



AMTA

Australian Mobile
Telecommunications
Association

EME Update

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CONTENTS

Update to EME exposure guidelines	3
Experts confirm 5G covered by safety standards	4
Swedish Expert Group - no reason to change safety limits	6
Millimetre exposures and health - state of the science	8
Restrictive European EMF limits under review	10
Small exposures from small cells	13
Level of environmental radio signals unchanged since 2012	15
Weak evidence for increased headache frequency due to lifestyle factors not phone use	16
No long term radio signal health risk for workers but some research lacking	17
Four recommendations to improve EME risk communication	18

Update to the international EME exposure guidelines

The human exposure guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) that form the basis for electromagnetic energy (EME) protection policy in most parts of the world, including Australia, are being updated to ensure they take account of the latest scientific evidence and potential technological advances.

The present international guidelines were published in 1998 and ICNIRP has already revised and updated the guidelines covering EME sources up to 100 kHz. The review for radio frequencies, including those used for mobile communications, commenced in 2014 and in July 2018 [ICNIRP](#) published a consultation draft for public comment.

In reviewing the scientific evidence ICNIRP concluded that there is 'no evidence that RF-EMF causes such diseases as cancer' and 'no evidence that RF-EMF impairs health beyond effects that are due to established mechanisms of interaction'.

This review included a critical examination of the United States Toxicology Program (NTP) and Italian Ramazzini Institute animal studies of radio signals and cancer published in 2018. [ICNIRP](#) identified 'major weaknesses, including a lack of blinding, difficulties interpreting statistical analyses due to the association between longer lifespans and tumor occurrence in the exposed rats (NTP only), and failure to account for chance' concluding that 'these substantial limitations preclude conclusions being drawn concerning RF EMFs and carcinogenesis'.

As a result ICNIRP proposes to keep the whole body and partial body exposure limits as well as the reference levels above 400 MHz largely unchanged in value compared to the ICNIRP 1998 guidelines. It plans to keep a six-minute averaging time for local exposure and increase the averaging time for whole body exposures to 30 minutes as this better relates to the thermal response of the whole body. New limits were proposed for local exposure that are important for devices operating above 6 GHz.

ICNIRP says of the proposed guidelines:

'These guidelines specify quantitative EMF levels for safe personal exposure. Adherence to these levels is intended to protect people from all known harmful effects of radiofrequency EMF exposure.'

For those countries presently using the ICNIRP 1998 guidelines, ICNIRP made clear in December 2017 that these limits still remain protective.

'...ICNIRP therefore concluded that the 1998 guidelines do remain protective. That is, the 1998 guidelines still provide protection against all known health effects of high-frequency radiation within the frequency range 100 kHz - 300 GHz...'

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), which is responsible for the EME protection standards, has already commenced a review of the existing standard (based on the ICNIRP 1998 guidelines) and is awaiting the outcome of the ICNIRP process to complete the task.

About 120 contributions with over 1,000 individual comments were submitted during the consultation and ICNIRP plans to respond via its website after the publication of the final guidelines, now expected December 2019.



Experts confirm 5G covered by safety standards

Authorities and independent experts have confirmed that all the frequencies in use for and planned for 5G are included in current Australian and international safety standards and therefore no risks to health or the environment are anticipated.

ARPANSA

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has been in forefront of challenging misinformation about 5G networks. ARPANSA is responsible for the safe human exposure limits that apply to all mobile networks. In March 2019, Dr Ken Karipidis, Assistant Director of ARPANSA's Assessment and Advice Section stated that 'no health effects are expected from radio frequency exposures below the limits set in the ARPANSA standard'. In June, ARPANSA expressed concern about anti-5G campaigns causing unfounded fear within the community emphasising once again that 'contrary to some claims, there are no established health effects from the radio waves that the 5G network uses'.

