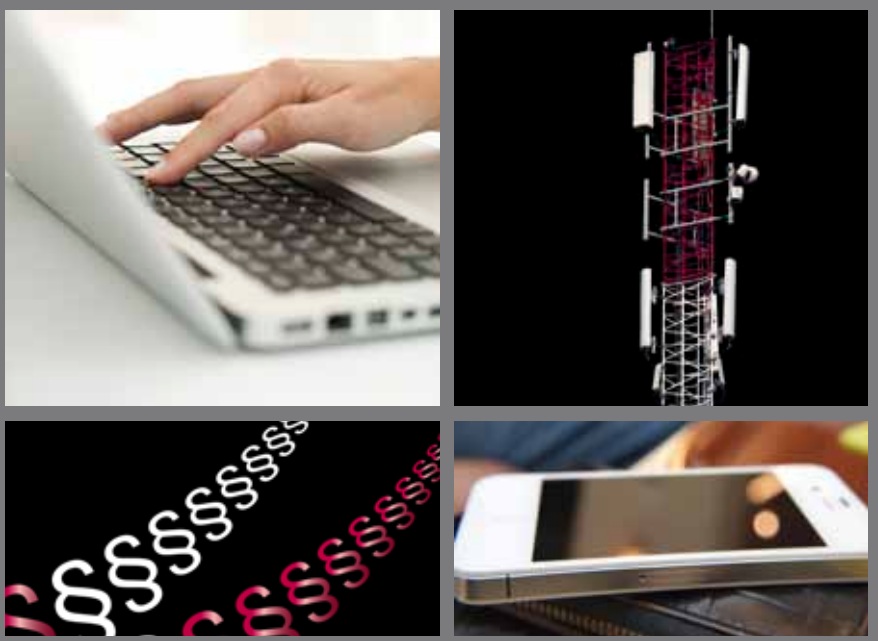
report 2012:3

Low-level radiofrequency electromagnetic fields – an assessment of health risks and evaluation of regulatory practice



Report from the Expert Committee appointed by the Norwegian Institute of Health, commissioned by the Ministry of Health and Care Services and the Ministry of Transport and Communications

English summary

Norwegian Institute of Public Health

Summary

This is the English summary extracted from the Norwegian report about low-level radiofrequency electromagnetic fields (2012:3). The summary is translated by the Norwegian Institute of Public Health.

The use of equipment that emits radio waves has increased in recent years. Wireless communication technologies such as mobile phones are widespread. In recent years, the demands for better coverage, enhanced technology and extended features for mobile phone services have resulted in a significant increase in the number and density of radio transmitters. Exposure to electromagnetic fields and its potential health effects is a prominent topic in the media. This has led to public concern and uncertainty, not only about electromagnetic fields emitted from mobile phones, but also about electromagnetic fields emitted from base stations used by mobile phones and other wireless networks. The Norwegian Radiation Protection Authority receives daily enquiries about the possible adverse health effects from such exposure. The Norwegian health authorities decided that there was a need for a wider review and assessment of the potential health effects to be carried out by scientists from various disciplines, in order to clarify any risks to human health and to assess the need for changes in the regulation of electromagnetic fields.

On the basis of the public concerns, the Ministry of Health and Care Services and the Ministry of Transport and Communications requested, in a letter dated 16.11.2009, that the Norwegian Institute of Public Health should assemble a cross-disciplinary Expert Committee. The mandate requested that the group should: "… summarise the knowledge regarding exposure to weak high-frequency fields. It shall provide a summary of the current management practices in Norway and in comparable countries. The purpose is to investigate the management and regulations concerning electromagnetic radiation, including the placement of mobile masts, base stations and wireless networks. The analysis should also include an assessment of the suitability of the threshold limit values, as well as an assessment of how the potential risks related to exposure from electromagnetic fields should be managed in Norway."

The Expert Committee was established in spring 2010 and was composed of individuals with expertise in environmental and occupational medicine, biology, physics, metrology, biophysics, biochemistry, epidemiology and philosophy, as well as expertise in administration and risk management:

Jan Alexander, MD PhD, Prof., Deputy Director-General, Norwegian Institute of Public Health (Chair of Committee)
Gunnar Brunborg, PhD, Department Director, Norwegian Institute of Public Health
Maria Feychting, PhD, Prof., Karolinska Institutet
Ellen Marie Forsberg, PhD, Senior Scientist, Work Research Institute/ Oslo and Akershus University College of Applied Sciences
Svein Gismervik, Civil Engineer, Technical Team Leader, Trondheim Municipality
Jan Vilis Haanes, MD, Chief Medical Officer, University Hospital of North Norway
Yngve Hamnerius, Prof., Chalmers University of Technology
Merete Hannevik, MSc, Head of Section, Norwegian Radiation Protection Authority
Per Eirik Heimdal, MSc, Head of Section, Norwegian Post and Telecommunications Authority
Lena Hillert, MD PhD, Associate Prof., Senior Medical Officer, Karolinska Institutet
Lars Klæboe, PhD, Senior Scientist, Norwegian Radiation Protection Authority
Petter Kristensen, MD PhD, Prof., Research Director, National Institute of Occupational Health
Bente Moen, MD PhD, Prof., University of Bergen
Gunnhild Oftedal, PhD, Associate Prof., Sør-Trøndelag University College
Tore Tynes, MD PhD, Senior Medical Officer, National Institute of Occupational Health
Bjørn Tore Langeland, PhD, Norwegian Institute of Public Health (Secretary until 31.1.2012)
Observer: Solveig Glomsrød, Foreningen for el-overfølsomme (FELO) (Association of electromagnetic-hypersensitive citizens)

Summary

The Expert Committee has reviewed and evaluated recent research in the relevant fields. They have reviewed recent research reports and expert review reports by international and national expert groups. Based on this review and on available data about exposure to electromagnetic fields, the Committee has conducted a risk assessment and also evaluated the current regulatory practice.

