Background document to the advisory report 5G and health

No. 2020/16Ae, The Hague, September 2, 2020

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Health Council of the Netherlands

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01 introduction

In this background document to the advisory report 5G and health, drafted by the Electromagnetic Fields Committee of the Health Council of the Netherlands, chapter 2 contains the search strategies used by the committee for the different topics. In chapter 3 the in- and exclusion criteria of the WHO are presented. In chapter 4 the committee gives an overview of the relevant publications on diseases and conditions, and in chapter 5 of the relevant publications on biological processes.

02 literature search strategies

The committee used the following search strategies.

2.1 Frequencies 700 MHz – 5.0 GHz

2.1.1 Cancer

Epidemiological studies since 2015

PubMed: cancer AND epidemiology AND mobile phone AND ("2015/01/01"[Date - Entrez] : "3000"[Date - Entrez]); search date 19-03-2020.

EMF Portal: Keyword: cancer; Epidemiological studies, Radio frequency (>10 MHz) and Mobile communications, Complete time span; search date 19-03-2020.

Experimental studies since 2015

PubMed: (microwaves[MeSH Terms] OR extremely high frequency radio waves[MeSH Terms] OR radio waves[MeSH Terms] OR cellular phone[MeSH Terms] OR telephone, cellular[MeSH Terms] OR ((Base station OR antenna) AND radiofrequency) OR mobile phone* OR cellular phone* OR cellular telephone* OR radiofrequenc* OR radio wave* OR radio-waves OR cellphone* OR cell phone* OR cellular *phone* OR mobile phone* OR microwave OR radiofrequency OR cell phone OR mobile phone OR umts OR gsm OR MHz OR ultra*wideband* OR wireless phone* OR millimeter*wave*) AND (animal OR rat OR mouse OR rats OR mice OR murine OR in vivo) AND (cancer OR carcinogenesis) NOT (ultrasound OR sound OR hyperthermia OR ablation OR imaging OR therap*) AND ("2015/07/30"[Date - Entrez] : "2020/03/19"[Date - Entrez]); search date 19-03-2020.

EMF Portal: Keyword: cancer; Experimental studies; Radio frequency (>10 MHz) and Mobile communications; Complete time span; search date 19-03-2020.

2.1.2 Non-cancer effects

Draft WHO review on health effects of RF EMF[1] and reports of the Swedish Radiation Safety Authority.[2-4]

2.2 Frequencies in the 3.5 GHz band

2.2.1 All effects

Epidemiological studies

EMF Portal: Keywords: WiFi or GHz; Epidemiological studies; Radiofrequency and Mobile communications; Complete time span; search date 19-03-2020.

Experimental studies

EMF Portal: Keywords: WiFi or GHz; Experimental studies; Radiofrequency and Mobile communications; Complete time span; search date 19-03-2020.

Non-cancer effects

Draft WHO review on health effects of RF EMF [1] and reports of the Swedish Radiation Safety Authority.[2-4]

2.3 Frequencies >20 GHz

Epidemiological studies

PubMed: (millimeter*wave* OR millimetre*wave* OR terahertz OR THz OR radar) AND (epidemiol*) NOT (ultrasound OR sound OR acoustic OR ablation OR imaging OR therap* OR spectroscopy); search date: 20-03-2020.

EMF Portal: Keyword: Radar; Epidemiological studies; Radiofrequency and Mobile communications; Complete time span; search date 20-03-2020.

Experimental studies

PubMed: (((millimeter*wave* OR millimetre*wave* OR terahertz OR THz) AND (animal OR rat OR mouse OR rats OR mice OR murine OR in vivo OR human) NOT (ultrasound OR sound OR acoustic OR ablation OR imaging OR therap* OR spectroscopy))); search date:19-03-2020.

2.4 Non-cancer effects, all frequencies (update 2019-2020)

(microwaves[MeSH Terms] OR extremely high frequency radio waves[MeSH Terms] OR radio waves[MeSH Terms] OR cellular phone[MeSH Terms] OR telephone, cellular[MeSH Terms] OR ((base station OR antenna) AND radiofrequency) OR mobile phone* OR cellular phone* OR cellular telephone* OR radiofrequenc* OR radio wave* OR radio-waves OR cellphone* OR cell phone* OR cellular *phone* OR mobile phone* OR microwave OR radiofrequency OR cell phone OR mobile phone OR umts OR gsm OR MHz OR ultra*wideband* OR wireless phone* OR millimeter*wave*) AND (animal* OR rat OR rats OR mouse OR mice OR murine) NOT (“in vitro”[Publication Type] OR “in vitro”[All Fields] OR cells, cultured OR DNA/analysis OR Diagnostic Techniques OR light OR ultraviolet OR ultrasound OR sound OR acoustic OR ablation OR imaging OR therap*)AND (“2019/01/01”[Entrez Date] : “2019/12/31”[Entrez Date]); search date 28-02-2020.

EMF Portal: Experimental studies; Radiofrequency and Mobile communications; Complete time span, selected: 2019 studies; search date 28-02-2020.

2.5 Other sources, all frequencies

A recent review by Simkó and Mattsson.[5]

A recent report of ANSES (Agence nationale de sécurité sanitaire de l’alimentation, de l’environnement et du travail from France).[6]

03
criteria for inclusion in the analysis

Copied from WHO (2014).[1] The reports of the Swedish Radiation Safety Authority use the same criteria.[2-4]

3.1 Quality criteria for inclusion of papers in the Monograph

In order to be able to draw conclusions from a study, it is imperative that it complies with certain requirements regarding design and methodology and that sufficient information is provided to document the compliance. Inclusion criteria based on such quality requirements were specified a priori for the different types of studies. Papers that did not comply with one or more of these criteria, or for which this could not be determined, are not included in the analysis, but are listed at the end of the relevant section with a motivation for the exclusion. The inclusion criteria are:

Epidemiological studies

- The study base is identified (i.e. the population intended for inclusion was identified, eligible participants were either the whole population or a randomly selected sample, either through sampling from the whole study base, or through a method that allowed assessment of the representativity of the participants. Cross-sectional or case-control studies with self-selection of participants from an unidentified study base, e.g. through advertisement, are excluded). Sufficient information is provided for an appropriate judgment of all items specified for inclusion, e.g. the paper provides information about the source of study subjects (study base), and how subjects were selected for inclusion.
- Proper denominators are used for calculations of prevalence/incidence in a descriptive or incidence study.
- At least two levels of exposure are considered (except in incidence time trend studies)
- Relevant statistical analysis is performed.

Volunteer studies

- The exposure conditions are blinded to the participants and sufficient information is provided to assess this.
- The study includes at least two exposure levels, whereof one could be a sham exposure, under otherwise similar conditions. Standby mode of a mobile phone is not regarded as RF exposure, so any study that used a mobile phone in standby mode as the only source of exposure is excluded.[7]
- The exposure levels are sufficiently controlled and documented. Sufficiently controlled means that the output power of the exposure source is fixed or recorded (e.g. a mobile phone in talk mode without level control is not sufficiently controlled). Sufficiently documented means that SAR or other relevant exposure measures, such as power density or electric field, and methods for determining the actual quantity are provided. For volunteers studies it is also sufficient if output power together with geometrical information about exposure setup are described.

- Exposures were not given in fixed order.
- A relevant statistical analysis has been performed when this is needed to conclude on statistical significance.

Animal studies

- The study includes at least two exposure levels, one of which being sham exposure, with otherwise similar conditions. Standby mode of a mobile phone is not regarded as RF exposure, so any study that used a mobile phone in standby mode as the only source of exposure is excluded.
- There is relevant statistical analysis when this is needed to conclude on statistical significance.
- The exposure levels are sufficiently controlled and documented. Sufficiently controlled means that the output power of the exposure source is fixed or recorded (e.g. a mobile phone in talk mode without level control is not sufficiently controlled). Sufficiently documented means that SAR or other relevant exposure measures, such as power density or electric field, and methods for determining the actual quantity are provided.
- Exposures were not given in fixed order.

In vitro studies

- The study includes at least two exposure levels, one of which being sham exposure, with otherwise similar conditions. Standby mode of a mobile phone is not regarded as RF exposure, so any study that used a mobile phone in standby mode as the only source of exposure is excluded.
- There is relevant statistical analysis when this is needed to conclude on statistical significance.
- The exposure levels are sufficiently controlled and documented. Sufficiently controlled means that the output power of the exposure source is fixed or recorded (e.g. a mobile phone in talk mode without level control is not sufficiently controlled). Sufficiently documented means that SAR or other relevant exposure measures, such as power density or electric field, and methods for determining the actual quantity are provided.
- The biological assay has been properly carried out.
- The number of independent experiments is sufficient (3 or more).

3.2 Quality assessment of papers included in the Monograph

All papers included in the Monograph were fully assessed. Assessment criteria were developed mainly based on recognised recommendations and checklists for what to include in the reports of the respective study types. For all study types, the following main issues should be assessed for each individual study:

- statistical precision/statistical power (width of confidence intervals when provided, primarily study size);

- consistency and plausibility of results and, when relevant, dose-response relation;
- potential bias;
- indirectness (reduced validity in relation to such as study population, exposure, time lag between exposure and outcome assessment, and endpoints).

For each of the study types more specific assessment criteria were specified.

Epidemiological studies

The quality criteria for epidemiological studies were elaborated mainly based on recommendations in STROBE, which is an initiative to strengthening the reporting of observational studies in epidemiology (www.strobe-statement.org). STROBE does not make quality assessments, but provides a checklist with items that are important to include in reports of observational studies. Important items for adequate reporting are also of importance for assessment of study quality and evaluation of the findings. Other quality assessment scales were also discussed and taken into consideration when elaborating the quality criteria, e.g. GRADE (www.gradeworkinggroup.org) and the Newcastle-Ottawa Scale (www.ohri.ca/programs/clinical_epidemiology/oxford.asp). These scales were, however, judged to be too superficial and technical and would miss essential quality aspects if applied on their own.

For the GRADE system the main limitation was that it has been developed to assess clinical trials and interventions, and is therefore less suitable for observational studies of potential risk factors for disease.

Potential biases from the following sources was assessed:

- selection bias (likelihood of inclusion of eligible cases and controls (state source of control selection), successful follow-up in cohort studies (should not be related to exposure) (NB: selection bias can also occur as internal missing data);
- outcome misclassification (detection bias, nocebo);
- exposure assessment and categorization (choice of cut-points);
- non-differential exposure misclassification;
- differential exposure misclassification (recall bias) – can also occur as differential completeness of reporting, observer bias;
- reverse causation (including also prodromal effects);
- confounding;
- statistical methods;
- internal consistency, external consistency/validity, dose-response.

Volunteer studies

For volunteer studies the CONSORT statement and checklist for trials[8] was the main source for developing quality assessment criteria and in addition the Gold Standard Publication Checklist was used, which is targeted at experimental animal studies.[9] Some adjustments, mostly by

adding criteria, were done to adapt to the specific conditions of volunteer studies with RF EMF exposure.