European Commission

In response to recent questions on 5G safety from members of the European Parliament, Mariya Gabriel, a Bulgarian politician and the European Commissioner for Digital Economy and Society emphasised that 'the strict and safe exposure limits for electromagnetic fields recommended at EU level by Council Recommendation 1999/519/EC on the exposure of the general public to electromagnetic fields apply for all frequency bands currently envisaged for 5G'. These are based on the ICNIRP 1998 guidelines and are the same as the limits that apply in Australia. She added that

'the 5G networks are expected to have similar or lower levels of emission than 4G networks. Combined with 4G a modest cumulative increase is possible in dense areas, still far below the limits'.

ICNIRP

The International Commission for Non-Ionizing Radiation Protection (ICNIRP) is currently updating the guidelines for radiofrequency exposure (see our other article). ICNIRP Commissioner Professor Rodney Croft, who is based at the University of Wollongong, told the [BBC](#) in July 2019 that ‘the exposure that 5G will produce has been considered in great depth by ICNIRP, with the restrictions set well below the lowest level of 5G-related radio frequency that has been shown to cause harm’.

The University of Wollongong is one part of the National Health and Medical Research Council (NHMRC) funded Australian Centre for Electromagnetic Bioeffects Research (ACEBR) that produced a [5G fact sheet](#) concluding that extensive research has been conducted on the current and future 5G frequencies with ‘no indication of any health impacts from exposures at the intensities related to mobile communications have been observed’.

Public Health England

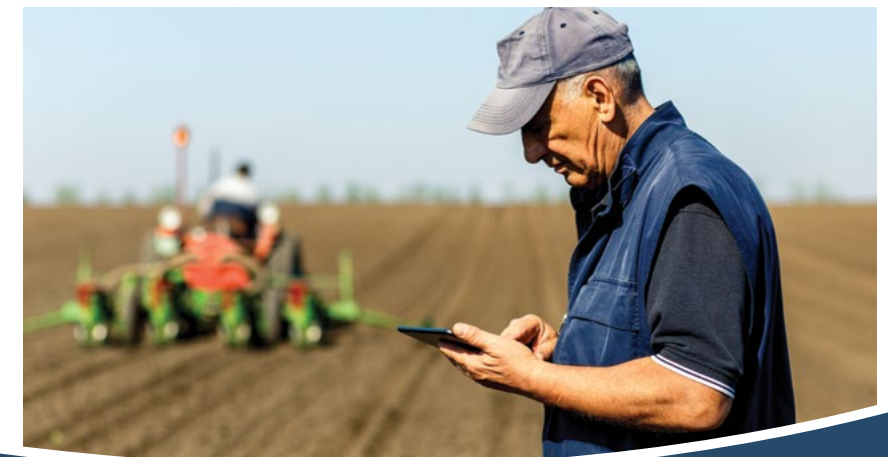
Public Health England (PHE) [confirm](#) that the ICNIRP guidelines ‘apply to frequencies up to 300 gigahertz and cover exposures arising from new 5G base stations as well as from older technologies’. They explain that the strength of the radio waves from base-station antennas falls off very quickly with increasing distance and in places normally accessible to the public levels are many times below guideline levels. This has been confirmed by many measurements made at publicly accessible locations near to base stations.

‘...no indication of any health impacts from exposures at the intensities related to mobile communications have been observed.’ - ICNIRP

Bundesamt für Strahlenschutz

The German Federal Office for Radiation Protection has examined whether radio signals can harm animals or plants. They conducted a comprehensive review of studies in this area and their conclusion ([in German](#)) is that ‘according to the current scientific knowledge, there is no scientifically reliable evidence of a risk to animals and plants due to high-frequency electromagnetic and low-frequency and static electric and magnetic fields below the limits’. They further say that the limit values that protect humans also protect animals and plants.

A recent [blog](#) by Dr Jack Rowley of the GSMA, the global trade association for the mobile industry, expressed concern that the public could be misled by unverified claims of 5G causing the death of birds ([false](#)), damage to trees ([false](#)), harm to firefighters ([false](#)) or interference with weather forecasting ([false](#)).



Swedish Expert Group - no reason to change safety limits

Published in June 2019 by the Swedish Radiation Safety Authority, the 13th report of the Scientific Council on Electromagnetic Fields concludes that 'no new causal relationship between EMF exposure and health risks have been established' and there is no reason to change the limits or recommendations.