The Committee's experts on health and exposure to electromagnetic fields share the main responsibility for part I and part II of this report. The Committee's experts on health effects and biophysics have primarily contributed to the recommendations regarding the regulatory practices, and ensured that these are consistent with the professional evaluations.

A reference group was established in response to requests from the Ministry of Health and Care Services and the Ministry of Transport and Communications. A number of institutions were invited. The reference group consisted of: Per Morten Hoff (ICT Norway), Bjørn Erikson and Ali Reza Tirna (The Norwegian Confederation of Trade Unions (LO)), and Solveig Glomsrød (FELO). The reference group has held meetings with the Chair and the Committee's Secretariat and has provided valuable input on an ongoing basis.

1.1 Process

An overall assessment of the health risks of exposure to electromagnetic fields – the part of the frequency spectrum called radiofrequency fields (RF fields; frequency range 100 kHz-300 GHz) – has been implemented in the same way as is common for other types of environmental exposure. Health risks have been evaluated on the basis of internationally published research literature, which is very extensive for RF fields. Exposure to RF fields in the Norwegian population has been considered primarily using measurements taken by the Norwegian authorities in the course of 2010. The Expert Committee has assessed the overall health risk based on these measurements.

Part I of the report describes the current exposure to RF fields, sums up the knowledge of potential health hazards and contains a risk assessment. *Part II* of the report addresses the general health problems that are attributed to electromagnetic fields (electromagnetic hypersensitivity). *Part III* describes the risk management, risk perception and concern for harmful effects of RF fields. *Part IV* reviews the present regulation of RF fields in other countries as well as in Norway. *Part V* assesses the current regulations in Norway and provides advice on how to regulate RF fields.

1.2 Exposure to low-level RF electromagnetic fields (Chapter 3)

Levels of natural (i.e. not man-made) RF fields are very low. RF fields in the environment are therefore generated by human activity.

The sources of RF fields are primarily equipment used in communications, industry and medicine. In communication systems (e.g., mobile phones), the antenna functions most often as both the transmitter and receiver of the electromagnetic field. The main factors that affect exposure are distance from the antenna, the effect from the transmitter, frequency, the antenna's transmission

direction, the antenna location (e.g. height above ground), and the number of antennas. The source that most often provides the strongest exposure is the mobile phone.

In 2010, the Norwegian Post and Telecommunications Authority and the Norwegian Radiation Protection Authority conducted a study of exposure to RF fields in the environment. Prior to this, systematic studies had only been conducted in Norway to a limited extent, although individual measurements had been conducted on many occasions. The 2010 study included exposure from broadcasting, wireless internet (WLAN) and base stations for services like mobile broadband, mobile telephony and the public safety radio network (TETRA) in a selection of buildings and outdoors. Total exposure from all sources in the environment was less than 0.01 W/m^2 for 99 per cent of the measurement points and below 0.001 W/m^2 for 70 per cent of the measurement points. In most places, the level was well below 1/1000 of the reference values for maximum exposure as recommended by the International Commission on Non-ionising Radiation Protection (ICNIRP). These reference values apply as the threshold limit values in the Norwegian radiation protection regulations. Wireless networks were generally the weakest of the RF field sources. Base stations for mobile telephony (GSM900 and GSM1800) were, on average, the source type that contributed the most in relative terms, although the levels from these sources were still low. In office environments, wireless networks were the dominant source, but the overall exposure to RF fields was low. Similar measurements carried out in some other European countries show that the levels in Norway are comparable, with the same technology.

Due to the short distance, local exposure to the head from hand-held mobile phones is significantly higher than that from the other RF sources in the environment, and mobile phones provide the highest contribution to the total exposure for individuals. The use of hands-free mobile phones reduces exposure significantly. When a GSM mobile phone transmits at maximum power, the exposure from some models approaches the ICNIRP's reference values for maximum exposure. A greater density of base stations leads to better coverage so that mobile phones can transmit with lower power, leading to lower exposure. In recent years, technological developments have contributed further to lower exposure to RF fields. Even if usage time of mobile telephony were to continue to increase, it is assumed that the total exposure from mobile phone use may decrease because of better transmission networks and because the emitted power from newer UMTS phones is much lower than from GSM phones.

1.3 Health effects from exposure to electromagnetic fields (Chapter 4)

Chapter 4 provides a summary of possible health hazards following exposure to weak RF fields, and at which exposure levels these may occur when fields are stronger. In addition, the Expert Committee has reviewed scientific evidence about the significance of electromagnetic field exposure for individuals who experience health problems from electromagnetic fields (electromagnetic hypersensitivity).