Potential biases from the following sources were assessed:

- study design (randomization, counterbalance, habituation sessions);
- design of exposure sessions (adaptation periods, time between exposures);
- blinding;
- background exposure (particularly important with low exposure levels and in studies including participants with IEI-EMF);
- artefacts (e.g. RF EMF signals interference with recording equipment, heat generated by exposure equipment);
- effects of other factors (exposures and conditions before and during sessions);
- confounding factors in between-group analyses;
- statistical methods;
- dropouts or exclusion of participants or of individual outcomes;
- deviations from predefined protocol.

Concerning indirectness, the following was assessed:

- the characteristics of exposure used in studies with IEI-EMF participants deviated from that reported by the participants to cause symptoms.

Animal studies

The criteria for the quality assessment of animal studies were based on the Gold Standard Publication Checklist:[9]

- proper dosimetry;
- proper statistical analysis;
- sufficient group size;
- blinding of exposure and analysis.

In vitro studies

The quality assessment of in vitro studies has primarily applied criteria suggested for toxicological investigations. Some adjustments were done to take into account the issues related to RF EMF exposure:[10,11]

- proper dosimetry;
- proper temperature control;
- sufficient number of independent experiments;
- appropriateness of cell types vs. the endpoint investigated;
- proper statistical analysis.

04
overviews of publications relevant for 5G: diseases and conditions

In the tables in this and the next chapter a distinction has been made between studies in which an unfavourable effect on health has been observed, studies with a favourable health effect, studies with both favourable and unfavourable effects, studies with an effect that is not clearly favourable or unfavourable, and studies in which no effect of exposure to radiofrequency electromagnetic fields has been observed. In some studies, multiple endpoints have been investigated. Even if in such cases an effect, however large or small, has been observed for only one endpoint, the study has been categorized into one of the effect categories. Some studies have investigated more than one frequency, and are therefore reported under more than one frequency band.

The studies have been independently assessed by two experts on the basis of the short summaries from the WHO and SSM reports and the abstracts of the papers for the more recent publications. Agreement has been sought on the classification for each type of study (epidemiological, human or animal experimental). When such agreement could not be obtained, the opinion of a third expert has been decisive. The overall judgement on the classification of each disease/condition or biological process as presented in table 1 in the main advisory report has then been given by the entire committee.

Some studies do not comply with minimal quality criteria and have therefore been excluded from the analysis. The inclusion criteria drafted by the WHO, as presented in chapter 2 of this background document, have been used for this pupose.[1] Also some epidemiological studies on radar workers have been excluded, either because the frequencies of the radar systems were outside the ranges considered in this analysis, or because the used frequencies were not indicated in the studies. All excluded studies have been listed in separate tables.

4.1 Cancer

Cancer includes all malignant neoplasms. In addition to the studies included in previous reports, the committee has taken 25 more recent studies into account in the current report, see table 1.

Table 1. Numbers of publications on the relation with cancer, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
19 epidemiological 4 experimental animals	No publications	2 epidemiological	14 epidemiological

700-2200 MHz

Since the publication in 2016 of the Health Council report on mobile phones[12], 19 epidemiological and 4 experimental animal studies on the relation between exposure to electromagnetic fields with frequencies between 700 and 2200 MHz and the incidence of cancer have been published. Thirteen epidemiological studies do not show an association, 5 show an unfavourable association (an increased risk for salivary gland

tumours, brain tumours, thyroid cancer, breast cancer and leukaemia) and 1 a favourable association (a decreased risk of pituitary tumours). One animal study shows no effect on implanted brain tumours, 1 study shows an unfavourable effect on cardiac schwannomas, brain tumours and adrenal tumours, 1 study shows an unfavourable effect on cardiac schwannomas and 1 study shows a favourable effect (delayed growth of implanted tumour cells).

Table 2. Publications on the relation with cancer in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Vila et al. (2018)[13]	Epidemiology case-control	Mobile telephone	No association
Luo et al. (2019)[14]	Epidemiology case-control	Mobile telephone	No association
Al-Qahtani (2016)[15]	Epidemiology case-control	Mobile telephone	Unfavourable association / higher risk
Balekouzou et al. (2017)[16]	Epidemiology case-control	Mobile telephone	Unfavourable association / higher risk
Shresta et al. (2015)[17]	Epidemiology case-control	Mobile telephone	Favourable association / lower risk
Sato et al. (2017)[18]	Epidemiology cross-sectional	Mobile telephone	No association
Satta et al. (2018)[19]	Epidemiology case-control	Base station	No association
Dabouis et al. (2016)[20]	Epidemiology cohort	Radar	No association
Degrave et al. (2009)[21]	Epidemiology cohort	Radar	Unfavourable association / higher risk
Kim et al. (2015)[22]	Epidemiology incidence	Not specified	No association
Sato et al. (2016)[23]	Epidemiology incidence	Not specified	No association
Chapman et al. (2016)[24]	Epidemiology incidence	Not specified	No association
Gonzalez-Rubio et al. (2017)[25]	Epidemiology incidence	Not specified	No association
Karipidis et al. (2018)[26]	Epidemiology incidence	Not specified	No association
Keinan-Boker et al. (2018)[27]	Epidemiology incidence	Not specified	No association
Nilsson et al. (2019)[28]	Epidemiology incidence	Not specified	No association
Natukka et al. (2019)[29]	Epidemiology incidence	Not specified	No association
Carlberg et al. (2016)[30]	Epidemiology incidence	Not specified	Unfavourable association / higher risk
Hardell & Carlberg (2017)[31]	Epidemiology incidence	Not specified	Unfavourable association / higher risk
Smith-Roe et al. (2019)[32]	Animal	900 and 1900 MHz, GSM and CDMA	No effect
NTP (2018)[33]	Animal	900 and 1900 MHz, GSM and CDMA	Unfavourable effect / higher risk
Falcioni et al. (2018)[34]	Animal	1800 MHz GSM	Unfavourable effect / higher risk
Kryukova et al. (2016)[35]	Animal	1000 MHz	Favourable effect / lower risk

2.2-5.0 GHz

Frequencies around 2.5 GHz have been included in the reports on mobile phones and cancer.[12, 36] These frequencies have been used in a number of animal studies, but have not been investigated in epidemiological studies. Since 2015 no new studies have been published.

20-40 GHz

Two epidemiological studies have been found on people working with or near radar equipment. In 1 study no association with the incidence of cancer has been observed, in the other an increased risk was found.

Table 3. Publications on the relation with cancer in the frequency range 20-40 GHz

Reference	Type of study	Source of exposure	Effect
Baumgard-Elms et al. (2002)[37]	Epidemiology case-control	Radar	No association
Finkelstein (1998)[38]	Epidemiology cohort	Radar	Unfavourable association / higher risk

Excluded

Table 4. Excluded publications on the relation with cancer

Epidemiological studies	Reason for exclusion
Lester & Moore (1982)[39]	Ecological study
Polson & Merritt (1985)[40]	Ecological study
Garland et al. (1987)[42]	Non-specified radar
Hayes et al. (1990)[41]	Non-specified radar
Garland et al. (1990)[43]	Non-specified radar
Hardell et al. (1998)[44]	Non-specified radar
Smulevich et al. (1999)[45]	Non-specified radar
Stang et al. (2001)[46]	Non-specified radar
Groves et al. (2002)[47]	Non-specified radar
Møllerløkken & Moen (2008)[48]	Radar frequencies outside ranges (9.1-9.4 GHz)
Peleg et al. (2018)[49]	Case series
Shen et al. (2018)[50]	Case series , no use of mobile phone
Sato et al. (2019)[51]	Model study
Olsson et al. (2019)[52]	Only survival within case series

Conclusion

In previous reports the committee concluded that an association between long-term and frequent use of mobile phones and an increased risk of tumours in the head and neck region cannot be proven, but can also not be excluded. The recent epidemiological studies in the frequency range 700-2200 MHz do not lead to a different conclusion. Animal experiments provide limited indications that exposure to radiofrequency electromagnetic fields may have an effect on the induction of tumours or promotion of their growth. No statement is possible for the frequency range 20-40 GHz.

4.2 Symptoms

Some people attribute a number of symptoms to exposure to electromagnetic fields; examples are headache, insomnia, concentration problems, tinnitus and skin rashes. They consider themselves ‘electrosensitive’. For some of these people, their symptoms result in severe negative consequences for their functioning. The committee has taken 64 studies into account that investigate the relation between exposure to radiofrequency electromagnetic fields and the occurrence of symptoms, both in people that consider themselves ‘electrosensitive’ as in people that don’t do that, see table 5.

Table 5. Numbers of publications on the relation with symptoms, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
28 epidemiological 36 experimental humans	1 epidemiological	No publications	20 epidemiological 19 experimental humans

700-2200 MHz

In 28 epidemiological studies it has been investigated whether the use of a mobile phone or living in the vicinity of a base station (and in some studies the associated exposure to electromagnetic fields) is associated with reported symptoms. In 10 of these studies no association was observed and 18 studies found an unfavourable association.

In experimental studies only symptoms that occur during or shortly after exposure can be investigated. In 35 of the 36 human experimental studies no effect of exposure to electromagnetic fields on the occurrence of symptoms has been observed. This is the case for both healthy adults and children, and for people that consider themselves ‘electrosensitive’. In 1 study a favourable effect was observed (increased calmness).

Table 6. Publications on the relation with symptoms in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Mohler et al. (2012)[53]	Epidemiology cohort	Mobile telephone	No association
Cho et al. (2016)[54]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Schoeni et al. (2017)[55]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Frei et al. (2012)[56]	Epidemiology cross-sectional	Mobile telephone	No association
Chia et al. (2000)[57]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Wilén et al. (2003)[58]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Söderqvist et al. (2008)[59]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Heinrich et al. (2010, 2011)[60, 61]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Sudan et al. (2012)[62]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Redmayne et al. (2013)[63]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Chiu et al. (2014)[64]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Zheng et al. (2015)[65]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Cho et al. (2016)[66]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Stalin et al. (2016)[67]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Durusoy et al. (2017)[68]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Frei et al. (2012)[56]	Epidemiology cohort	Base station	Unfavourable association / higher risk
Mohler et al. (2012)[53]	Epidemiology cohort	Base station	Unfavourable association / higher risk
Baliatsas et al. (2016)[69]	Epidemiology cohort	Base station	Unfavourable association / higher risk
Schoeni et al. (2016)[70]	Epidemiology cohort	Base station	Unfavourable association / higher risk
Thomas et al. (2008)[71]	Epidemiology cross-sectional	Base station	No association
Berg-Beckhoff et al. (2009)[72]	Epidemiology cross-sectional	Base station	No association
Frei et al. (2012)[56]	Epidemiology cross-sectional	Base station	No association
Mohler et al. (2012)[53]	Epidemiology cross-sectional	Base station	No association
Baliatsas et al. (2015)[73]	Epidemiology cross-sectional	Base station	No association
Schoeni et al. (2016)[70]	Epidemiology cross-sectional	Base station	No association
Martens et al. (2017)[74]	Epidemiology cross-sectional	Base station	No association
Hutter et al. (2006)[75]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
Heinrich et al. (2010, 2011)[60, 61]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
Durusoy et al. (2017)[68]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
Mann & Röschke (1996)[76]	Experimental humans adults	Mobile telephone	No effect
Borbély et al. (1999)[77]	Experimental humans adults	Mobile telephone	No effect
Huber et al. (2000, 2003)[78, 79]	Experimental humans adults	Mobile telephone	No effect

