exposed and exclusion of brain tumor cases because of death or too ill to respond.

7.3.3. Results of Meta-analysis

The meta-analysis shows that long-term cell phone usage can approximately double the risk of developing a glioma or acoustic neuroma in the more exposed brain hemisphere. Each of the three tumor types studied is associated with different odds ratios and confidence intervals and elevated risks of only 2 of the 3 types, namely, glioma and acoustic neuroma, reached statistical
significance. This work address an important and timely public health concern, namely, long-term cell phone usage elevates the user’s risk of developing a brain tumor [155].

7.3.4. Overestimation and Underestimation

Recall bias noticed in the Interphone study has lead to EMR-exposure overestimation and not underestimation [155]. The overestimation due to recall bias may be countered by exposure underestimation secondary to four key methodological limitations [156-160]. In the context of the aforementioned methodological issues, any statistically significant elevated risk in Interphone studies may be expected to be an under-estimate of the true risk [147, 163-164].

7.3.5. Risk Agreement

The long-term epidemiologic data suggest an increased risk of being diagnosed with an ipsilateral brain tumor related to cell phone usage of 10 years or more. The data achieve statistical significance for glioma and acoustic neuroma, except for meningioma. It is concluded that the current long-term epidemiologic data are consistent in determining an increased risk of brain tumors associated with ipsilateral long-term cell phone usage. The findings of the laterality analysis of the Hardell group are consistent with those of the Interphone group when the long-term data are specifically assessed [146-147, 149]. It is observed that the results are subject to the effects of variations in subject participation rates and selection and recall biases. The currently available long-term epidemiologic evidence points to the adverse health effects. Furthermore, the findings pertaining to brain tumors are strengthened by the long-term data recently reported by Sadetzki et al. [165]. They have found significantly elevated odds for the development of ipsilateral parotid gland tumors among heavy cell phone users, effects observed to be dose-dependent. Findings from [147-148] on brain tumors and on parotid tumors [165] two groups that comprehensively assessed cell phone users in a dose-dependent manner, suggest time to tumor development and exposure or EMR-dose, i.e., cumulative cell phone use in hours.

7.3.6. Outdated CBTRUS Tumor Data

The CBTRUS (central brain tumor registry of the United States) maintains a comprehensive and unique record of age-adjusted incidence of primary central nervous system tumors. The
current CBTRUS data suggest that malignant brain tumor age-adjusted incidence overall has not increased [166-167] and the most recent data are already at least 4 years outdated.

7.4. Various Adverse Health Outcomes by Cell Phone Use

A brief overview of brain tumors and other adverse effects caused by cell phones exposures are listed below:

(i) Glioma

Glioma is a malignant type of brain tumor and comprises about 60% of all central nervous system tumors. The survival rate of malignant glioblastoma multiform is found very poor. The type of brain tumors is usually known after the cells within the nerve tissue from which they originate. There are more than 100 different types of brain tumors and the most common of these tumors originate from the supporting glial cells of the brain; hence they are called gliomas. Gliomas do not affect tissues outside the nervous system and do not usually spread outside the brain and spinal cord. There are four main types of glioma—astrocytoma, ependymoma, oligodendroglioma and glioblastoma multiforme (GBM). Gliomas are the most common malignancy of the central nervous system in adults and the prognosis is extremely poor. Recently, considerable interest has focused on whether the use of mobile phones is associated with an increased risk of gliomas and other brain tumors, even though little is known about potential mechanisms. Analogue phones emit higher average power levels than digital phones. This study suggests that there are no substantially raised risks of glioma in the 10 years after first mobile phone use. Only future studies will be able to address longer latency periods for the development of glioma [133, 148-151, 162, 168-171].

(ii) Acoustic neuroma

Acoustic neuromas are benign tumors that arise from the schwann cells, which enfold the vestibulocochlear nerve. These tumors do not undergo malignant transformation. These tumors grow slowly and the primary symptoms usually include unilateral hearing loss accompanied by tinnitus and dizziness. The tumor occurs mainly in people aged 50 years or more, except for rare tumors that develop during the course of neurofibromatosis type II, which are often diagnosed in younger persons. Women are more often affected than men, with a sex ratio close to 1.3. A
number of environmental factors have been suspected to increase the risk of acoustic neuroma. The suspected factors include electromagnetic fields emitted by hand-held cellular telephones, since this type of tumor is located in an anatomic region where a considerable amount of the power emitted from cell phones is absorbed. The power absorption is attenuated by more than 90 percent within 4–5 cm.