1.3.1 Known health effects from strong RF fields

Thermal effects, i.e., heating of cells and tissues, can occur from exposure to RF fields that exceed certain intensities in the frequency range 100 kHz - 10 GHz. The degree of heating may depend on the field intensity and frequency and also on the balance between the amount of

absorbed energy per unit time and the body or tissue's ability to dissipate the heat. There are exposure thresholds above which heating becomes harmful following exposure to RF fields. It is known that whole body exposure with SAR = 4 W / kg (for a mean of 30 minutes) can cause a temperature increase of about 1 °C which is considered to be a threshold for adverse health effects, implying that a temperature increase of up to 1 °C has no negative consequences. So-called basic restriction values are derived from the exposure threshold values, with additional safety factors. For workers and the general public, the basic restriction values are, respectively, 1/10 and 1/50 of the exposure threshold value of 4 W / kg for SAR, i.e. 0.4 and 0.08 W/kg. From the basic restriction values, the so-called reference values are derived for external fields, i.e., these are values which can be measured in the air outside the body.

Excitation of nerve tissue, i.e. the initiation of nerve signals, can occur from exposure to RF fields in the frequency range up to 10 MHz when electric fields are induced above certain intensities in the body. The exposure levels required to cause excitation of nerve tissue vary with frequency. As for heating, the ICNIRP basic restriction values of electric field intensities are derived from the exposure levels, with additional safety factors. From the basic restriction values, reference values are derived for the external field.

There is a broad international consensus among experts that the ICNIRP reference values (recommended values for maximum exposure) provide good protection against both the excitation of nerve tissue and harmful heating of body tissues. For exposure at levels below the ICNIRP reference values, the ICNIRP has found no documented adverse effects, despite extensive research. No mechanisms have been identified which could account for any such effect.

The Expert Committee has used the ICNIRP's basic restriction and reference values as the foundation for its review and assessment of possible adverse effects that may occur as a result of exposure to weak RF fields. The questions discussed by the Expert Committee mainly concern whether there may be adverse effects at exposures lower than the ICNIRP basic and reference values, i.e., weak RF fields. Is there evidence of harmful effects from the scientific study of cells, animals or people? If the answer to that question is no - how good is the evidence that exposure is safe at levels below the ICNIRP levels?

1.3.2 Health effects of weak RF fields[1]

There are a large number of older and newer studies of possible health effects caused by RF fields. Compared with many other types of environmental exposure where there is a proven health risk, the research literature for weak RF fields is extensive.

The Expert Committee has reviewed previous scientific reports from independent expert panels worldwide, as well as recently published studies on the possible effects on health following exposure to weak RF fields. Emphasis has been placed on whether there is consensus among the conclusions of the various expert groups. The health effects that are most studied are : the risk of cancer development and effects associated with cancer development (e.g., DNA damage); the effects on reproduction; the nervous system; the cardiovascular system; the immune system; hormone regulation; gene expression in cells; and the significance of electromagnetic fields for individuals who experience health problems following exposure to electromagnetic fields (electromagnetic hypersensitivity). The conclusions below are based on an overall assessment of both older and newer studies, performed in either cells and tissues, in animals, or in humans - i.e., experimental clinical trials and population studies.

[1]Weak RF fields are defined by the Expert Committee as being below ICNIRP´s Reference Values

Most recent studies have investigated the possible health effects from exposure to weak RF fields at levels that are lower than those known to cause dielectric heating or excitation of nerve tissue.

Some studies observed that exposure to weak RF fields may have measurable biological effects. In several studies, it is difficult to rule out that exposure might have led to local heating. It is important to note that cells and tissues that are exposed to very low heat will respond with measurable biological responses in the same way that the body responds to other physical influences, such as heat and cold from other sources. In such cases, the body will seek to maintain normal body temperature. Thus, such biological responses do not imply that an adverse health effect has been induced.

1.3.2.1 Cancer

A number of population studies have studied possible cancer risks as a result of RF exposure. Most studies have been on head tumours in connection with the use of mobile phones, since this is the area with the highest RF exposure. Methodological problems in these studies include the risk of erroneous registration of RF exposure by mobile phone use. In cohort studies (where populations are followed and exposure data is collected before any disease diagnosis), inaccurate exposure data can mean that possible associations are not detected. In case-control studies, mobile phone use among patients who developed brain cancer is compared with mobile phone use among healthy control subjects. Exposure data is collected after diagnosis. In such studies, exposure reports can be affected by disease status, leading to false or apparent associations, where in reality there are none (recall bias). It is reasonable to assume that the gradually increasing and widespread use of mobile phones would have led to an increased cancer incidence over time, if use was carcinogenic. Using several cancer registries, incidence studies have examined changes in the incidence of suspected cancers since mobile telephony was introduced. An overall assessment must take into account the results from all types of studies, i.e., cohort studies, case control studies and incidence studies. With the exception of some case-control studies, the majority of the case-control studies and cohort studies have reported no increased risk of cancer. The results of the incidence studies show no evidence of increasing incidence of these cancers over time.

The Expert Committee considers the increased risk reported in some case-control studies to be inconsistent with the results from studies of time trends based on cancer registry data in either the Nordic or other countries.

Overall, the available data show no association between exposure to RF fields from a mobile phone and fast-growing tumours, including gliomas in the brain which have a short induction period (time from exposure to disease).

For slow-growing tumours, including meningiomas and acoustic neuromas, the data available so far do not indicate an increased risk. However, it is too early to completely exclude the possibility that there may be an association with exposure to RF fields from mobile phones, because the period of use of mobile phones is still too short. Available epidemiological cohort and case-control studies provide no information about a possible effect after a long induction period. The longest induction period studied is 13 years, and no participants had used mobile phones for more than 20 years old when the studies were conducted.