The 104-page consensus report by the Scientific Council on Electromagnetic Fields examines studies published from April 2017 to March 2018 and includes static, extremely low frequency, intermediate frequency and radiofrequency exposures. In assessing research the Council assigned a weight to positive and negative findings within the overall assessment that takes into account 'the observed magnitude of the effect and the quality of the studies'.

Studies of exposure and disease among people (human epidemiology) is critical to the evaluation and the Council stresses that:

In assessing research the Council assigned a weight to positive and negative findings within the overall assessment that takes into account 'the observed magnitude of the effect and the quality of the studies'.

Previous Council reports concluded that 'no, or at most small, indications were found for a brain tumour risk up to approximately 15 years of mobile phone use.' Recently published studies do not add much new information as they mostly reanalysed existing data. They observe that:

'Overall, time trends of brain tumour incidence stay rather constant over time. Increases have been reported for specific subtypes of tumours and decreases in some others. Most likely changes in coding praxis are responsible for shifting number of cases between different diagnoses'.





They add that uncertainties regarding possible long-term effects 'justifies caution' and they repeat existing advice to use hands-free kits to reduce exposure to the head.

A focus of the 13th report is animal studies of radio signal effects on cancer. In particular the Council discusses the United States Toxicology Program (NTP) and Italian Ramazzini Institute studies.

Overall, the Council view is that 'the results are inconsistent between the studies in terms of the exposure levels where increased tumour incidences are observed' adding that 'the Council does not feel that these studies can be considered as clear indications for carcinogenicity of RF fields in humans.'

Regarding the NTP study, the Council notes that the core temperature of the highest exposed male rats (where the strongest effects were observed) was likely to have increased and this plus the lack of tumours in the control group (small numbers of tumours would be expected based on historical data) means that '...there is considerable uncertainty about how to interpret the results'.

The report notes that many studies had to be excluded because they were poor quality. For example, the conditions of the exposure were poorly described and or the studies were missing unexposed (sham) controls. Future research priorities for radio signal exposures include possible long-term effects, links to oxidative stress and wireless energy transfer systems.

This is the 13th report by the Council, which was established in 2002, and together the reports makeup a gradually developing health risk assessment of exposure to electromagnetic fields. The Council that prepared the report includes expert scientists from Denmark, Germany, Italy, the Netherlands, Switzerland and Sweden.

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Millimetre wave exposures and health - state of the science