Reference	Type of study	Source of exposure	Effect
Koivisto et al. (2001)[80]	Experimental humans adults	Mobile telephone	No effect
Tahvainen et al. (2004)[81]	Experimental humans adults	Mobile telephone	No effect
Curcio et al. (2005)[82]	Experimental humans adults	Mobile telephone	No effect
Loughran et al. (2012)[83]	Experimental humans adults	Mobile telephone	No effect
Fritzer et al. (2007)[84]	Experimental humans adults	Mobile telephone	No effect
Cinel et al. (2008)[85]	Experimental humans adults	Mobile telephone	No effect
Kleinlogel et al. (2008)[86]	Experimental humans adults	Mobile telephone	No effect
Johansson et al. (2008)[87]	Experimental humans adults	Mobile telephone	No effect
Curcio et al. (2009)[88]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[89]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[90]	Experimental humans adults	Mobile telephone	No effect
Spichtig et al. (2012)[91]	Experimental humans adults	Mobile telephone	No effect
Lustenberger et al. (2013)[92]	Experimental humans adults	Mobile telephone	No effect
Vecsei et al. (2013)[93]	Experimental humans adults	Mobile telephone	No effect
Verrender et al. (2016)[94]	Experimental humans adults	Mobile telephone	No effect
Verrender et al. (2018)[95]	Experimental humans adults	Mobile telephone	No effect
Lowden et al. (2019)[96]	Experimental humans adults	Mobile telephone	No effect
Croft et al. (2010)[97]	Experimental humans children	Mobile telephone	No effect
Choi et al. (2014)[98]	Experimental humans children	Mobile telephone	No effect
Hietanen et al. (2002)[99]	Experimental humans electrosensitive	Mobile telephone	No effect
Rubin et al. (2006)[100]	Experimental humans electrosensitive	Mobile telephone	No effect
Wilén et al. (2006)[101]	Experimental humans electrosensitive	Mobile telephone	No effect
Oftedal et al. (2007)[102]	Experimental humans electrosensitive	Mobile telephone	No effect
Nam et al. (2009)[103]	Experimental humans electrosensitive	Mobile telephone	No effect
Lowden et al. (2011)[104]	Experimental humans electrosensitive	Mobile telephone	No effect
Kwon et al. (2012)[105]	Experimental humans electrosensitive	Mobile telephone	No effect
Verrender et al. (2018)[95]	Experimental humans electrosensitive	Mobile telephone	No effect
Danker-Hopfe et al. (2010)[106]	Experimental humans adults	Base station	No effect
Augner et al. (2009)[107]	Experimental humans adults	Base station	Favourable effect / lower risk
Riddervold et al. (2008)[108]	Experimental humans children	Base station	No effect
Regel et al. (2006)[109]	Experimental humans electrosensitive	Base station	No effect
Eltiti et al. (2007)[110]	Experimental humans electrosensitive	Base station	No effect
Leitgeb et al. (2008)[111]	Experimental humans electrosensitive	Base station	No effect
Furubayashi et al. (2009)[112]	Experimental humans electrosensitive	Base station	No effect

2.2-5.0 GHz

In 1 observational study an association was observed (in 1 of the 57 subjects) between the occurrence of symptoms and exposure to electromagnetic fields.

Table 7. Publications on the relation with symptoms in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Bolte et al. (2019)[113]	Observational humans electrosensitive	Base station	Unfavourable effect / higher risk

Excluded

Table 8. Excluded publications on the relation with symptoms

Epidemiological studies	Reason for exclusion
Robinette et al. (1980)[114]	No correction for bias
Cao et al. (2000)[115]	No information on selection of participants and participation rates; phone user group has much higher income, more smoking and drinking than control group
Santini et al. (2001)[116]	No information on selection of participants and participation rates
Navarro et al. (2003)[117]	Study population not defined
Santini et al. (2002)[118]	Study population not defined; exposure measure is self-estimated distance to base station
Santini et al. (2003)[119]	Study population not defined; exposure measure is self-estimated distance to base station
Al-Khlaiwi & Meo (2004)[120]	Study population not defined
Wilén et al. (2004)[121]	No information on selection of participants and participation rates
Balikci et al. (2005)[122]	No information on exposure assessment, symptom questions or procedures for selection of participants or participation rates
Meo & Al-Drees (2005)[123]	No information on exposure assessment, symptom questions
Abdel-Rassoul et al. (2007)[124]	No information on selection of participants and participation rates
Blettner et al. (2009)[125]	No useful information on exposure assessment
Eger & Jahn (2010)[126]	No peer-reviewed journal
Baliatsas et al. (2011)[127]	No exposure, just distance
Bortkiewicz et al. (2012)[128]	Random selection participants unclear; no information on participation rates
Liu et al. (2014)[129]	No information on selection of participants and participation rates
Lamech (2014)[130]	Descriptive study, no information on exposure
Silva et al. (2015)[131]	Exposure measure is self-estimated distance to mobile phone base stations
Singh et al. (2016)[132]	Study population not defined
Hegazy et al. (2016)[133]	Study population not defined

Human experimental studies	
Adair et al. (1998)[134]	No statistical analyse for subjective parameters
Braune et al. (1998)[135]	Fixed order of exposures
Zhang et al. (2000)[136]	No information on control of exposure level
Barth et al. (2000)[137]	Insufficient information on exposure
Adair et al. (2001)[138]	No statistical analyse for subjective parameters
Adair et al. (2001)[139]	No statistical analyse for subjective parameters
Bortkiewicz et al. (2002)[140]	No information on control of exposure level
Hocking & Westerman (2002)[141]	No blinding
Adair et al. (2003)[142]	No statistical analyse for subjective parameters
Uloziene et al. (2005)[143]	No statistical analyse for subjective parameters
Adair et al. (2005)[144]	No statistical analyse for subjective parameters
Eliyahu et al. (2006)[145]	No statistical analyse for subjective parameters
Bachmann et al. (2007)[146]	No statistical analyse for subjective parameters
Hung et al. (2007)[147]	No statistical analyse for subjective parameters
Luria et al. (2009)[148]	No statistical analyse for subjective parameters
Mortazavi et al. (2011 [149]	No information on control of exposure level
Alsanosi et al. (2013)[150]	No control of lower exposure condition
Havas & Marrongelle (2013)[151]	Paper retracted
Trunk et al. (2013)[152]	No statistical analysis for subjective parameters

Conclusion

The committee concludes that for the frequency range of 700-2200 MHz no relation has been found between exposure to radiofrequency electromagnetic fields and the occurrence of symptoms such as headache, insomnia, concentration problems, tinnitus and skin rashes. The committee has given the experimental studies – that did not show effects – more weight than the epidemiological studies. In these studies the observed associations can result from the use of a mobile phone as such, for instance to continuously follow social media and being available, even at night, and the stress and lack of sleep that go with that. No statement is possible for the frequency ranges 2.2-5.0 GHz and 20-40 GHz.

4.3 Auditory system

Diseases and conditions of the auditory system include various problems with the ear and inner ear, such as hearing impairment and deafness. The committee has taken 25 studies into the relation between exposure to radiofrequency electromagnetic fields and auditory conditions into account, see table 9. The effects on hearing have been investigated using objective testing methods, where the perception of sound by the subjects (human or animal) does not play a role.

Table 9. Numbers of publications on the relation with diseases and conditions of the auditory system, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
6 epidemiological 10 experimental humans 9 experimental animals	No publications	No publications	1 epidemiological 17 experimental humans 8 experimental animals

700-2200 MHz

No effects have been observed in 6 epidemiological studies, 10 human experimental studies and 7 animal experimental studies. In 2 animal experimental studies a favourable effect has been found.

Table 10. Publications on the relation with diseases and conditions of the auditory system in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Hutter et al. (2010)[153]	Epidemiology case-control	Mobile telephone	No association
Frei et al. (2012)[56]	Epidemiology cohort	Mobile telephone	No association
Mortazavi et al. (2007)[154]	Epidemiology cross-sectional	Mobile telephone	No association
Sudan et al. (2013)[155]	Epidemiology cross-sectional	Mobile telephone	No association
Gupta et al. (2015)[156]	Epidemiology cross-sectional	Mobile telephone	No association
Bhagat et al. (2016)[157]	Epidemiology cross-sectional	Mobile telephone	No association
Janssen et al. (2005)[158]	Experimental humans adults	Mobile telephone	No effect
Uloziene et al. (2005)[143]	Experimental humans adults	Mobile telephone	No effect
Parazzini et al. (2005)[159]	Experimental humans adults	Mobile telephone	No effect
Parazzini et al. (2007)[160]	Experimental humans adults	Mobile telephone	No effect
Paglialonga et al. (2007)[161]	Experimental humans adults	Mobile telephone	No effect
Bamiou et al. (2008, 2015)[162, 163]	Experimental humans adults	Mobile telephone	No effect
Stefanics et al. (2008)[164]	Experimental humans adults	Mobile telephone	No effect
Parazzini et al. (2009)[165]	Experimental humans adults	Mobile telephone	No effect
Parazzini et al. (2010)[166]	Experimental humans adults	Mobile telephone	No effect
Kwon et al. (2010)[167]	Experimental humans adults	Mobile telephone	No effect
Marino et al. (2000)[168]	Animal	936 and 950 MHz continuous	No effect
Aran et al. (2004)[169]	Animal	900 MHz GSM	No effect
Galloni et al. (2005)[170]	Animal	923 and 936 MHz continuous	No effect
Galloni et al. (2005)[171]	Animal	900 and 1800 MHz GSM	No effect
Parazzini et al. (2007)[172]	Animal	900 MHz continuous	No effect
Galloni et al. (2009)[173]	Animal	1946 MHz UMTS	No effect
Hidisoglu et al. (2018)[174]	Animal	2100 MHz 217 Hz modulated	Favourable effect / lower risk
Kim et al. (2019) [175]	Animal	1850 MHz	Favourable effect / lower risk

Excluded

Table 11. Excluded publications on the relation with diseases and conditions of the auditory system

Epidemiological studies	Reason for exclusion
Sagiv et al (2018)[176]	Insufficient exposure information
Human experimental studies	
Kellenyi et al. (1999)[177]	No sham control; no blinding
de Sèze et al. (2001)[178]	No sham control; no blinding
Ozturan et al. (2002)[179]	No sham control; no blinding
Arai et al. (2003)[180]	No sham control; no blinding
Bak et al. (2003)[181]	No sham control; no blinding
Monnery et al. (2004)[182]	No information on blinding; no control of exposure level
Pau et al. (2005)[183]	No information on blinding
Sievert et al. (2005)[184]	No information on blinding
Oysu et al. (2005)[185]	No sham control; no blinding
Mora et al. (2006)[186]	No sham control; no blinding
Sievert et al. (2007)[187]	No information on blinding (studies also reported in Pau et al.[183] and Sievert, Eggert & Pau[184])
Stefanics et al. (2007)[188]	No statistical analyse; insufficient data to conclude on differences between sham and real exposures
Colletti et al. (2011)[189]	No control of exposure level
Balachandran et al. (2012)[190]	No sham control; no blinding
Alsanosi et al. (2013)[150]	No sham control; no blinding; no control of exposure level.
Mandala et al. (2014)[191]	No control of exposure level
Singh (2015)[192]	No information on exposure level; no blinding
Animal studies	
Kizilay et al. (2003)[193]	No exposure level
Budak et al. (2009)[194]	No exposure level; unclear whether controls are sham controls
Budak et al. (2009)[195]	No exposure level; unclear whether controls are sham controls
Budak et al. (2009)[196]	No information on exposure setup; no exposure level; unclear whether controls are sham controls
Kayabasoglu et al. (2011)[197]	No information on exposure setup; no exposure level; unclear whether controls are sham controls
Kaprana et al. (2011)[198]	No exposure level
Seckin et al. (2014)[199]	No sham control
Sagiv et al (2018)[176]	Insufficient exposure information

Conclusion

The committee concludes that for the frequency range of 700-2200 MHz no unfavourable effects on the auditory system have been observed. No statement is possible for the frequency ranges 2.2-5.0 GHz and 20-40 GHz.