For leukaemia, lymphoma, salivary gland tumours and other tumours, there are insufficient data to draw conclusions, but the available studies do not suggest an increased risk. The only study that looked at exposure to RF fields from mobile phones and the possible risk of brain tumours among children and adolescents does not support an association, but a minor increase in risk cannot be excluded as a result of limited statistical power in the study.

There are several registry-based studies that have examined the development of the incidence of brain tumours over time among children and adolescents. They show no indication of increased disease incidence in these groups after the introduction of mobile phones.

Exposure from base stations and radio and television transmitters is significantly lower than from using a mobile phone and the available data do not suggest that such low exposure could increase the risk of cancer.

A number of studies of cancer in animals have been performed, and relevant mechanisms have also been studied using micro-organisms and cells. Overall, these studies provide further evidence that exposure to weak RF fields does not lead to cancer.

As a result of the specific methodological problems, new case-control studies would probably only provide limited new information. In new studies, it will be more important to monitor the incidence of brain tumours in population-based cancer registries with high quality records. This should identify whether the incidence of these tumours in children, adolescents and adults remains unchanged.

1.3.2.2 Reproductive health

It is well known that exposure to RF fields at levels that provide thermal effects (dielectric heating), can damage sperm. Several studies of sperm samples from humans and animals have been carried out to investigate possible non-thermal effects of RF exposure on sperm. Since sperm cells are particularly sensitive to heating from RF fields, it is important that there is good control of exposure during the experiments. Most of the earlier studies were of too poor quality, particularly with regard to control of this aspect of exposure, for any conclusion to be drawn from them. Some recent experimental studies have high methodological quality and good control of exposure. The results of these studies are ambiguous. Several new animal studies of high quality showed no effect on sperm quality after RF exposure. There are three new studies of reasonable quality where the exposure is performed on human sperm samples. Two showed effects from weak RF fields, while one study showed no effect. The effects are observed on mature sperm, and the changes are likely to revert when new sperm are produced. The results must be reproduced and confirmed by several research groups before conclusions can be made. It is uncertain what the relevance of exposure of sperm outside the body is compared to exposure of sperm in the testicles. Furthermore, there is a lack of knowledge about the significance of moderate changes in sperm quality on male fertility. There are few population studies of a possible change in fertility caused by RF exposure, and they have significant weaknesses, so conclusions cannot be drawn from these.

Very few of the older studies show evidence of harmful effects on the foetus after exposure to weak RF fields. Recent animal studies with good exposure control have shown no signs of injury. A few population studies of possible effects on the foetus after exposure to weak RF fields have been carried out, and those that exist have significant weaknesses.

Summary

Behaviour and development in children of mothers who used mobile phones during pregnancy have been studied in a few, relatively large population studies. These studies provide little evidence that there is a link between pregnant mothers' use of mobile phones and the risk of changes in the behaviour and development of the child.

Overall, there is little indication that exposure to weak RF fields adversely affects fertility. The few studies that do exist do not provide evidence that exposure to weak RF fields during pregnancy has adverse effects on the foetus.

1.3.2.3 Heart, blood pressure and circulation

There are several earlier studies of the cardiovascular system in animals and humans exposed to weak RF fields, but relatively few studies have been reported in recent years. Overall, the studies of high quality present no evidence that weak RF fields have adverse effects on the cardiovascular system.

1.3.2.4 The immune system

There are several earlier studies of the possible effects of RF exposure on the immune system; in some of these, transient effects due to heat and stress have been observed. In recent years, there have only been a few studies on the immune system of animals and humans and on immune cells outside the body (*in vitro*). Older studies, as well as recent high quality studies, provide no clear evidence of negative effects of exposure to weak RF fields on the immune system.

1.3.2.5 Hormonal effects

There are relatively few earlier or recent studies where the effect of exposure to weak RF fields on hormonal regulation has been investigated. Several studies have examined whether there are changes in melatonin production, a hormone that regulates circadian rhythm. There is less information on other hormone systems. Several studies have methodological weaknesses, and therefore emphasis should not be placed on them; however there are also some high quality studies. Previous and recent studies do not provide evidence that exposure to weak RF fields adversely affects the hormone system in humans.

1.3.2.6 Effects on the nervous system

The possible effects of weak RF fields on the nervous system have been investigated in many studies, and are divided into three main groups. These include biological effects and functional changes, effects on performance and behaviour, and possible adverse health effects. As previously mentioned, any observed biological effects and functional changes do not necessarily have an impact on performance or health or disease, even in the nervous system. In many cases, the responses can represent a physical adaptation to external stimuli, as with other physical stimuli such as heat or cold

Animal studies provide no basis for assuming that exposure to weak RF fields causes biological effects in the nervous system. Most human studies monitor electrical brain activity using EEG. Many of these are of high quality, and they provide some evidence that exposure to RF fields from GSM phones can cause small and transient changes measured at rest and during sleep. The changes in brain activity are not accompanied by symptoms or poor sleep quality. 3G (UMTS) phones do not seem to have such an effect, but there are few studies of this type of phone. Some human studies have examined blood flow in the brain, or effects on brain metabolism following RF exposure, but there are few studies and the results are inconsistent.

Performance and behaviour in adults after exposure to weak RF fields have been studied in several large studies of high quality. There are few studies of adolescents and these are of variable quality. Overall, there is no evidence that exposure to weak RF fields affects performance or behaviour.