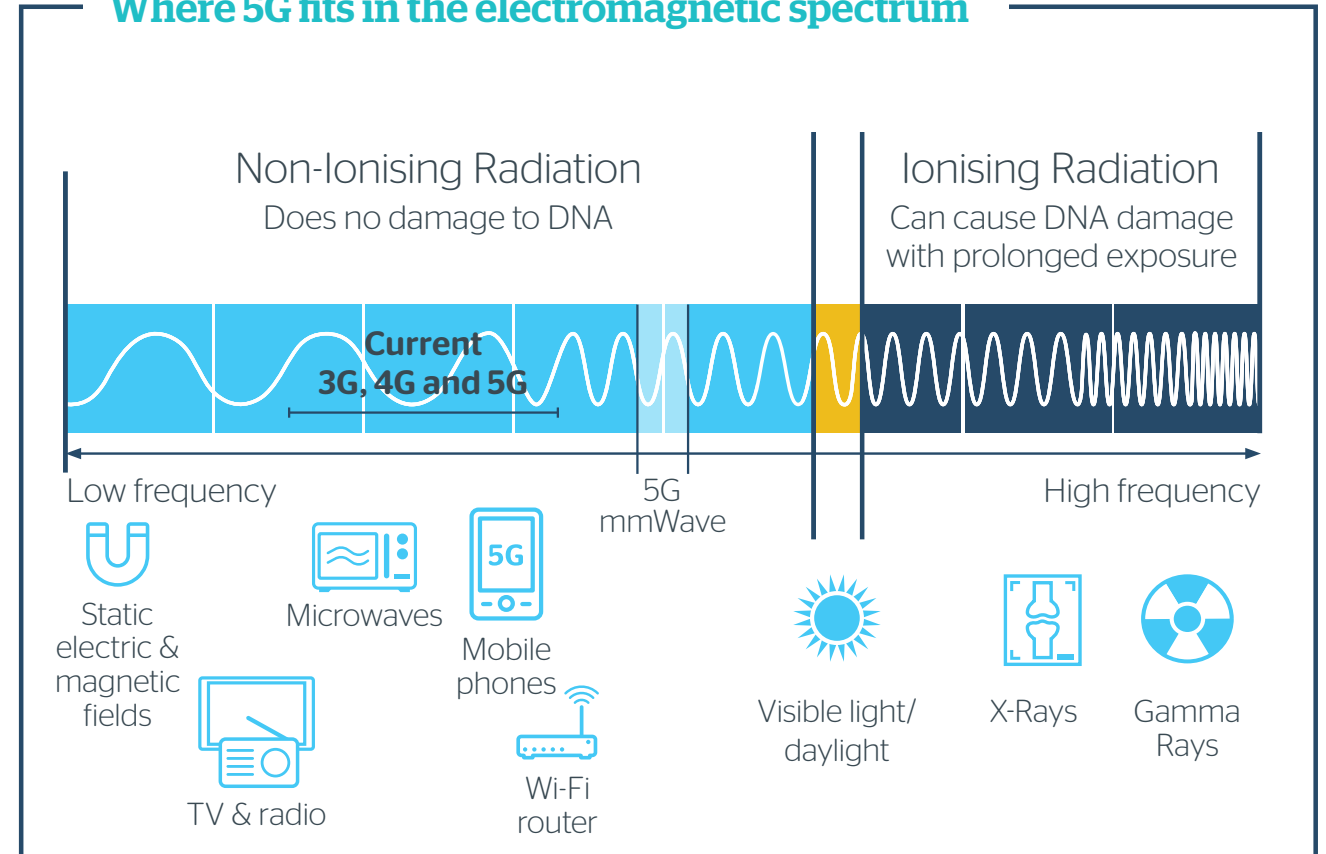
Millimetre wave (mmWave) frequencies have been used for many years for communications, radar and airport security scanners and they are covered by existing safety guidelines for radio signals.

Initial Australian 5G deployments are using frequencies around 3.5 GHz, which are close to existing mobile and Wi-Fi frequencies. In order to deliver ultra-high speeds and the lowest latencies, future 5G deployments in Australia and other parts of the world are also considering frequency bands between 26 and 86 GHz.

mmWave (also known as MMW) frequencies span the frequency range 30 to 300 GHz, however, typically biological studies cover the range up to 100 GHz. Due to their high frequency more than 90% of the energy is absorbed in the outer layers of the skin with the remainder absorbed in underlying fat and muscle layers. Absorption of high intensities of mmWave energy by the skin results in heating, however, the thermoregulatory system of humans is efficient and protection standards conservative so that heating is not perceptible at exposure levels below the limit values.

A recent [review](#) by Stanislav Alekseev of the Russian Academy of Sciences and Marvin Ziskin of Temple University School of Medicine (USA) identified more than 470 papers on the biological effects of mmWaves. Many of these studies come from the former Soviet Union where mmWaves are widely used in medical therapies. However, the effectiveness of such therapies awaits scientific confirmation by means of well-controlled clinical trials.

Where 5G fits in the electromagnetic spectrum





Research on mmWave health effects has examined impacts on the nervous and immune systems, cell membranes, gene activity and cancer. These studies show no genetic damage at levels below the safety standards. Some studies show mmWaves producing an anticancer effect and the authors describes the data on cancer promotion as 'controversial'. Alekseev and Ziskin caution that most claimed effects of low-intensity mmWaves are awaiting replication.

Another area of research has been the possibility of mmWave injury to the eyes, especially the lens of the eye, which does not have the blood flow required to remove excess heat. Experiments indicate that a temperature increase of about 20°C was required for damage to the eye and this is far higher than exposures permitted by safety standards.