4.4 Eyes

Diseases and conditions of the eyes include eye inflammation, cataract, glaucoma, looking cross-eyed, impaired vision and blindness. The committee has taken 9 studies into the relation between exposure to radiofrequency electromagnetic fields and conditions of the eyes into account in this report, see table 12. Studies into effects on the eyes have used different endpoints, varying from effects on vision in humans to damage to tissues in the eye.

Table 12. Numbers of publications on the relation with diseases and conditions of the eye, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
4 experimental humans 1 experimental animals	4 experimental animals	No publications	1 epidemiological 1 experimental humans 10 experimental animals

700-2200 MHz

No effects on vision have been observed in 4 human experimental studies. In 1 animal study, an increased expression of two genes that are involved in programmed cell death (apoptosis) has been observed in tissues of the eye. However, the implication for damage to the eye is not known.

Table 13. Publications on the relation with diseases or conditions of the eye in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Schmid et al. (2005)[200]	Experimental humans adults	Mobile telephone	No effect
Wilén et al. (2006)[101]	Experimental humans adults	Mobile telephone	No effect
Irlenbusch et al. (2007)[201]	Experimental humans adults	Mobile telephone	No effect
Unterlechner et al. (2008)[202]	Experimental humans adults	Mobile telephone	No effect
Eker et al. (2018)[203]	Animal	1800 MHz	Unfavourable effect / higher risk

2.2-5.0 GHz

In 2 animal studies, damage to eye tissues has been observed. In 2 other animal studies, both replications of the first ones, no effects were observed.

Table 14. Publications on the relation with diseases or conditions of the eye in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Kues et al. (1992)[206]	Animal	2.45 GHz pulsed	Animal
Kamimura et al. (1994)[204]	Animal	2.45 GHz	No effect
Ye et al. (2001)[207]	Animal	2.45 GHz	Unfavourable effect / higher risk
Lu et al. (2010)[205]	Animal	2.45 GHz 34 Hz pulsed	No effect

Excluded

Table 15. Excluded publications on the relation with diseases or conditions of the eye

Epidemiological studies	Reason for exclusion
Cleary et al. (1965)[208]	Non-specified radar
Human experimental studies	
Gawit et al. (2017)[209]	Parallel group design, no information on exposure, no sham control group
Animal studies	
Inalöz et al. (1997)[210]	No dosimetry
Balci et al. (2007)[211]	No dosimetry, no exposure level
Balci et al. (2009)[212]	No information on exposure
Hässig et al. (2009)[213]	No exposure level
Zareen et al. (2009)[214]	Unclear exposure level; inconsistent information on group size
Demirel et al. (2012)[215]	No information on exposure
Hässig et al. (2012)[216]	No comparison exposed / non-exposed
Amer et al. (2013)[217]	No dosimetry
Akar et al. (2013)[218]	No sham exposed group
Tök et al. (2014)[219]	No dosimetry

Conclusion

The conclusion for the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz is that no effect has been found. No statement is possible for the frequency range 20-40 GHz.

4.5 Cardiovascular system and autonomous nerve system

Conditions of the cardiovascular system and the autonomous nerve system include circulation disorders of the cardiac muscle (ischemia), heart attack, heart rhythm disorders and inflammation of cardiac valves or the cardiac muscle. The committee has taken 27 studies into the relation between exposure to radiofrequency electromagnetic fields and conditions of the cardiovascular system and autonomous nerve system into account in this report, see table 16. Both direct effects on the cardiovascular system and indirect effects due an influence on the autonomous nerve system have been included, since these effects cannot always be clearly distinguished.

Table 16. Numbers of publications on the relation with conditions of the cardiovascular system and autonomous nerve system, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
1 epidemiological 24 experimental humans	1 epidemiological 21 experimental humans	1 epidemiological	1 epidemiological

700-2200 MHz

One epidemiological study has been published that found an increased risk for ischemic heart disease associated with daily use of a mobile phone. An association with exposure to radiofrequency electromagnetic fields cannot be established from this study. In 20 human experimental studies no effects have been observed, 3 studies show an unfavourable effect on variations in heart rhythm, and 1 study shows an effect that is not clearly favourable or unfavourable (an increased blood circulation in the skin).

Table 17. Publications on the relation with conditions of the cardiovascular system and autonomous nerve system in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Benson et al. (2013)[220]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Mann et al. (1998)[221]	Experimental humans adults	Mobile telephone	No effect
Braune et al. (2002)[222]	Experimental humans adults	Mobile telephone	No effect
Tahvanainen et al. (2004) [81]	Experimental humans adults	Mobile telephone	No effect
Barker et al. (2007)[223]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[89]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[90]	Experimental humans adults	Mobile telephone	No effect
Atlasz et al. (2006)[224]	Experimental humans adults	Mobile telephone	No effect
Curcio et al. (2009)[88]	Experimental humans adults	Mobile telephone	No effect
Ghosn et al. (2012)[225]	Experimental humans adults	Mobile telephone	No effect
Ghosn et al. (2015)[226]	Experimental humans adults	Mobile telephone	No effect
Huber et al. (2003)[79]	Experimental humans adults	Mobile telephone	No effect
Parazzini et al. (2013)[227]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Spichtig et al. (2012)[91]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Loos et al. (2013)[228]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Lindholm et al. (2011)[229]	Experimental humans children	Mobile telephone	No effect
Choi et al. (2014)[98]	Experimental humans children	Mobile telephone	No effect
Wilén et al. (2006)[101]	Experimental humans electrosensitive	Mobile telephone	No effect
Oftedal et al. (2007)[102]	Experimental humans electrosensitive	Mobile telephone	No effect
Nam et al. (2009)[103]	Experimental humans electrosensitive	Mobile telephone	No effect
Kwon et al. (2012)[105]	Experimental humans electrosensitive	Mobile telephone	No effect
Andrianome et al. (2017)[230]	Experimental humans electrosensitive	Mobile telephone	No effect
Hietanen et al. (2002)[99]	Experimental humans electrosensitive	Mobile telephone	Unfavourable effect / higher risk
Eltiti et al. (2009)[231]	Experimental humans adults	Base station	No effect
Furubayashi et al. (2009)[112]	Experimental humans adults	Base station	No effect

2.2-5.0 GHz

No effects were observed on heart rhythm in 1 study of ‘electrosensitive’ people.

Table 18. Publications on the relation with conditions of the cardiovascular system and autonomous nerve system in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Andrianome et al. (2017)[230]	Experimental humans electrosensitive	Wi-Fi	No effect

20-40 GHz

In 1 study of people working with aircraft tracking radar, an increased risk for cardiac failure was observed.

Table 19. Publications on the relation with conditions of the cardiovascular system and autonomous nerve system in the frequency range 20-40 GHz

Reference	Type of study	Source of exposure	Effect
Tikhonova (2003)[232]	Epidemiology cross-sectional	Radar	Unfavourable effect / higher risk

Excluded

Table 20. Excluded publications on the relation with conditions of the cardiovascular system and autonomous nerve system

Epidemiological studies	Reason for exclusion
Møllerløkken & Moen (2008)[48]	Radar frequencies outside ranges (9.1-9.4 GHz)
Human experimental studies	
Braune et al. (1998)[135]	Fixed order of exposures; no information on control of exposure level
Paredi et al. (2001)[233]	No information on control of exposure level; no blinding
Monfrecola et al. (2003)[234]	No information on control exposure level; no information on blinding
Celik & Hascalik (2004)[235]	No blinding; no information on control of exposure level; fixed order of exposures
Esen & Esen (2006)[236]	No information on control exposure and on order of exposures
Nam et al. (2006)[237]	Fixed order of exposures
Ahamed et al. (2008)[238]	No sham control; no blinding; no information on control of exposure level
Andrzejak et al. (2008)[239]	No sham control; no blinding; no information on control of exposure level
Rezk et al. (2008)[240]	No sham control; no blinding; no information on control of exposure level
Tamer et al. (2009)[241]	No information on control exposure level
Yilmaz & Yildiz (2010)[242]	No information on control exposure level; fixed order of exposures
Havas et al. (2010)[243]	No statistical analysis; insufficient information to draw conclusions on difference between sham and real exposure
Faust et al. (2011)[244]	No sham control; no blinding; no information on control of exposure level

Human experimental studies	
Barutcu et al. (2011)[245]	No sham control; no blinding; no information on control of exposure level
Mortazavi et al. (2011)[149]	No information on control exposure level
Alhusseiny et al. (2012)[246]	No information on control exposure level; no blinding; fixed order of exposures
Havas & Marrongelle (2013)[151]	Paper retracted
Devasia et al. (2014)[247]	No information on control exposure level
Malek et al. (2015)[248]	Incorrect information on exposure levels; insufficient information to draw conclusions on difference between sham and real exposure
Messina et al. (2017)[249]	No sham control; no blinding; no information on control of exposure level and frequency
Umar et al. (2014)[250]	No information on control exposure level; no blinding

Conclusion

The committee concludes that no effects of exposure to radiofrequency electromagnetic fields on the cardiovascular system and the autonomous nerve system have been found in the frequency range of 700-2200 MHz. No statement is possible for the frequency ranges 2.2-5.0 GHz and 20-40 GHz.

4.6 Neurodegenerative diseases

Neurodegenerative diseases result from functional decline or necrosis or disappearance of nerve tissue in the brain. Examples are Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS). The committee has taken 1 study into the relation between exposure to radiofrequency electromagnetic fields and neurodegenerative diseases into account in this report, see table 21.