Based on a large number of studies, many of which are of high quality, there is no evidence that weak RF fields cause symptoms such as headache, fatigue or concentration problems, either after short or long-term exposure. From animal studies there is no evidence of damage to vision, hearing or the balance organ. Human studies support this conclusion with regard to short-term effects on hearing and balance. Long-term effects on hearing have only been investigated in a few studies, which have methodological limitations. Few animal studies and epidemiological studies have examined severe effects on the central nervous system. So far there is no evidence that severe disorders can occur as a result of exposure to weak RF fields.

Although certain changes in electrical brain activity from some forms of exposure to weak RF fields have been observed, there is no evidence that such exposure can have negative effects on performance or behaviour, or have health-related consequences for the nervous system. There is no evidence that exposure to weak RF fields leads to an increased risk of disease of the nervous system. A limited number of studies have been conducted with children and adolescents, but the results so far provide no evidence that children differ from adults in terms of possible effects on the nervous system.

1.3.2.7 Changes in gene expression

In recent years, there have been a large number of cell and animal studies on the effect of RF fields on gene expression. Gene expression in cells is normally in constant change, e.g., when cells are exposed to internal or external stimuli. Changes in gene expression have been observed after RF exposure, but studies show inconsistent results, especially with regard to which groups of genes show altered regulation. At present, there is little to suggest that exposure to weak RF fields causes changes in gene expression that can be linked to adverse effects in humans.

1.3.2.8 Health problems attributed to electromagnetic fields (electromagnetic hypersensitivity)

A large number of controlled experiments have been carried out on groups of individuals with adverse health effects that they attribute to electromagnetic fields (see also 1.5). Most studies are performed in the laboratory, in the workplace or in the home. Although the quality varies, there are many trials that are methodologically sound. One study of good quality was a follow-up study of groups of individuals (defining themselves as electromagnetic hypersensitive or not; the former group had more health problems but they did not seem to be related to electromagnetic field exposure); this is the only prospective study that is available. A few experiments have been designed to examine individuals with repeated exposure. The relatively extensive literature provides no evidence that exposure to electromagnetic fields is the real cause of the health problems that individuals attribute to electromagnetic fields, whether exposure occurs alone or in combination with other factors that may affect the induction of symptoms. There is also no evidence that individuals with health problems that they attribute to electromagnetic fields are able to detect such exposure. Blind trials show that symptoms also occur when subjects are not exposed. This means that electromagnetic fields do not need to be present for health problems attributed to electromagnetic fields to occur. Health

problems can thus be due to other factors; see further discussion in Section 1.5. The Expert Committee concludes that scientific studies indicate that electromagnetic fields are not the direct or contributing cause of the condition of health problems attributed to electromagnetic fields (electromagnetic hypersensitivity).

1.3.3 Overall conclusion on the possible health hazards from exposure to weak RF fields

A large number of studies have examined the possible effects of exposure to weak RF fields (i.e., exposure within the ICNIRP's reference values). The studies have been performed on cells and tissues, and in animals and humans. The effects that have been studied apply to changes in organ systems, functions and other effects. There are also a large number of population studies with an emphasis on studies of cancer risk. The large total number of studies provides no evidence that exposure to weak RF fields causes adverse health effects. Some measurable biological / physiological effects cannot be ruled out.

1.4 Characterisation of risk and assessment of uncertainty (Chapter 5)

Characterisation of risk following exposure to weak RF fields in the Norwegian population is accomplished by comparing the actual exposure, as described in Chapter 3, with the health problems that can be caused by different degrees of RF exposure, described in Chapter 4.

As typical exposure lies far below the ICNIRP's recommended reference values, and since it is not scientifically proven that adverse health effects may occur after exposure under the ICNIRP reference levels, there is no reason to assume that the low typical exposure in Norway is associated with health risks. On this basis the Expert Committee considers that the general public is well protected against adverse health effects from RF exposure.

In the mandate, the Committee was also asked to assess any *uncertainties in the risk assessment,* and how they should be taken into account in the risk management.

The Committee believes that our knowledge of typical public exposure is based on realistic measurements. With regards to potential health hazards from exposure to weak RF fields, many studies have been carried out with different methodologies. In general, the documentation is very comprehensive. The scope and quality vary with respect to the various health effects that have been studied. In particular, for health effects of a more severe nature, such as cancer and effects on the nervous system, many studies have been carried out using both animal and human data. Many of the experimental studies have used exposure with weak RF fields, although the levels are relatively high compared to typical exposure. The remaining uncertainties in the risk assessment mainly relate to health effects arising after a very long time, and to situations that produce the highest exposure (i.e., personal use of a mobile phone). This uncertainty in the risk assessment is considered to be low. There is negligible uncertainty in the risk assessment associated with other sources, such as base stations, wireless networks, television transmitters and the use of mobile phones by other individuals.

Overall, the uncertainty in risk assessment is therefore small.

1.5 Health problems attributed to electromagnetic fields (electromagnetic hypersensitivity) (Chapter 6)

Health problems attributed to electromagnetic fields, often referred to as electromagnetic hypersensitivity, denotes a condition where individuals believe that their health problems are caused by electromagnetic fields. A large number of scientific studies provide evidence that electromagnetic fields do not cause the symptoms (see 1.3.2.8). However, their health problems as such are genuine and must be taken seriously. There are large differences between individuals with health problems attributed to electromagnetic fields, such as the symptoms they experience, their severity, and which forms of electromagnetic fields trigger them. The proportion of the population with such health problems is unknown. Figures from other countries are uncertain and vary significantly, from 1.5 per cent up to 10 per cent of the population.