Electromagnetic radiation from a cell phone can penetrate the skull and deposit energy 4–6 cm into the brain. This can potentially result in a heating of the tissue of up to 0.1°C. Therefore, it has been debated whether these fields could initiate or promote cancer. Because radio-frequency signals are unlikely to cause genetic mutations, the biologic basis for a possible association between cell phone use and cancer risk has been proposed to be a thermal mechanism, such as changes in protein phosphorylation, or a nonthermal mechanism that promotes tumor growth. Although the epidemiologic studies have shown the association between use of cellular telephones and risk of acoustic neuroma. However, only the most recent case control study of prevalence showed a significantly increased risk of acoustic neuroma among users of analogue cellular telephones [147, 162, 168, 170-176].

(iii) Meningioma

Meningioma arises from the pia or archnoid, which are the covering layers of the central nervous system. The majority are benign tumors that are encapsulated and well-demarcated from surrounding tissue. Meningiomas are neoplasms originating from the meningeal tissue covering the brain and spinal cord. They are usually benign, with 1-3% exhibiting malignant growth. The incidence of meningiomas varies between populations, being higher among women than men. The aetiology of meningiomas has remained elusive, with some hereditary syndromes and high doses of ionizing radiation among the few established risk factors. Although some positive findings have been reported, so far the totality of epidemiological evidence does not demonstrate an increase in risk of meningiomas related to mobile phone use. The findings were similar regardless of telephone network type, age or sex [147, 150-151, 169-171, 177].

(iv) Testicular cancer

An increasing incidence of testicular cancer has been noted in most western countries during the recent decades. It is the most common cancer type in young men and is not regarded to be
Cryptorchidism is established risk factors, but also perinatal exposure to persistent organic pollutants with hormone activity has been suggested to be another risk factor. There has been concern in the population that use of mobile phones might be a risk factor for testicular dysfunction [168, 179-180]. A study reported an 80% increased near-significant risk (93.9%) of testicular cancer when the cell phone was kept in the left pocket, then the left testicle developed cancer; kept in the right pocket, then the right testicle developed cancer. Because there have been no cell phone studies on female fertility it is unknown if there are deleterious effects [178].

(v) Salivary gland tumors

The salivary glands, especially the parotid gland, are targets for near-field microwave exposure during calls with wireless phones. Most salivary gland tumors are benign and occur in the parotid glands. A painless salivary mass is the most common sign and is evaluated by fine-needle aspiration biopsy. Salivary gland neoplasms represent the most complex and diverse group of tumors encountered by the head and neck oncologist. Their diagnosis and management is complicated by their relative frequency (1% of head and neck tumors), the limited amount of pre-treatment information available and the wide range of biologic behavior seen with the different pathologic lesions. Further complicating the analysis of these tumors in the pediatric population is that fewer than 5% of all salivary gland tumors occur in patients younger than 16 years. Approximately 80% of salivary gland tumors are found in the parotid gland, 10 to 15% in the submandibular gland and 5 to 10% in the minor salivary glands. Approximately, 80% of parotid tumors and 50% of submandibular tumors are benign. In the pediatric population, 35% of salivary gland tumors are regarded to be malignant. Proper management of these tumors requires an accurate diagnosis by the pathologist, correct interpretation by the surgeon, knowledge of the surgical anatomy of salivary glands with a clear understanding of the factors leading to recurrence and complications. There is no association between the use of cellular or cordless phones and salivary gland tumors was found, although few studies reported for long term heavy use [133, 181].

(vi) Brain tumor risk for use of mobile phone in urban and rural areas
There is a difference in output power of digital mobile phones between urban and rural areas. Adaptive power control regulates power depending on the quality of the transmission. In rural areas with on average longer distance to the base station the output power level is higher than in urban areas with dense population and shorter distance to the base stations. The studies show risk for brain tumors in rural areas increasing as compared to urban [139].