As noted above, high intensity mmWave energy can cause heating of the skin and this is used in the Active Denial System developed by the US military as a non-lethal method of crowd control. The system uses mmWaves at 94 GHz (where the depth of penetration is about the same as 3 sheets of paper) in very short exposures at intensities about 1,000 times higher than the public limits to cause a skin heating sensation of about 10°C (similar to opening an oven door) that causes people to move away. The US Department of Defence says that more than 13,000 volunteers were exposed during 15 years of development of the system and detailed human effects research has been conducted. They are 'very confident there will be no long-term adverse side effects'.

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Restrictive European EMF limits under review

Several countries in Europe with restrictive radiofrequency (RF) exposure limits are recognising that these policies represent a barrier to 5G deployment and activities are underway to review the limits. Here we profile three countries.



Switzerland

The Swiss regulations include two sets of limits, the international guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) which apply to the overall level of exposure; and an Ordinance relating to Protection from Non-Ionising Radiation (ONIR) which specifies a precautionary ‘Installation Limit’ (i.e applying to installed base stations only) about 100 times below the international exposure limit values. The Installation Limit Values apply to places such as regularly occupied rooms and children’s playgrounds where people may spend long periods of time.

Swiss authorities note that, for the ICNIRP limits, **‘...if these limits are complied with, none of the scientifically accepted negative effects on our health can occur’.**

The Swiss Agency responsible for the installation limits explains that the Installation Limit Values are not based on medical or biological findings, but are instead linked to the Federal Law on the Protection of the Environment that require actions to ‘limit effects which could become harmful or a nuisance’ where it is feasible on technical

and operational grounds and the measures are economically acceptable.

A PWC [analysis](#) conducted on behalf of the Swiss operators estimated deployment costs to be 40-110% higher in Switzerland, with about one third of the extra costs linked to complying with the restrictive installation limit values.

Swiss operators have warned that these limits impact the capacity of current mobile networks and create significant challenges for the deployment of 5G. In order to find a way forward, the Federal Office for the Environment (FOEN) established a working group to analyse the ‘radiation risks in the short and medium term’ with a particular focus on 5G. A [media release](#) says (in French) that:

‘The working group, composed of representatives of the relevant interests, will analyze the needs of mobile telephony and radiation risks in the short and medium term, particularly in the context of the introduction of 5G. It will also consider the limit values to be adopted in this area with due regard to the precautionary principle’.

The working group has not yet issued any recommendations from this inquiry.

Brussels, Belgium

The RF limits applying to mobile networks in Belgium have gone down and back up over the last 10 years and are once again under examination. In 2009, the Belgian constitutional court handed the legal competence to set limits to the regions (Brussels, Flanders and Walloon). Each region has adopted a different limit and all are more restrictive than the international recommendations but it is the rules in Brussels that have had the greatest impact.

Initially Brussels set a limit equivalent to 3 V/m or about 400 times below the international limits with the additional restriction that each operator could only use 25% of the limit. It was not possible to deploy 4G in Brussels under these restrictive limits and in 2014 the Brussels Environment Minister relaxed the limits to 6 V/m (shared) to allow 4G to proceed although much delayed.

The situation with 5G is a repeat of that with 4G. The Belgian operators are again unable to implement 5G pilots in Brussels due to RF restrictions. A 2018 report ([PDF](#)) by the Federal Belgian Institute for Postal Services and Telecommunications (BIPT) concluded that the present Brussels limits negatively impact current 4G indoor coverage and prevents the deployment of additional frequencies to increase capacity.

BIPT recommends adopting the international limits but says as a minimum the limit should be more than double the present local limit to allow 5G.

This recommendation has not so far been adopted. In Belgium, the issue is further complicated by political disputes with the Belgian inter-governmental Consultative Committee failing to agree on the distribution of funds from the planned auction for 5G spectrum licences and elections having been conducted in May 2019. Belgium has still to form a Federal government and as a consequence there cannot be a sale of 5G spectrum so commercial deployment of 5G is currently on hold.