There are several possible circumstances that may contribute to health problems attributed to electromagnetic fields. There is probably no single explanatory model that will apply to all of these problems. The primary cause of symptoms may be other influences: physical, psychological and social; and different circumstances can play a role. Cultural conditions, stress reactions, adaptation and other psychological mechanisms can explain why electromagnetic fields in particular are perceived to be the cause of health problems, even if there is no physical link.

An overall assessment of health and of possible adverse physical, psychological and social burdens, as well as the patient's own motivation, is needed as a basis for medical treatment and other interventions. The goal of treatment and intervention is to reduce symptoms and their negative impact on life. It is important to develop a relationship of trust between doctor and patient, and that the patient's own experience of problems is taken seriously while scientific information is provided in a supportive way. In some cases, it has emerged that a diagnosable disease is causing the symptoms. It is therefore important that the first consultation with the doctor should always result in an adequate medical examination of patients reporting such problems. Scientific knowledge gives no basis to recommend measures to reduce or avoid exposure to electromagnetic fields.

Patients with health problems attributed to electromagnetic fields can be characterised as a sub-group of patients with health problems attributed to environmental factors (e.g., multiple chemical hypersensitivity and hypersensitivity to their own amalgam fillings). A common feature for the group of patients who attribute their health problems to electromagnetic fields, and patients who attribute their health problems to other environmental factors is that they often have a strong belief in a causal relationship, but scientific studies are unable to demonstrate or to confirm this.

1.6 Risk management and risk perception (chapters 7 and 8)

The result of the risk assessment, i.e., the degree of risk of adverse health effects and severity of health problems, is essential for the authorities' risk management. Risk management may cover legal regulation, including the establishment of threshold limit values, information, and other measures. In addition, any uncertainties in risk assessment will have significance, among other things, in selecting a precautionary strategy.

1.6.1 Precautionary measures

Risk management also involves assessing whether there is a need to introduce precautionary measures (if applicable) and if so at what level. The Committee has outlined three levels of precaution that can be exercised when handling a risk, depending on the nature of the risk, the severity, uncertainty in the assessment, and any consequences. These levels can be described as follows:

Level 1: "Any exposure should not be higher than needed to achieve the intended purpose." For example, in order to achieve the intended purpose of a technology, in many cases only a fraction of the acceptable exposure from a health risk perspective is required. This is particularly true for exposures where adverse health effects are unknown.

Level 2: "Prudent avoidance" is an internationally used principle that implies a stricter level of caution than the "general caution" specified in level 1.

Level 3: The "precautionary principle" is a regulatory principle that is used when there are substantial scientific uncertainties and injury scenarios that are based on plausible scientific knowledge. The potential damage is severe or potentially irreversible. The use of the precautionary principle may have significant societal implications, such as economic and other disadvantages. There is consensus that there should be requirements for grounds on which the principle should be applied.

1.6.2 Perception of risk

A number of factors associated with how the risk is interpreted could help to modify individual risk perception of possible adverse health effects from environmental exposure. This also applies to electromagnetic fields. The majority of the population seems to have low or moderate concern about adverse health effects resulting from exposure to RF/electromagnetic fields. However, a significant minority is concerned to varying degrees and/or believes that they experience health problems due to exposure. This concern does not correspond with the result of the risk assessment described in part I of this report.

Whether a precautionary strategy should be introduced depends on the nature and severity of the uncertainty in the basis of the risk assessment. Measures to further reduce public exposure to RF fields should not be implemented unless there is a scientific basis for assuming that the exposure could be harmful. It is relatively well supported that the use of certain types of precautionary measures not justified by a risk assessment does not reduce public concern about the adverse health effects. In some cases, such measures may increase concern. Good risk communication is considered to be a useful tool in the dialogue between the authorities and the public. This should be transparent and should form the basis for good understanding of the risks and for the implementation of measures.

1.7 International regulation practices and strategies (Chapter 9)

Chapter 9 gives a brief overview of international organisations' findings and recommendations. There is also a brief review of regulatory practices and strategies in various parts of the world with emphasis on comparable countries. In most industrial countries in recent years, organisations and expert committees have been established with a mission to evaluate research in

this area and/or make recommendations to the authorities. This applies to both threshold limit values and other regulatory measures. In recent years, several other national and international institutions have compiled and published reports in this area, either on their own initiative or commissioned by governments or international organisations. These include the World Health Organization (WHO) and the ICNIRP. The ICNIRP recommends guidelines for maximum exposure to non-ionising radiation, based on extensive and ongoing research into the health effects of exposure to such radiation. ICNIRP guidelines are used in more than 80 countries. ICNIRP collaborates with WHO. WHO decides on its advice on an independent basis.

1.7.1 Regulations in Europe

The European Commission has funded research into electromagnetic fields and potential health effects since 1999. The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), an independent scientific European Committee under the Directorate General for Health and Consumers (DG SANCO), has summarised and reviewed research into electromagnetic fields, the last time in 2009. The European Union's Ministerial Council Recommendation, dated 12.7.1999, concerning the restriction of exposure of the public to electromagnetic fields (0 Hz to 300 GHz), follows the ICNIRP's recommended levels for maximum exposure. In some countries, the recommendations have been incorporated into binding national legislation, meaning that the ICNIRP's recommended reference levels must be followed. This applies to: Cyprus, the Czech Republic, Estonia, Finland, France, Hungary, Ireland, Malta, Portugal, Romania, Spain, Germany and Slovakia. Other EU member countries encourage adherence to the ICNIRP recommendations, although this is not compulsory, or they have less stringent threshold limit values or no regulation. These include: Austria, Denmark, Latvia, the Netherlands, Sweden and the United Kingdom. A third group of Member States has introduced more stringent limits than the ICNIRP's recommendations, including Belgium and Luxembourg. This is a result of political decisions to use the precautionary principle, and/or public pressure. There are different practices about the choice of the exposure levels and which sources of exposure should be regulated.