Table 21. Numbers of publications on the relation with neurodegenerative diseases, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
1 epidemiological	No publications	No publications	2 epidemiological 3 experimental animals

700-2200 MHz

One epidemiological study has been published that found an increased risk for ALS.

Table 22. Publications on the relation with neurodegenerative diseases in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Luna et al. (2019)[251]	Epidemiology case-population	Base station	Unfavourable association / higher risk

Excluded

Table 23. Excluded publications on the relation with neurodegenerative diseases

Epidemiological studies	Reason for exclusion
Silva & Santana (2004)[252]	Non-specified radar
Beard et al. (2016)[253]	Non-specified radar
Animal studies	
Arendash et al. (2010)[254]	Therapy
Dragicevic et al. (2011)[255]	Therapy
Banaceur et al. (2013)[256]	Therapy

Conclusion

The committee concludes that due to the limited amount of data is not possible to make a statement on a relation between exposure to radiofrequency electromagnetic fields and neurodegenerative diseases.

4.7 Male fertility

The committee has taken 19 studies into the relation between exposure to radiofrequency electromagnetic fields and effects on male fertility into account in this report, see table 24. The endpoints vary from the number of spermatozoa in different stages of development, aberrations in the appearance of spermatozoa, motility of spermatozoa and necrosis of cells in the testes (a biological process called apoptosis or planned cell death), to the levels of testosterone (a hormone that is made in the testes).

Table 24. Numbers of publications on the relation with male fertility, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
10 experimental animals	9 experimental animals	No publications	7 epidemiological 2 experimental humans 36 experimental animals

700-2200 MHz

No effects on male fertility endpoints were observed in 5 animal studies, in 1 study unfavourable effects were found, in 2 studies a favourable effect and in 2 studies both favourable and unfavourable effects.

Table 25. Publications on the relation with male fertility in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Ribeiro et al. (2007)[257]	Animal	1800 MHz	No effect
Daşdağ et al. (2008)[258]	Animal	900 MHz GSM	No effect
Lee et al. (2010)[259]	Animal	848.5 MHz CDMA	No effect
Lee et al. (2012)[260]	Animal	849 MHz CDMA and 1950 MHz WCDMA	No effect
Trošić et al. (2013)[261]	Animal	915 MHz GSM	No effect
Qin et al. (2014)[262]	Animal	1800 MHz	Unfavourable effect / higher risk
Houston et al. (2019)[263]	Animal	905 MHz	Unfavourable effect / higher risk
Azimzadeh & Jelodar (2019)[264]	Animal	900 MHz	Unfavourable effect / higher risk
Yahyazadeh et al. (2020)[265]	Animal	900 MHz	Unfavourable effect / higher risk
Forgács et al. (2006)[266]	Animal	1800 MHz GSM	Favourable effect / lower risk

Reference	Type of study	Source of exposure	Effect
Imai et al. (2011)[267]	Animal	1950 MHz WCDMA	Favourable effect / lower risk
Nisbet et al. (2012)[268]	Animal	900 MHz GSM and 1800 MHz GSM	Favourable and unfavourable effect
Taş et al. (2014)[269]	Animal	900 MHz	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 9 animal studies an unfavourable effect on male fertility endpoints was observed, in particular on testis function and the development of sperm.

Table 26. Publications on the relation with male fertility in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Saygin et al. (2011)[270]	Animal	2450 MHz 217 Hz pulse modulated	Unfavourable effect / higher risk
Meena et al. (2014)[271]	Animal	2450 MHz	Unfavourable effect / higher risk
Shahin et al. (2014)[272]	Animal	2450 MHz	Unfavourable effect / higher risk
Saygin et al. (2015)[273]	Animal	2450 MHz	Unfavourable effect / higher risk
Daşdağ et al. (2015)[274]	Animal	2450 MHz Wi-Fi	Unfavourable effect / higher risk
Saygin et al. (2016)[275]	Animal	2450 MHz	Unfavourable effect / higher risk
Jonwal et al. (2018)[276]	Animal	2450 MHz	Unfavourable effect / higher risk
Bilgici et al. (2018)[277]	Animal	2450 MHz Wi-Fi	Unfavourable effect / higher risk
Shahin et al. (2018)[278]	Animal	2450 MHz	Unfavourable effect / higher risk
Yu et al. (2020)[279]	Animal	2575–2635 MHz	Unfavourable effect / higher risk

Excluded

Table 27. Excluded publications on the relation with male fertility

Epidemiological studies	Reason for exclusion
Weyandt et al. (1996)[280]	Non-specified radar
Schrader et al. (1998)[281]	Non-specified radar
Ding et al. (2004)[282]	Non-specified radar
Yan et al. (2007)[283]	Non-specified radar
Møllerløkken & Moen (2008)[48]	Radar frequencies outside ranges (9.1-9.4 GHz)
Baste et al. (2008)[284]	Radar frequencies outside ranges (9.1-9.4 GHz)
Baste et al. (2012)[285]	Radar frequencies outside ranges (9.1-9.4 GHz)
Human experimental studies	
de Sèze et al. (2001)[178]	No blinding
Davoudi et al. (2002)[286]	No blinding
Animal studies	
Daşdağ et al. (1999)[287]	Incomplete dosimetry, no exposure level
Daşdağ et al. (2003)[288]	Incomplete dosimetry, no exposure level
Ozguner et al. (2005)[289]	No sham control group
Yan et al. (2007)[290]	No dosimetry, no exposure level
Mailankot et al. (2009)[291]	No dosimetry, no exposure level
Kesari et al. (2010)[292]	No sham control group; no dosimetry, no exposure level
Meo et al. (2010)[293]	No sham control group; no dosimetry, no exposure level
Otitoloju et al. (2010)[294]	No controlled laboratory conditions
Esmekaya et al. (2011)[295]	SAR incorrectly calculated from external electric veld
Kesari et al. (2011)[296]	No dosimetry, no exposure level
Meo et al. (2011)[297]	No sham control group; no dosimetry, no exposure level
Sarookhani et al. (2011)[298]	No sham control group; no dosimetry, no exposure level
Al-Damegh (2012)[299]	No dosimetry, no exposure level
Çelic et al. (2012)[300]	No dosimetry, no exposure level
Kesari & Behari (2012)[301]	No dosimetry, no exposure level
Atasoy et al. (2013)[302]	No sham control group; no dosimetry, no exposure level
Ghanbari et al. (2013)[303]	No dosimetry; insufficient information on exposure level
Shahin et al. (2013)[304]	No quantification of effects, no statistical analysis

Epidemiological studies	Reason for exclusion
Karaman et al. (2014)[305]	No dosimetry, no exposure level
Kumar et al. (2014)[306]	No dosimetry, no exposure level
Oksay et al. (2014)[307]	Incorrect dosimetry, no exposure level
Sepehrimanesh et al. (2014)[308]	Insufficient information on exposure and dosimetry
Azadi Oskouyi et al. (2015)[309]	No sham control group; no dosimetry, no exposure level
Bin-Meferij & El-Kott (2015)[310]	No sham control group; no dosimetry, no exposure level
Tumkaya et al. (2016)[311]	Incomplete dosimetry
Çetkin et al. (2017)[312]	No dosimetry, no exposure level
Pandey et al. (2017)[313]	No sham control group
Sepehrimanesh et al. (2017)[314]	No sham control group
Shahin et al. (2017)[315]	Incomplete description of exposure; incorrect dosimetry
Oyewopo et al. (2017)[316]	No dosimetry
Narayanan et al. (2018)[317]	No exposure level
Oh et al. (2018)[318]	Exposure level unclear (2 distances but 1 SAR value)
Shahin et al. (2018)[319]	SAR calculation refers to Shahin et al. (2017)[315]; which gives an incorrect calculation (for uterus!) for a mobile phone at maximum power
Hu et al. (2019)[320]	Incomplete dosimetry, no frequency
Yahyazadeh & Altunkaynak (2019)[321]	No sham control group
Gautam et al. (2019)[322]	No sham control group; incomplete description of exposure

Conclusion

The committee concludes on the basis of animal studies that for exposure to electromagnetic fields in the frequency range of 700-2200 MHz no statement is possible. In the frequency range of 2.2-5.0 GHz unfavourable effects on the testis function and development of sperm are possible. No statement is possible for the frequency range of 20-40 GHz.

4.8 Pregnancy and birth defects

The committee has taken 15 studies into the relation between exposure to radiofrequency electromagnetic fields and the course of pregnancy and the incidence of birth defects into account in this report, see table 28 (in some studies multiple frequency bands have been studied). Epidemiological studies investigated the association between exposure and duration of pregnancy. In animal studies mainly the outcome of pregnancy, such as the number of offspring, and birth defects have been investigated.

Table 28. Numbers of publications on the relation with pregnancy and birth defects, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
1 epidemiological 9 experimental animals	1 epidemiological 8 experimental animals	No publications	25 experimental animals

700-2200 MHz

In 1 epidemiological study an unfavourable effect was observed (decreased duration of pregnancy). In 7 animal studies no effects were found and in 1 animal study an unfavourable effect (a reduction in the number of nerve cells in the hippocampus of newborns). In another animal study both favourable and unfavourable effects on prenatal development were found.

Table 29. Publications on the relation with pregnancy and birth defects in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Tsarna et al. (2019)[323]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Bornhausen & Scheingraber (2000)[324]	Animal	900 MHz GSM	No effect
Ferreira et al. (2006)[325]	Animal	834 MHz	No effect
Sommer et al. (2009)[326]	Animal	1966 MHz UMTS	No effect
Ogawa et al. (2009)[327]	Animal	1950 MHz WCDMA	No effect
Lee et al. (2009)[328]	Animal	848.5 MHz CDMA and 1.95 GHz WCDMA	No effect
Fragopoulou et al. (2010)[329]	Animal	900 MHz GSM	No effect
Shirai et al. (2017)[330]	Animal	880–5180 MHz	No effect
Koç et al. (2016)[132]	Animal	900 MHz	Unfavourable effect / higher risk
Nisbet et al. (2016)[331]	Animal	900 and 1800 MHz	Favourable and unfavourable effect

2.2-5.0 GHz

In 1 epidemiological study no association was observed between exposure to Wi-Fi during pregnancy and spontaneous abortion. In 6 out of 8 animal studies no effect was found of prenatal exposure to electromagnetic fields on the development of young animals. In the 2 other studies an unfavourable effect was found: decreased growth.