Poland

The [5G Strategy for Poland](#) published by the Polish Ministry of Digital Affairs sets as targets that at least one Polish city should have a commercial 5G network by the end of 2020 and that all cities and major transport routes should have 5G service by 2025. The Strategy identifies the restrictive Polish limit of 7 V/m from 300 MHz to 300 GHz (about 100 times below the international guidelines) as a barrier to 5G rollout:

“Currently, ...the limit of exposure to electromagnetic fields in places accessible to the public does not allow the commissioning of additional radio stations working in one place.”

The Strategy proposes adjustment of the limit values to ‘the requirements of modern mobile communication network’ and streamlining administrative procedures.

To support this plan the Digitalisation Ministry has been [debunking 5G myths](#) and there have been reports that there is a plan to harmonise the RF limit values in early 2020 in preparation for a 5G spectrum auction with first commercial 5G services expected later that year.

The Polish situation was a key piece of evidence in an [International Telecommunications Union \(ITU\)](#) report. ITU is the United Nations specialized agency for information and communication technologies. The ITU report concluded that restrictive RF limits affect all facets of enhancing wireless infrastructure and the deployment of 5G. ITU said that there was an urgent need to harmonize electromagnetic field (EMF) standards worldwide.

“Currently, ...the limit of exposure to electromagnetic fields in places accessible to the public does not allow the commissioning of additional radio stations working in one place.”

Small exposures from small cells

An international study that measured almost 100 small cell base stations in three countries confirmed low levels of exposure to radio signals, similar to those of the macro network. Small cells provide additional network capacity or coverage in a local area. They operate at lower power than traditional mobile phone base stations and use smaller equipment.

The 98 small cell sites were located in South Africa (80 sites), the Netherlands (16 sites in Amsterdam) and Italy (2 sites in Torino). The small cell sites in Amsterdam were located on bus shelters while those in Torino were part of advertisement infrastructure. About half the sites (47) were indoor, thirty were mounted at heights of 2-4m and 21 at heights greater than 4m.

A frequency selective measurement device was used to assess both the total exposure from all radio frequency sources from 27 MHz to 3 GHz, including the contributions from FM broadcast and sources at 2450 MHz, such as Wi-Fi and the contributions from mobile (uplink and downlink). Measurements were conducted during periods when

network activity is normally high but were not extrapolated for the maximum possible scenario. An active download was initiated to ensure that the small cell was transmitting.

In total 295 positions were measured near the 98 small cells. The maximum measured value was 30 times below the international exposure limits for the public (the same limits are used in Australia). The typical level was about 0.6 V/m, more than 4,000 times below the public exposure limit for mobile communication signals. Similar levels were seen for indoor and both low mounted and high mounted small cell antennas. The levels were also comparable to measurements made in France and South Africa on existing macro mobile networks.

The [paper](#) was published in the August 2019 issue of *Radiation Protection Dosimetry*. The study was supported by the Mobile and Wireless Forum and the Small Cell Forum.

In December 2018, the French spectrum agency [ANFR](#) (L'Agence nationale des fréquences) published the results of measurements made on 4G small cells as part of pilots conducted in 2017-2018 with the French operators, Orange, Bouygues Telecom and SFR.





The overall analysis found that small cells resulted in an exposure level that was of the same order of magnitude as that which the “macro” network creates. The report also found increased uplink data rates, with more than 20 Mb/s in 75% of cases compared to an average of 11 Mb/s on the “macro” network, and increased downlink data rates, with more than 50 Mb/s in 50% of cases compared to an average of 30 Mb/s on the “macro” network.

Earlier this year [Telstra](#) reported the results of independent testing of small cells in Australia, with typical levels 500 times below the public limit values, even when standing directly below a small cell attached to a light pole. Telstra also pointed out that small cells have been in use since the 2G era, more than 25 years, to provide both capacity in urban areas and coverage in rural areas where a mobile base station was not feasible.

The [Australian Communications and Media Authority](#), which regulates radiocommunications and telecommunications services, explains that small cells (like macro base station sites) only transmit data when required, after which their power output is reduced. They add that ‘5G base stations will go into “sleep mode” when there are no active users, making their power output levels even lower than current 4G base stations’ within the period.