1.8 Regulations in Norway (Chapter 10)

Several government agencies are involved or have responsibility in the themes addressed in this report. The Norwegian Radiation Protection Authority is the regulatory and supervisory authority for electromagnetic fields and must be scientifically up-to-date on the health effects of electromagnetic fields. The Norwegian Post and Telecommunications Authority regulates and monitors the postal and telecommunications sector. The health service is responsible for providing treatment and follow up to patients, while the Norwegian Directorate of Health is responsible for providing professional recommendations and regulations for the health service. The Norwegian Institute of Public Health provides research-based advice in public health issues. In addition, other governmental agencies, such as the Directorate for Civil Protection and Emergency Planning, the Directorate for Emergency Communication, the County Governor and the Parliamentary Ombudsman are all potential stakeholders with regards to electromagnetic fields.

Municipalities often encounter various issues related to electromagnetic fields, both in the role of local community planning and as the local health authority with responsibility for the new public health act that covers health education, preventive health measures and monitoring of factors that affect health. Municipalities have some direct governmental and administrative tasks relating to exposure to RF fields. With regards to establishing electromagnetic field-based

communication, larger antenna systems require planning permission according to building regulations. For smaller antenna systems with heights up to 2 metres, there is no obligation to apply for planning permission. Consideration of applications does not normally include assessment of emission power; the only condition is that section 34 of the Regulations on Radiation Protection and Use of Radiation (Forskrift om strålevern og bruk av stråling), in effect from 01.01.2011, should be met. The regulations are practised according to the regulation's definitions of threshold limit values (see 1.2) and the requirement that "any exposure should be kept as low as reasonably practicable".

As building owners, some municipalities have followed a more stringent practice when it comes to positioning base stations than that imposed by the radiation protection regulations. Some municipalities may not allow installation of base stations for mobile phones on, or in the immediate vicinity of, the municipality's own schools and kindergartens. The municipalities' motive in such cases is to reduce the risk of exposure from base stations for mobile telephony. However, the result of such a practice might be that users of mobile phones near these buildings actually experience increased exposure from their own mobile phone usage due to the lower coverage.

The Norwegian Radiation Protection Authority provides advice and information according to the current regulations about how exposure can be "as low as reasonably practicable". For the base stations for mobile telephony/emergency network, the Norwegian Radiation Protection Authority recommends that transmitter direction, transmitter power and proximity to areas where individuals stay for long periods should be considered before mounting. The Norwegian Radiation Protection Authority provides information to those who want to reduce exposure from wireless networks by mounting routers at some distance from where people will spend time. There is also information about how exposure from personal mobile phone use can be reduced. The Norwegian Radiation Protection Authority does not recommend that wireless networks should be replaced by wired networks.

1.9 Expert Committee's recommendations for regulations (Chapter 11)

The Committee's recommendations for regulations are based on the conditions stated in part I-IV of the report. The assessment contained in part V is primarily based on the results of risk assessment in Chapter 5, the medical discussion of health problems attributed to electromagnetic fields (electromagnetic hypersensitivity) in Chapter 6, the discussion of risk management in Chapter 7, the discussion of public concern and risk communication in Chapter 8, and the discussion of international and national policy in chapters 9 and 10. Recommendations for regulations are discussed based on three different issues:

1. Health risks arising from the physical exposure to electromagnetic fields/RF
2. Health problems attributed to electromagnetic fields (electromagnetic hypersensitivity)
3. Concern about the hazardous effects of electromagnetic fields

In line with the mandate and the Committee's interpretation of it, the discussion of section 1 is limited to the RF field, whereas points 2 and 3 to a lesser extent differentiate between frequencies within the electromagnetic field spectrum.

The Committee's recommendations for risk management do not include occupational exposure to RF fields beyond that of occupational exposure in conjunction with mobile telephony, wireless networks, etc, and applies as for the general public. Hence, the Expert Committee considers it unnecessary to introduce specific recommendations on the use of wireless communication in a professional context.

Moreover, the report does not include exposure to RF fields in connection with medical diagnostics (MRI-scans), treatment (surgical use of diathermy), or medical implants that may be sensitive to RF fields.

1.9.1 General recommendations

The current regulations are based on the ICNIRP reference values for maximum exposure. The Expert Committee does not recommend special measures to reduce exposure, e.g., by changing the threshold limit values. The knowledge base in this health risk assessment provides no reason to assert that adverse health effects will occur from the typical public exposure. This also applies to the use of wireless communications in the office environment.

The mandate also asks the Committee to consider whether uncertainties are revealed that require the application of the precautionary principle when managing the risk and, if so, how the precautionary principle should be applied.

The Committee has therefore thoroughly discussed whether there are grounds to apply the precautionary principle for weak RF fields. The Committee considers that the conditions for applying the principle have not been met. Furthermore, the Committee considers that the administrative authorities can select a precautionary strategy according to the lowest level, i.e. "any exposure should not be higher than needed for the intended purpose to be achieved".