Table 30. Publications on the relation with pregnancy and birth defects in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Abad et al (2016)[332]	Epidemiology cohort	Wi-Fi	No effect
Takahashi et al. (2010)[333]	Animal	2140 MHz WCDMA	No effect
Aït-Aïssa et al. (2012)[334]	Animal	2450 MHz Wi-Fi	No effect
Poulletier de Gannes et al. (2012)[335]	Animal	2450 MHz Wi-Fi	No effect
Poulletier de Gannes et al. (2013)[336]	Animal	2450 MHz Wi-Fi	No effect
Shirai et al. (2014)[337]	Animal	2140 MHz WCDMA	No effect
Woelders et al. (2017)[338]	Animal	5.6 GHz WLAN	No effect
Sangun et al. (2015)[339]	Animal	2.45 GHz 217 Hz modulated	Unfavourable effect / higher risk
Kuybulu et al. (2016)[340]	Animal	2.45 GHz	Unfavourable effect / higher risk

Excluded

Table 31. Excluded publications on the relation with pregnancy and birth defects

Animal studies	Reason for exclusion
Magras & Xenos (1997)[341]	No sham control group
Inalöz et al. (1997)[210]	No quantitative data; no statistics; exposure by location next to microwave oven; no dosimetry
Nakamura et al. (2000)[342]	No sham control group
Nakamura et al. (2003)[343]	No sham control group
Bas et al. (2009)[344]	No sham control group
Gul et al. (2009)[345]	Incomplete dosimetry, no frequency
Rağbetli et al. (2009)[346]	No dosimetry, no exposure level
Aldad et al. (2012)[347]	Mobile telephone on cage; no dosimetry, no exposure level
Jing et al.(2012)[348]	No exposure level, no frequency
Haghani et al. (2013)[349]	SAR values provided, but no information on dosimetry, no other exposure information
Köktürk et al. (2013)[350]	No dosimetry, no exposure level

Animal studies	Reason for exclusion
Seckin et al. (2014)[199]	No sham control group
Bedir et al. (2015)[351]	No dosimetry, no exposure level
Odacı et al. (2015)[352]	No sham control group
Türedi et al. (2015)[353]	No sham control group
Zhang et al. (2015)[354]	No information on exposure setup, no exposure level
Erkut et al. (2016)[355]	No sham control group; no dosimetry, no exposure level
Razavinasab et al. (2016)[356]	Calculation SAR unclear, no other exposure information
Türedi et al. (2016)[357]	No sham control group
Othman et al. (2017)[358]	No dosimetry, no exposure level
Othman et al. (2017)[359]	No dosimetry, no exposure level
Yilmaz et al. (2017)[360]	No sham control group, insufficient information on exposure level
Alimohammadi et al. (2018)[361]	No sham control group, insufficient information on exposure level
Tumkaya et al. (2019)[362]	No sham control group, unclear exposure and assessment of exposure level
Amandokht Saghezchi et al. (2019)[363]	No dosimetry

Conclusion

The committee concludes that unfavourable effects of exposure to radiofrequency electromagnetic fields during pregnancy on the course of pregnancy, on birth defects and on early development are possible for the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz. No statement is possible for the frequency range of 20-40 GHz.

05
overviews of publications relevant for 5G: biological processes

For several biological processes indications have been observed for an unfavourable effect of exposure to radiofrequency electromagnetic fields. This is the case for behaviour, cognition, brain neurotransmitters, brain electrical activity, sleep, blood-brain barrier, blood, oxidative stress and gene expression in brain tissue. For other biological processes – immune system and hormones – no indications for adverse effects have been observed. The observed effects indicate that radiofrequency electromagnetic fields may have the potential to cause adverse health effects, but there is no proof that health is indeed affected. The committee did not analyse whether the effects reported may have a threshold, or whether and how the effect increases with increasing exposure level.

5.1 Behaviour

Several types of behaviour have been investigated. Studies in humans generally involve behavioural problems in children. In animals, more specific behaviours have been studied: explorative behaviour, recognition of objects and situations, anxiety and effects on learned behaviour.
The committee has taken 58 studies into the relation between exposure to radiofrequency electromagnetic fields and behaviour into account in this report, see table 32.

Table 32. Numbers of publications on the relation with behaviour, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
9 epidemiological 29 experimental animals	1 epidemiological 19 experimental animals	No publications	2 epidemiological 22 experimental animals

700-2200 MHz

In 3 out of 9 epidemiological studies, no relation has been observed between exposure to electromagnetic fields and behaviour. In the other 5 epidemiological studies unfavourable effects were observed and in 1 study a favourable effect. In 16 animal studies no effect on behaviour was found, in 8 an unfavourable effect, in 3 a favourable effect and in 2 both favourable and unfavourable effects.

Table 33. Publications on the relation with behaviour in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Guxens et al. (2019)[364]	Epidemiology cohort	Mobile telephone	No association
Divan et al. (2008)[365]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Divan et al. (2012)[366]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Byun et al. (2013)[367]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Sudan et al. (2016)[368]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Roser et al. (2016)[369]	Epidemiology cohort	Mobile telephone	Favourable association / lower risk
Zheng et al. (2014)[370]	Epidemiology cross-sectional	Mobile telephone	No association
Roser et al. (2016)[369]	Epidemiology cross-sectional	Base station	No association
Thomas et al. (2010)[371]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
D'Andrea et al (1989)[372]	Animal	1300 MHz pulsed	No effect
Quock et al. (1994)[373]	Animal	1800 MHz continuous	No effect
Bornhausen & Scheingraber (2000)[324]	Animal	900 MHz GSM	No effect
Dubreuil et al. (2003)[374]	Animal	900 MHz GSM	No effect
Mausset-Bonnefont et al. (2004)[375]	Animal	900 MHz GSM	No effect
Nittby et al. (2008)[376]	Animal	900 MHz GSM	No effect
Takahashi et al. (2010)[333]	Animal	2140 MHz WCDMA	No effect
Bouji et al. (2012)[377]	Animal	900 MHz GSM	No effect
Shirai et al. (2014)[337]	Animal	2140 MHz WCDMA	No effect
Klose et al. (2014)[378]	Animal	900 MHz GSM	No effect
Son et al. (2015)[379]	Animal	1950 MHz WCDMA	No effect
Son et al. (2016)[380]	Animal	1950 MHz WCDMA	No effect
Barthélémy et al. (2016)[381]	Animal	900 MHz GSM	No effect
Petitdant et al. (2016)[382]	Animal	900 MHz GSM	No effect
Gupta et al. (2018)[383]	Animal	900 and 1800 MHz	No effect
Gupta et al. (2019)[384]	Animal	900 and 1800 MHz	No effect
Lebovitz (1981)[385]	Animal	1300 MHz pulsed	Unfavourable effect / higher risk
Lebovitz (1983)[386]	Animal	1300 MHz pulsed	Unfavourable effect / higher risk
Akyel et al. (1991)[387]	Animal	1250 MHz pulsed	Unfavourable effect / higher risk
Daniels et al. (2009)[388]	Animal	840 MHz	Unfavourable effect / higher risk
Khirazova et al. (2012)[389]	Animal	905 MHz	Unfavourable effect / higher risk
Schneider & Stangassinger (2014)[390]	Animal	900 MHz GSM and 1966 MHz UMTS	Unfavourable effect / higher risk
Zhang et al. (2017)[391]	Animal	1800 MHz	Unfavourable effect / higher risk
Jeong et al. (2018)[392]	Animal	1950 MHz	Unfavourable effect / higher risk

Reference	Type of study	Source of exposure	Effect
Kumlin et al. (2007)[393]	Animal	900 MHz GSM	Favourable effect / lower risk
Kim et al. (2017)[394]	Animal	835 MHz	Favourable effect / lower risk
Wang et al. (2017)[395]	Animal	1800 MHz	Favourable effect / lower risk
Son et al. (2018)[396]	Animal	1950 MHz	Favourable and unfavourable effect
Broom et al. (2019)[397]	Animal	1846 MHz	Favourable and unfavourable effect

2.2-5.0 GHz

In 1 epidemiological study no effect on behaviour was observed.

In 6 animal studies no effect was found, in 11 unfavourable effects, in 1 a favourable effect and in 1 effects that are not clearly favourable or unfavourable.

Table 34. Publications on the relation with behaviour in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Guxens et al (2019)[364]	Epidemiology cohort	Wi-Fi	No association
Quock et al. (1987)[398]	Animal	2450 MHz continuous	No effect
Mitchell et al. (1989)[399]	Animal	2450 MHz continuous	No effect
Quock et al. (1994)[373]	Animal	4.7 GHz continuous	No effect
Kemerov et al. (1999)[400]	Animal	2375 MHz, 433.93 MHz, 27.13 MHz	No effect
Cosquer et al. (2005)[401]	Animal	2450 MHz pulsed	No effect
Crouzier et al. (2007)[402]	Animal	2450 MHz pulsed with 1 kHz	No effect
Thomas et al. (1982)[403]	Animal	2.8 GHz continuous and pulsed	Unfavourable effect / higher risk
Lai et al. (1983)[404]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
D'Andrea et al. (1988)[405]	Animal	2450 MHz	Unfavourable effect / higher risk
Chou et al. (1992)[406]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Raslear et al. (1993)[407]	Animal	3 GHz pulsed	Unfavourable effect / higher risk
Shtemberg et al. (2001)[408]	Animal	4.2 GHz modulated with 20 Hz-20 kHz	Unfavourable effect / higher risk
Chaturvedi et al. (2011)[409]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Kumar et al. (2016)[410]	Animal	2450 MHz continuous and modulated with 400 Hz	Unfavourable effect / higher risk
Obajuluwa et al. (2017)[411]	Animal	2.5 GHz Wi-Fi	Unfavourable effect / higher risk

Reference	Type of study	Source of exposure	Effect
Gupta et al. (2018)[383]	Animal	2450 MHz	Unfavourable effect / higher risk
Gupta et al. (2019)[384]	Animal	2450 MHz	Unfavourable effect / higher risk
Sinha et al. (2008)[412]	Animal	2450 MHz modulated with 1 kHz	Favourable effect / lower risk
Sinha (2008)[413]	Animal	2450 MHz modulated with 1 kHz	Effect, not clearly favourable or unfavourable

Excluded

Table 35. Excluded publications on the relation with behaviour

Epidemiological studies	Reason for exclusion
Calvente et al. (2016)[414]	Exposure assessment meaningless
Guxens et al (2019)[364]	Excluded for presence of phones and Wi-Fi, included for number of calls
Animal studies	
Galloway (1975)[415]	No statistical analysis; no exposure level
Mattsson & Oliva (1976)[416]	Study with 1 animal
Thomas et al. (1980)[417]	No sham control group; no statistical analysis
Carratalá & Moya (1991)[418]	No sham control group
Jensh (1997)[419]	No data or p-values reported
Crouzier et al. (2007)[420]	No data reported
Narayanan et al. (2009)[421]	No exposure information; no sham control group
Narayanan et al. (2010)[422]	No exposure information; no sham control group
Carballo-Quintás et al. (2011)[423]	No data reported
Ntzouni et al. (2011)[424]	No exposure level
Aldad et al. (2012)[347]	Mobile telephone on cage; no dosimetry, no exposure level
El Kholy & El Husseiny (2012)[425]	No dosimetry, no exposure level; no sham control group
Sokolovic et al. (2012)[426]	No quantitative data on behaviour
Haghani et al. (2013)[349]	SAR values provided, but no information on dosimetry, no other exposure information
Ntzouni et al. (2013)[427]	No exposure level
de Caires Júnior et al. (2014)[428]	No exposure level
Saikhedkar et al. (2014)[429]	Incorrect dosimetry (SAR calculated for humans), no other exposure information
Lee et al. (2015)[430]	Mobile telephone in aquarium, no dosimetry
Zhang et al. (2015)[354]	No information on exposure setup, no exposure level
Shehu et al. (2016)[431]	Mobile telephone in cage, no dosimetry
Hassanshahi et al. (2017)[432]	No dosimetry
Othman et al. (2017)[359]	No dosimetry, no exposure level

Conclusion

The committee concludes that both favourable and unfavourable effects of exposure to radiofrequency electromagnetic fields cannot be excluded. The conclusion for the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz is that an effect is possible. No statement is possible for the frequency range of 20-40 GHz.