A fact sheet from the [Australian Mobile Telecommunications Association](#) provides guidance on the operation and deployment rules for small cells.

Earlier this year Telstra reported the results of independent testing of small cells in Australia, with typical levels 500 times below the public limit values, even when standing directly below a small cell attached to a light pole.

Level of environmental radio signals unchanged since 2012

A systematic review of studies of everyday public exposure to radio signals in Europe by a combined group of researchers from Switzerland and Iran concludes that average radio signals levels are well below safety guidelines with no noticeable increase since 2012.

The research group consisted of scientists from the Shiraz University of Medical Sciences and the Bushehr University of Medical Sciences, both Iranian, and two Swiss institutions, the Swiss Tropical and Public Health Institute and the University of Basel.

The study published in the September 2019 issue of [Environmental Research](#) was an update to a 2017 analysis of 21 radio signal measurement studies in European countries. Both studies examined exposures in different microenvironments. The researchers explain that a microenvironment is 'a small area distinguished from its immediate surrounding by its function.' Examples include inside homes, outdoor areas and public transport.

An important conclusion of the 2017 study (published in the [Journal of Exposure Science & Environmental Epidemiology](#)) was that there was no obvious change in exposure level during the period 2005 to 2013.

The new analysis added 26 more studies with data from 12 European countries. The study types included spot measurement; fixed site EMF monitors; personal measurements by volunteers and measurements made by researchers who move about within a microenvironment.

Overall, typical personal exposure was more than 18,000 times below the international guidelines for human exposure to radio signals produced by the International Commission on Non-Ionising Radiation Protection (ICNIRP). The ICNIRP guidelines are the basis for the safety limits in Australia that apply to base stations, TV transmitters and other radio sources.

The European results are similar to levels [reported](#) in 2018 for Australian environments.

The researchers say that overall for public transport and outdoor environments there were no major changes in exposure levels since 2012. They suggest that the reason for the stable trends despite increased use of wireless technologies may be '...improvements in efficiency of these technologies and improved power controls of all emitters...'

They observed that exposure levels in urban areas tended to be higher than in rural areas and that the main signal source in urban areas was mobile network base stations.

Levels in outdoor areas also tended to be higher than in private homes and schools. The highest measurements were found in public transport locations such as, train and tram stations.

Where studies included exposure from personal mobile phone use, this was the main source of exposure with environmental radio signals contributing only about 10%. The researchers recommend further studies to better quantify radio signal exposure from personal device use.

The researchers say that overall for public transport and outdoor environments there were no major changes in exposure levels since 2012.

Weak evidence for increased headache frequency due to lifestyle factors not phone use

An analysis of data from the COSMOS study in Sweden and Finland found 'limited evidence' for a small increase in weekly headache in the group with the highest mobile phone use and concluded that this was likely due to lifestyle factors and not radio signals as the effect was found on the lower exposure 3G and not for 2G.



The international Cohort Study of Mobile Phone Use and Health ([COSMOS](#)) is investigating the possible health effects of long-term use of mobile phones and other wireless technologies. It commenced in 2007 and now involves six European countries (Denmark, Finland, France, Sweden, the Netherlands, and the United Kingdom). Currently, 290,000 adult mobile phone users have been enrolled and France recently issued invitations to 40,000 persons to join the study.

The new [analysis](#) was based on data from the COSMOS study for Sweden (21,049 participants) and Finland (3,120 participants). In order to reduce uncertainties when participants estimate their own mobile phone use, the researchers obtained permission for network operators to provide data for participants on the duration of calls made and received for about 3 months. This was used to estimate the total call-time.

The researchers also conducted separate analyses based on 2G or 3G connections with the rationale that any biological effects related to radio signal exposure should show stronger associations for 2G than 3G as the former produces higher

exposure 'by approximately a factor of 150.' They reported similar call time for both 2G (74 minutes per week) and 3G (72 minutes per week).

Information on health outcomes was obtained from the participants who completed questionnaires for headache, tinnitus and hearing loss at baseline and after four years.