1.9.2 Recommendations for health problems attributed to electromagnetic fields (electromagnetic hypersensitivity)

A large number of scientific studies agree that it is probable that the physical characteristics of electromagnetic fields are not the direct or contributory cause of health problems attributed to electromagnetic fields (electromagnetic hypersensitivity). The Committee believes that there is no need to revise radiation protection legislation for individuals who attribute their health problems to electromagnetic field exposure.

It is scientifically improbable that the reduction of exposure to electromagnetic fields is significant for health problems attributed to electromagnetic fields. The Committee therefore believes that there is no basis to recommend measures aiming to reduce exposure to electromagnetic fields for individuals with health problems attributed to electromagnetic fields. The health service and other parties should instead encourage the reduction of avoidance behaviour and discourage implementation of measures for which there is no scientific basis. However, it is always important to respect individuals and their choices.

The Committee does not recommend the building of "electronic-free" treatment rooms in hospitals, but that affected patients should be given appropriate medical assistance with support and practical measures.

The Expert Committee believes that patients with these types of health problems can mainly be taken care of within the primary and specialist health services. The health problems that

these individuals experience are genuine and must be taken seriously. However, the competence of the health service and health administration regarding patients with health problems attributed to electromagnetic fields and other environmental factors is low. There is a need for expertise in environmental health (e.g., in the regional occupational- and environmental health hospital departments) that are responsible for providing knowledge and guidelines to the health service. The Norwegian Directorate of Health should ensure that there is information specifically prepared for the health service and those who are affected. The Committee further proposes the establishment of a new expert committee to review the literature and to provide advice on management practices and the health service's treatment for patients with health problems attributed to electromagnetic fields and other environmental factors.

Employers should ensure that there is information about the risk to employees who are concerned about electromagnetic field exposure in their working environment. If the information does not help reduce concerns, in special cases the employer should consider implementing simple facilitation measures. It is important to clarify that these measures are implemented to alleviate concerns and to find practical solutions in a difficult situation, and not because the exposure itself is deemed to pose a health risk.

1.9.3 Recommendations for information requirements and concerns

There is no reason to recommend reduced exposure to RF fields as a tool to reduce general concerns about the hazardous effects of electromagnetic fields.

There is a need for good information and communication about the weak RF fields and possible health risks, through a deliberate strategy that includes information, communication and use of the media. Information should be provided by, amongst others, the Norwegian Radiation Protection Authority and the Norwegian Post and Telecommunications Authority. These authorities are responsible for ensuring that relevant information is tailored to different target groups, including local authorities, employers and the general public.

1.9.3.1 Recommendations for establishing networks for mobile telephony and mobile broadband

The establishment of new network operator antennas should point to locations that meet the general principle that "any exposure should not be higher than needed for the intended purpose to be achieved". This means that good coverage for mobile phones should be established as it will give the lowest possible exposure to the mobile phone user. Also, if it does not cause significant inconvenience and cost, an antenna location should be selected that provides the lowest exposure levels in areas where individuals spend long periods.

The Norwegian Post and Telecommunications Authority should evaluate procedures to include planned new installations in the current list of base stations which can be found on the website www.finnsenderen.no. This will make information available to stakeholders in a development and give the opportunity to provide input on the planned location. There should be no implementation of new threshold limit values for exposure, or of regulations that require application handling at a municipality level.

The Norwegian Post and Telecommunications Authority should take the initiative for a working group to establish common guidelines for safe distances to base stations for mobile telephony. Safe distances would ensure that nobody is exposed to levels above the ICNIRP reference values; essentially, this would apply when working close to antennas (e.g., clearing snow from a roof).

1.9.4 Recommendations for measurement of exposure

Individuals sometimes request measurements of exposure from RF fields for health-related purposes. Before such measurements are taken, it should be considered how the results will be interpreted and communicated. Based on the type of exposure situation, in many cases it is possible to use prior experiences about exposure levels. If the current situation is extraordinary in that previous measurements and theoretical calculations cannot be applied, or when other circumstances give reason to believe that the exposure is high, it may be appropriate to take measurements. Concern by itself is rarely a reason to take measurements. Instead, it is important to provide good information about exposure and communicate with the concerned individuals. Measurements should always be performed by qualified personnel.

Relevant government agencies, such as the Norwegian Radiation Protection Authority and the Norwegian Post and Telecommunications Authority should monitor typical RF exposure levels and more specific exposure situations where relevant. In accordance with the intention of the radiation protection regulations, it may also be appropriate for the authorities to take measurements to assess whether exposure sources meet the general principle that "any exposure should not be higher than needed for the intended purpose to be achieved".

1.9.5 Recommendations for the industry's obligations

Personal mobile phone use accounts for the relatively highest exposure to the general public. Individuals can choose to easily reduce exposure. Mobile providers could equip all phones with hands-free kits and provide information about the SAR value for exposure and the importance of using hands-free. Dealers should have information about the SAR value for all new mobile phones available to the customer.

Consumer goods with low emission power (< 100 mW) represent such a low exposure that measures are unnecessary. The industry should supply information about exposure, and that increased distance gives lower exposure.

It is important that suitable information is made available to retailers and subcontractors who are responsible for sales of supplies and installation of base stations and antennas so that information can be used in contact with the public.

1.9.6 Recommendations for research and professional follow-up

The Norwegian research environments should contribute to and monitor international research about possible health effects of exposure to electromagnetic fields. The authorities should take into account the need for research funding in this area. The development of cancer incidence over time should be followed in cancer registries. WHO has presented recommendations on priority research areas in the field.

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