5.2 Cognition

Studies into the relation between radiofrequency electromagnetic fields and cognition include effects on memory, reaction speed and responsiveness, since these provide information on the functioning of the brain. Sometimes effects are very subtle. The committee has taken 107 studies into the relation between exposure to radiofrequency electromagnetic fields and cognition into account in this report, see table 36.

Table 36. Numbers of publications on the relation with cognition, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
11 epidemiological 46 experimental humans 24 experimental animals	2 experimental humans 24 experimental animals	No publications	9 epidemiological 16 experimental humans 18 experimental animals

700-2200 MHz

Two of the 11 epidemiological studies do not show an association, 4 an unfavourable association, 2 a favourable association, 2 a favourable and unfavourable association and 1 an association not clearly favourable or unfavourable. In 31 human experimental studies no effect was found, in 7 an unfavourable effect and in 8 a favourable effect. Out of the 24 animal studies, 14 show no effect, 9 an unfavourable effect and 1 a favourable effect.

Table 37. Publications on the relation with cognition in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Thomas et al. (2010)[433]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Foerster et al. (2018)[434]	Epidemiology cohort	Mobile telephone	Unfavourable association / higher risk
Ng et al. (2012)[435]	Epidemiology cohort	Mobile telephone	Favourable association / lower risk
Brzozek et al. (2019)[436]	Epidemiology cohort	Mobile telephone	Favourable and unfavourable association
Redmayne et al. (2016)[437]	Epidemiology cross-sectional	Mobile telephone	No association
Abramson et al. (2009)[438]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Lee et al. (2001)[439]	Epidemiology cross-sectional	Mobile telephone	Favourable association / lower risk
Guxens et al. (2016)[440]	Epidemiology cross-sectional	Mobile telephone	Association, not clearly favourable or unfavourable
Hutter et al. (2006)[75]	Epidemiology cross-sectional	Base station	No association
Roser et al. (2016)[369]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
Guxens et al. (2016)[440]	Epidemiology cross-sectional	Base station	Favourable and unfavourable association

Reference	Type of study	Source of exposure	Effect
Freude et al. (1998)[441]	Experimental humans adults	Mobile telephone	No effect
Freude et al. (2000)[442]	Experimental humans adults	Mobile telephone	No effect
Krause et al. (2000)[443]	Experimental humans adults	Mobile telephone	No effect
Krause et al. (2000)[444]	Experimental humans adults	Mobile telephone	No effect
Krause et al. (2007)[445]	Experimental humans adults	Mobile telephone	No effect
Haarala et al. (2003)[446]	Experimental humans adults	Mobile telephone	No effect
Haarala et al. (2004)[447]	Experimental humans adults	Mobile telephone	No effect
Haarala et al. (2003)[448]	Experimental humans adults	Mobile telephone	No effect
Aalto et al. (2006)[449]	Experimental humans adults	Mobile telephone	No effect
Kwon et al. (2011)[450]	Experimental humans adults	Mobile telephone	No effect
Kwon et al. (2012) [451]	Experimental humans adults	Mobile telephone	No effect
Hamblin et al. (2006)[452]	Experimental humans adults	Mobile telephone	No effect
Besset et al. (2005)[453]	Experimental humans adults	Mobile telephone	No effect
Curcio et al. (2008)[454]	Experimental humans adults	Mobile telephone	No effect
Luria et al. (2009)[148]	Experimental humans adults	Mobile telephone	No effect
Terao et al. (2006)[455]	Experimental humans adults	Mobile telephone	No effect
Terao et al. (2007)[456]	Experimental humans adults	Mobile telephone	No effect
Russo et al. (2006)[457]	Experimental humans adults	Mobile telephone	No effect
Cinel et al. (2007)[458]	Experimental humans adults	Mobile telephone	No effect
Haarala et al. (2007)[459]	Experimental humans adults	Mobile telephone	No effect
Fritzer et al. (2007)[84]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[89]	Experimental humans adults	Mobile telephone	No effect
Schmid et al. (2012)[90]	Experimental humans adults	Mobile telephone	No effect
Kleinlogel et al. (2008) [460]	Experimental humans adults	Mobile telephone	No effect
Sauter et al. (2011)[461]	Experimental humans adults	Mobile telephone	No effect
Curcio et al. (2012)[462]	Experimental humans adults	Mobile telephone	No effect
Krause et al. (2004)[463]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Hamblin et al. (2004)[464]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Eliyahu et al. (2006)[145]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Keetley et al. (2006)[465]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Lustenberger et al. (2012)[90]	Experimental humans adults	Mobile telephone	Unfavourable effect / higher risk
Preece et al. (1999)[466]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Koivisto et al. (2000)[467]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Koivisto et al. (2000)[468]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Curcio et al. (2004)[469]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk

Reference	Type of study	Source of exposure	Effect
Regel et al. (2007)[470]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Verrender et al. (2016)[94]	Experimental humans adults	Mobile telephone	Favourable effect / lower risk
Preece et al. (2005)[471]	Experimental humans children	Mobile telephone	No effect
Haarala et al. (2005)[472]	Experimental humans children	Mobile telephone	No effect
Loughran et al. (2013)[473]	Experimental humans children	Mobile telephone	No effect
Leung et al. (2011)[474]	Experimental humans children	Mobile telephone	Unfavourable effect / higher risk
Wilén et al. (2006)[101]	Experimental humans electrosensitive	Mobile telephone	No effect
Jech et al. (2011)[475]	Experimental humans electrosensitive	Mobile telephone	Favourable effect / lower risk
Wiholm et al. (2009)[476]	Experimental humans electrosensitive	Mobile telephone	Favourable effect / lower risk
Maier et al. (2004)[477]	Experimental humans adults	Base station	Unfavourable effect / higher risk
Eltiti et al. (2009)[231]	Experimental humans electrosensitive	Base station	No effect
Sienkiewicz et al. (2000)[478]	Animal	900 MHz 217 Hz pulsed	No effect
Dubreuil et al. (2002)[479]	Animal	900 MHz 217 Hz pulsed	No effect
Dubreuil et al. (2003)[374]	Animal	900 MHz 217 Hz pulsed	No effect
Yamaguchi et al. (2003)[480]	Animal	1439 MHz pulsed	No effect
Ammari et al. (2008)[481]	Animal	900 MHz GSM	No effect
Daniels et al. (2009)[388]	Animal	840 MHz	No effect
Mori & Arendash (2011)[482]	Animal	918 MHz GSM	No effect
Arendash et al. (2012)[483]	Animal	918 MHz GSM	No effect
Klose et al. (2014)[378]	Animal	900 MHz GSM	No effect
Bouji et al. (2016)[484]	Animal	900 MHz	No effect
Son et al. (2016)[380]	Animal	1950 MHz	No effect
Zhang et al. (2017)[391]	Animal	1800 MHz	No effect
Keleş et al. (2018)[485]	Animal	900 MHz	No effect
Bouji et al. (2020)[486]	Animal	900 MHz	No effect
Deshmukh et al. (2013)[487]	Animal	900 MHz	Unfavourable effect / higher risk
Jeong et al. (2015)[488]	Animal	1950 MHz WCDMA	Unfavourable effect / higher risk
Deshmukh et al. (2015)[489]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Tang et al. (2015)[490]	Animal	900 MHz continuous	Unfavourable effect / higher risk
Deshmukh et al. (2016)[491]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Sharma et al. (2017)[492]	Animal	1000 MHz	Unfavourable effect / higher risk
Tan et al. (2017)[493]	Animal	1500 and 2856 MHz	Unfavourable effect / higher risk
Ahmadi et al. (2018)[494]	Animal	900 MHz	Unfavourable effect / higher risk
Sharma et al. (2019)[495]	Animal	2100 MHz	Unfavourable effect / higher risk
Kumlin et al. (2007)[393]	Animal	900 MHz GSM	Favourable effect / lower risk

2.2-5.0 GHz

One of the 2 human experimental studies does not show an effect, the other shows an unfavourable effect. Also 7 animal studies show no effect and 17 show an unfavourable effect.

Table 38. Publications on the relation with cognition in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Hosseini et al. (2019)[496]	Experimental humans adults	Wi-Fi	No effect
Bamdad et al. (2019)[497]	Experimental humans adults	Wi-Fi	Unfavourable effect / higher risk
Cobb et al. (2004)[498]	Animal	2450 MHz pulsed	No effect
Cassel et al. (2004)[499]	Animal	2450 MHz pulsed	No effect
Cosquer et al. (2005)[500]	Animal	2450 MHz pulsed	No effect
Cosquer et al. (2005)[501]	Animal	2450 MHz pulsed	No effect
Cosquer et al. (2005)[401]	Animal	2450 MHz pulsed	No effect
Takahashi et al. (2010)[333]	Animal	2140 MHz WCDMA	No effect
Shirai et al. (2014)[337]	Animal	2140 MHz WCDMA	No effect
Lai et al. (1994)[502]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Wang & Lai (2000)[503]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Lai (2004)[504]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Li et al. (2008) [505]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Chaturvedi et al. (2011)[409]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Lu et al. (2012) [506]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Wang et al. (2013)[507]	Animal	2856 MHz pulsed	Unfavourable effect / higher risk
Qiao et al. (2014)[508]	Animal	2856 MHz pulsed	Unfavourable effect / higher risk
Wang et al. (2015)[509]	Animal	2856 MHz pulsed	Unfavourable effect / higher risk
Li et al. (2015)[510]	Animal	2856 MHz pulsed	Unfavourable effect / higher risk
Shahin et al. (2015)[511]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Deshmukh et al. (2015)[489]	Animal	2450 MHz	Unfavourable effect / higher risk
Deshmukh et al. (2016)[491]	Animal	2450 MHz	Unfavourable effect / higher risk
Tan et al. (2017)[493]	Animal	2856 MHz	Unfavourable effect / higher risk
Wang et al. (2017)[512]	Animal	2856 MHz pulsed	Unfavourable effect / higher risk
Shahin et al. (2018)[513]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Karimi et al. (2018)[514]	Animal	2450 MHz	Unfavourable effect / higher risk