The researchers found no association between weekly call-time at baseline and tinnitus or hearing loss four years later. There was a 'suggestive increase in the occurrence of weekly headache' among participants in the top 10% of weekly call time. This limited evidence was weakened by the absence of a clear trend with increasing call-time and the fact that it was found in the lower exposure 3G network rather than the 2G network. Furthermore, similar findings were found in an analysis of call-time with handsfree devices, which significantly reduce exposure to the head.

The authors say that this suggests that other factors related to the amount of mobile phone use (for example, life-style, when and how the phone is used) may explain the weak association, rather than an effect of radio signals.



No long term radio signal health risk for workers but some research lacking

A report commissioned by the Ministry of Social Affairs and Employment of the Netherlands concludes that the ‘scientific research has not yet proven any links between the exposure of workers and the occurrence of cancer, disorders of the nervous system or other illnesses in the long term,’ however, uncertainties remain.

The [report](#) was prepared by the National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu - RIVM). It reviews evidence of possible long term risks to workers from EME exposures at limits below the European worker limits. The same limits apply in Australia.

RIVM notes that high levels of EME in the workplace, for example due to electric welding or radar systems, ‘can have direct effects on the health of workers, including nerve stimulation and heating of organs’. However, most workplace exposures are levels below which direct effects are seen.

The report concludes that there is insufficient evidence to link workplace exposure to radio signals with the development of brain tumours or leukaemia. For some health topics, such as reproduction, cardiovascular disease and immune system effects, the RIVM says that ‘there is a lack of well-substantiated research’.

There are indications of links between low-frequency electromagnetic fields and certain neurological diseases. RIVM states:

‘However, it is still not clear whether the electromagnetic fields are the actual cause, or other factors at the workplace, such as chemical substances or electric shocks. For other diseases of the nervous system, such as dementia and multiple sclerosis (MS), studies contradict one another or too few studies on the effects of electromagnetic fields have been carried out.’

This report is a follow-up to a 2015 report on the same subject and the authors say that more recent studies do not change the earlier conclusions.

The Australian mobile industry supports safe working practices near antennas via information available from the [Radio Frequency National Site Archive \(RFNSA\)](#), which is managed by AMTA.

Four recommendations to improve EME risk communication

German and Australian scientists reviewed 28 papers describing studies of health risk communication related to the radiofrequency electromagnetic energy (EME) of wireless technologies and they make recommendations to improve communication practice in four areas.

In background they note that the World Health Organization position is that there is 'no conclusive evidence for any health effects of RF-EMF within the recommended exposure limits', however, activist groups disagree and surveys show that public risk perception is not declining.

Among the papers reviewed by the researchers, the majority focused on information about precautionary measures. A meta-analysis that combined the data of the fourteen studies on precautionary measures found that:

'...precautionary recommendations increase risk perceptions of the general public. It has to be noted, though, that the effect size is small. The framing of the recommendations seems to be of minor importance.'

The researchers make four recommendations based on the assumption that communicators do not want to increase public concern when communicating about potential risks.

1. In order to increase the credibility of risk assessments, they should be accompanied by 'a thorough explanation of how the assessment was achieved' so that people can better understand the process underlying the conclusions.

- 2.** People tend to overestimate their exposure from base stations and underestimate their exposure from their mobile phone. The researchers recommend explanation of exposure patterns so that risk perception better matches actual exposure.
- 3.** The evidence shows that precautionary recommendations increase risk perception for both mobile phones and base stations. They recommend that 'risk communicators should weigh the costs and benefits before recommending precaution and be aware of the fact that precautionary recommendations increase risk perception'.
- 4.** Considering that media suggesting health risk increased risk perception, the researchers recommend working with the media 'to achieve a balanced coverage about potential health effects of RF-EMF exposure that reflects the current state of knowledge'.

Further research should address the understanding of risk information; tests of audio-visual communication tools and evaluation of the effectiveness of public panel discussions. There should also be more collaboration between risk communication researchers and other EMF researchers to ensure that social science studies correctly present risk and exposure assessments.



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