(vii) *Malignant melanoma of the eye*

Stang et al. [182] conducted a hospital and population-based case–control study of uveal melanoma and occupational exposures to different sources of radiofrequency radiation. An elevated risk for exposure to RF-transmitting devices was reported. It is concluded that several methodologic limitations prevented their results from providing clear evidence on the hypothesized association.

(viii) *Intratemporal facial nerve tumor*

So far only one investigation has studied the risk of intratemporal facial nerve (IFN) tumor and the use of mobile phone. It is concluded that the short duration of use precludes definite exclusion as a risk for IFN tumor development [168, 183].

(ix) *Male fertility damaged by radiation*

Male fertility is damaged by cell phone radiation. This concern also is not about brain tumors, but is of such potential consequence that it is discussed here. Men and particularly teenage boys, place their cell phone in the trousers pockets when they are not holding it to their heads in conversation. There are multiple studies showing deleterious effects on sperm including decreased sperm counts and reduced sperm motility [182-186]. One study found a highly significant (99.99% confidence) 59% decline in sperm count in men who used cell phones for 4 or more hours per day as compared with those who did not use cell phones at all [185].

(x) *Breast cancer*

There is evidence from multiple areas of scientific investigations that low frequency EMF is related to breast cancer. Over the last two decades there have been numerous epidemiological studies on breast cancer in both men and women, although this relationship remains
controversial. Many of these studies reported that EMF exposures are related to increased risk of breast cancer [187]. The investigations on women in workplaces suggests that low EMF is a risk factor for breast cancer for women with long terms exposure of 10mG (1.0 μT) and higher. Laboratory examination of breast cancer cells have shown that low EMF exposure between 6mG and 12mG (0.6-1.2 μT) can interface with protective effects of melatonin for the growth of these breast cancer cells. Investigations also shows that breast cancer cells grow faster if exposed to low EMF at low environmental levels.

(xi) Non-Hogkin lymphoma (NHL)

A lymphoma is a cancer of the lymphatic system. The lymphatic system is a part of the body's immune system and helps filter out bacteria, viruses and other unwanted substances. The non-Hodgkin lymphomas (NHLs) are a diverse group of blood cancers that include any kind of lymphoma except Hodgkin's lymphomas. Types of NHL vary significantly in their severity, from indolent to very aggressive. Lymphomas are types of cancer derived from lymphocytes, a type of white blood cell. The NHL has increased since the 1960's in Sweden as well as in many western countries as a reliable cancer registry. Regarding NHL some subgroup analysis yielded increased risk but there results were based on low numbers [168].

7.5. Safety Standards and Safety Protections

7.5.1. Safety Standards

Various public health agencies have taken the initiative to develop safety standards for occupational and public exposure to RFR. The Institute of Electrical and Electronic Engineers (IEEE) has developed RFR exposure standards. It is required by law that the standards developed thereof be periodically updated and reviewed [161]. The standards can be revised if new evidence is brought to light. The World Health Organization (WHO) is also investigating the possible effects of RFR exposure as a result of cell phone and internet use and base stations. According to WHO, exposure to RFR from base stations is actually only 0.0002% to 2% of the levels of international exposure guidelines, lower or comparable to exposure from radio or television broadcast transmitters [146]. WHO, via the international electromagnetic field project, has established a program to monitor the electromagnetic field scientific literature to evaluate the
health effects from exposure to RFR. By these means WHO is able to provide advice about possible hazards and to identify suitable mitigation measures. WHO supports have promoted research to fill gaps in the knowledge of RFR exposure concerns. Another multinational consortium of independent experts, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), aims to review current literature and offer advice on the effects of non-ionizing radiation, which includes RFR from cell phones and base towers. ICNIRP and WHO periodically review the scientific literature and proceedings of scientific meetings in comparison with exposure guidelines published by ICNIRP. Agencies and initiatives such as these are important in guiding future research directives by identifying gaps in current research. Based on extensive research done on RFR exposure till date, the Federal Communications Commission (FCC) has issued warning label for cordless phones.

7.5.2. Safe radiation and cell phone radiation protection tips

As the expert groups have suggested that the radiation from mobile phones greatly exceeds safe levels even at normal usage. Therefore, even a short call can have harmful effects. Physicians and Scientists for Responsible Application of Science and Technology (PSRAST) propose European Union (EU) to require the production of mobile phones for young people allowing only SMS. There is now a considerable body of evidence proving that microwave radiation from mobile phones and cordless phones causes brain tumors, disturbed brain function and other health disturbances. The reason is that their microwave radiation has harmful effects at intensity levels far below the values declared as safe. Present safety norms have no tenable scientific support and must be updated, now that it is suggested by a considerable body of evidence that they permit far too strong radiation.

Here are some steps one can take to reduce exposure to electromagnetic energy from cell phones:
1. Limit the use of cell phones to essential calls and keep calls short.
2. Children should be allowed to use the cell phone in cases of emergency only. Because of their developing skulls, the radiation can penetrate much more deeply.
3. Wear an air tube headset (not regular wired headset). The regular wired headset has been found to intensify radiation into the ear canal. The wire transmits not only the radiation from the cell phone but also serves as an antenna attracting EMFs from the surroundings.
4. Don’t put the cell phone in pocket or belt while in use or while it is on. The body tissue in the lower body area has good conductivity and absorbs radiation more quickly than the head. One study shows that men who wear cell phones near their groin could have their sperm count dropped by as much as 30 percent.

5. If using the phone without a headset, wait for the call to connect before placing the phone next to the ear.

6. Do not use the cell phone in enclosed metal spaces such as vehicles or elevators, where devices may use more power to establish connection.

7. Do not make a call when the signal strength is one bar or less, which means the phone must work harder to establish a connection.

8. Purchase a phone with a low SAR (Specific Absorption Rate). Most phones have a SAR level listed in its instruction manual. The SAR level is a way of measuring the quantity of radiofrequency (RF) energy that is absorbed by the body.

9. Use a scientifically validated EMF protection device. There are advanced technologies available nowadays that strengthen the bioenergy field and immune system against the effects of EMF.

10. Use text instead of talk.

11. Use landlines.

12. Keep cell phone off most of the time. Let people leave messages and then call them back from a landline.

13. Limit the use of cells in rural areas.

7.5.3 Precautionary Principle (PP)

Precautionary principle should be used when there is a reasonable ground for concern. Accordingly, if there is some evidence that a problem exists and remedial actions are possible, then these actions should be undertaken. If cell phones induce brain tumors the potential public health costs are large. There is also a simple action that can reduce the absorbed cell phone radiation by several orders of magnitude. Cell phone radiation decreases as the square of the distance from the phone. As a result even small changes in distance have a dramatic effect. With the use of a headset connected the cell phone is not held directly against the ear and thus the absorbed cell phone radiation could be reduced by several orders of magnitude. An appropriate PP
action would be to mandate all cell phone manufacturers to remove the existing cell phone speaker that is placed to the ear and replace it with a headset directly connected to the cell phone.

7.6 Conclusions

There is no credible evidence to the Environmental Health and Safety Office (EHSO) about the cause of cancer or brain tumors with the use of cell phones. Most studies do not find association between the development of AN and cell phone use, but some studies that followed cases for 10 years or more did show an association. The evaluation of AN risk factors is challenging due to its long latency. Some studies of longer term cell phone use have found an increased risk of ipsilateral AN. Telecom-funded studies have been reporting highly questionable results in comparison to the independent studies. The Swedish team studies, independent of industry funding, have reported a link of brain tumor risk from cell phone use and cordless phone use. The results indicate that using a cell phone for 10 years approximately doubles the risk of being diagnosed with a brain tumor on the same (ipsilateral) side of the head as that preferred for cell phone use. People should be very restrictive with using mobile phones as there is a significant body of compelling scientific evidence indicating serious hazards from their usage. Therefore, it is advisable to reduce the usage to very few and brief calls. People below 20 should have mobile phones that allow SMS messages only, but no talking, because the risks are far higher in young people. Moreover, it has been repeatedly confirmed that the radiation from base stations is harmful to health. The existing International Council on Non-Ionizing Radiation Protection (ICNIRP) and Federal Communications Commission (FCC) exposure limits are based on a false premise that only thermal effects cause harm.

The precautionary principle clearly applies in this case, since the problem is possible but not certain and low cost ameliorating actions are easily implemented by industry. With over 3 billion people using cell phones and with children among the heaviest users, it is time for governments to mandate precautionary measures to protect their citizens. We conclude that the current standard of exposure to microwave during mobile phone use is not safe for long-term exposure and needs to be revised.