Excluded

Table 39. Excluded publications on the relation with cognition

Epidemiological studies	Reason for exclusion
Wilén et al. (2004)[121]	No information on selection of participants and participation rates, representativeness of participating subjects cannot be assessed
Arns et al. (2007)[515]	Recruitment process unclear, therefore comparability of groups is difficult to judge
Abdel-Rassoul et al. (2007)[124]	No information on selection of participants and participation rates, representativeness of participating subjects cannot be assessed
Mortazavi et al. (2013)[516]	Radar frequencies outside ranges (2-18 GHz)
Jarideh et al. (2015)[517]	No information on selection of participants, except that they were volunteers
Calvente et al. (2016)[414]	Exposure assessment meaningless
Guxens et al. (2016)[440]	Exposure assessment Wi-Fi meaningless, included for exposure base stations
Mohan et al. (2016)[518]	Only 9 subjects divided into 3 groups and compared with each other in relation to their self-reported mobile phone use
Meo et al. (2019)[519]	Difference between groups, exposure assessment incomplete
Human experimental studies	
Eibert et al. (1997)[520]	No numerical data provided, insufficient information to evaluate whether statistical analysis was relevant
Hladky et al. (1999)[521]	No information on control exposure level and blinding
Croft et al. (2002)[522]	Insufficient information about exposure
Edelstyn & Oldershaw (2002)[523]	No information on control of exposure level
Lee et al. (2003)[524]	Insufficient information on exposure and control of exposure level
Smythe & Costall (2003)[525]	No information on control of exposure level
Maier et al. (2004)[526]	No information on exposure level
Papageorgiou et al. (2004)[527]	Insufficient information on control of exposure level, no information on blinding
Papageorgiou et al. (2006)[528]	No information on blinding
Hareuveny et al. (2011)[529]	No sham control group
Mortazavi et al. (2012)[530]	No information on control of exposure level
Vecchio et al. (2012)[531]	No statistical comparison between sham and real exposure, insufficient data to conclude on statistical significance
Movvahedi et al. (2014)[532]	No information on control of exposure level
Malek et al. (2015)[248]	Incorrect information on exposure level; insufficient data to draw conclusions on difference between sham and real exposed
Kalafatakis et al. (2017)[533]	Parallel group design
Altuntas et al. (2018)[534]	No information on exposure level
Animal studies	
Kumar et al. (2009)[535]	No exposure level, no sham control group
Narayanan et al. (2009)[421]	No information on exposure
Fragopoulou et al. (2010)[536]	Exposure level not clear

Animal studies	
Arendash et al. (2010)[254]	Assessment of SAR not clear, no information about other relevant exposure quantities provided
Zhao et al. (2012)[537]	Type of RF EMF and timing of assay relative to exposure not specified
Hao et al. (2012)[538]	Power density measured in centre of cage, but large variation likely, therefore inadequate dosimetry
Hao et al. (2013)[539]	Power density measured in centre of cage, but large variation likely, therefore inadequate dosimetry
Banaceur et al. (2013)[256]	Assessment of SAR not clear, no information about other relevant exposure quantities provided
Ikinci et al. (2013)[540]	No dosimetry
Saikhedkar et al. (2014)[429]	Incorrect dosimetry (SAR calculated for humans), no other information on exposure level
Maaroufi et al. (2014)[541]	SAR incorrectly calculated using external electric field, which is not provided, no other information on exposure level
Narayanan et al. (2015)[542]	Mobile telephone in cage, no dosimetry
Razavinasab et al. (2016)[356]	Assessment of SAR not clear, no information about other relevant exposure quantities provided
Nirwane et al. (2016)[543]	Mobile telephone over aquarium, no dosimetry
Wang et al. (2016)[544]	Source of exposure not provided; incomplete dosimetry
Othman et al. (2017)[358]	No dosimetry, no exposure level
Varghese et al. (2017)[411]	Incomplete dosimetry
Nasser et al. (2018)[545]	No exposure level

Conclusion

The committee concludes that for the frequency ranges 700-2200 MHz and 2.2-5.0 GHz both favourable and unfavourable effects of exposure to radiofrequency electromagnetic fields on cognition are possible.
No statement is possible for the frequency range of 20-40 GHz.

5.3 Sleep

Sleep is a phase in the diurnal rhythm that is used for the processing of impressions and consolidation in long-term memory, and to reset the brain and the body. Sleep has a number of distinct cyclic phases: shallow sleep, deep sleep and REM (rapid eye movement) sleep. Dreams occur in the latter phase. Usually there are 4 or 5 cycles per night. Sustained disturbance of the sleeping pattern can have an unfavourable effect on health. The committee has taken 47 studies into the relation between exposure to radiofrequency electromagnetic fields and sleep problems into account in this report, see table 40.

Table 40. Numbers of publications on the relation with sleep, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
21 epidemiological 26 experimental humans	No publications	No publications	3 epidemiological

700-2200 MHz

Of the 21 epidemiological studies that were identified, 12 show no association, 6 show an unfavourable association, 2 show a favourable association and 1 an association that could be both favourable and unfavourable. In 12 experimental studies in human volunteers no effect on sleeping pattern was found, while in 14 other studies an effect was found that is not clearly favourable or unfavourable.

Table 41. Publications on the relation with sleep in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Cho et al. (2016)[54]	Epidemiology cohort	Mobile telephone	No association
Mohler et al. (2012)[53]	Epidemiology cohort	Mobile telephone	Association, not clearly favourable or unfavourable
Söderqvist et al. (2008)[59]	Epidemiology cross-sectional	Mobile telephone	No association
Redmayne et al. (2013)[63]	Epidemiology cross-sectional	Mobile telephone	No association
Cho et al. (2016)[66]	Epidemiology cross-sectional	Mobile telephone	No association
Heinrich et al. (2010, 2011)[60, 61]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Huss et al. (2015)[379]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Stalin et al. (2016)[67]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Durusoy et al. (2017)[68]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Cabré-Riera et al. (2019)[546]	Epidemiology cross-sectional	Mobile telephone	Unfavourable association / higher risk
Chiu et al. (2014)[64]	Epidemiology cross-sectional	Mobile telephone	Favourable association / lower risk
Tettamanti et al. (2020)[547]	Epidemiology cohort	Base station	No association
Röösli et al.(2010)[548]	Epidemiology cohort	Base station	Favourable association / lower risk
Hutter et al. (2006)[75]	Epidemiology cross-sectional	Base station	No association
Thomas et al. (2008)[71]	Epidemiology cross-sectional	Base station	No association
Berg-Beckhoff et al. (2009)[72]	Epidemiology cross-sectional	Base station	No association
Heinrich et al. (2011)[61]	Epidemiology cross-sectional	Base station	No association
Frei et al. (2012)[56]	Epidemiology cross-sectional	Base station	No association
Mohler et al. (2012)[53]	Epidemiology cross-sectional	Base station	No association
Martens et al. (2017)[74]	Epidemiology cross-sectional	Base station	No association
Huss et al. (2015)[379]	Epidemiology cross-sectional	Base station	Unfavourable association / higher risk
Wagner et al. (1998)[549]	Experimental humans adults healthy	Mobile telephone	No effect
Borbély et al. (1999)[77]	Experimental humans adults healthy	Mobile telephone	No effect
Wagner et al. (2000)[550]	Experimental humans adults healthy	Mobile telephone	No effect

Reference	Type of study	Source of exposure	Effect
Huber et al. (2000, 2003)[78, 79]	Experimental humans adults healthy	Mobile telephone	No effect
Fritzer et al. (2007)[84]	Experimental humans adults healthy	Mobile telephone	No effect
Danker-Hopfe et al. (2011)[551]	Experimental humans adults healthy	Mobile telephone	No effect
Lustenberger et al. (2015)[552]	Experimental humans adults healthy	Mobile telephone	No effect
Nakatani-Enomoto et al. (2013)[553]	Experimental humans adults healthy	Mobile telephone	No effect
Lowden et al. (2019)[96]	Experimental humans adults healthy	Mobile telephone	No effect
Mann and Röschke (1996)[76]	Experimental humans adults healthy	Mobile telephone	Favourable and unfavourable effect
Hung et al. (2007)[147]	Experimental humans adults healthy	Mobile telephone	Favourable and unfavourable effect
Lustenberger et al. (2013)[92]	Experimental humans adults healthy	Mobile telephone	Favourable and unfavourable effect
Huber et al. (2002)[554]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Loughran et al. (2005)[555]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Loughran et al. (2012)[83]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Regel et al. (2007)[470]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Schmid et al. (2012)[89]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Schmid et al. (2012)[90]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Danker-Hopfe et al. (2016)[556]	Experimental humans adults healthy	Mobile telephone	Effect, not clearly favourable or unfavourable
Danker-Hopfe et al. (2010)[106]	Experimental humans adults healthy	Base station	No effect
Jech et al. (2001)[475]	Experimental humans adults patient	Mobile telephone	No effect
Lowden et al. (2011)[104]	Experimental humans adults patient	Mobile telephone	Favourable and unfavourable effect
Leitgeb et al. (2008)[111]	Experimental humans electrosensitive	Base station	No effect

Excluded

Table 42. Excluded publications on the relation with sleep

Epidemiological studies	Reason for exclusion
Eger & Jahn (2010)[126]	No peer-reviewed journal
Huss et al. (2015)[379]	Excluded for Wi-Fi, included for mobile phones
Redmayne et al. (2013)[63]	Excluded for Wi-Fi, included for mobile phones

Conclusion

Both favourable and unfavourable effects of exposure to radiofrequency electromagnetic fields have been found. For the frequency range of 700-2200 MHz the conclusion is that an effect is possible. No statement is possible for the frequency ranges of 2.2-5.0 GHz and 20-40 GHz.

5.4 Brain neurotransmission

A decrease in neurotransmission in nerves and brain tissue will have adverse consequences for brain function and therefore for the functioning of the body. The committee has taken 28 studies into the relation between exposure to radiofrequency electromagnetic fields and brain neurotransmission into account in this report, see table 43.

Table 43. Numbers of publications on the relation with brain neurotransmission, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
14 experimental animals	14 experimental animals	No publications	10 experimental animals

700-2200 MHz

In 2 animal studies no effect was found on substances that are involved in brain neurotransmission, while in 8 studies an unfavourable effect was found. In 2 animal studies a favourable effect was found and in 2 others effects that are not clearly favourable or unfavourable.

Table 44. Publications on the relation with brain neurotransmission in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Hata et al. (2005)[557]	Animal	1439 MHz TDMA	No effect
Crouzier et al. (2007)[420]	Animal	1800 MHz GSM	No effect
Mausset et al. (2001)[558]	Animal	900 MHz GSM and continuous	Unfavourable effect / higher risk
Mausset-Bonnefont et al. (2004)[375]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Aboul Ezz et al. (2013)[559]	Animal	1800 MHz GSM	Unfavourable effect / higher risk
Megha et al. (2015)[560]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Kim et al. (2017)[492]	Animal	835 MHz	Unfavourable effect / higher risk
Zhang et al. (2017)[391]	Animal	1800 MHz	Unfavourable effect / higher risk
Kim et al. (2019)[561]	Animal	835 MHz	Unfavourable effect / higher risk
Belyaev et al. (2006)[562]	Animal	900 MHz GSM	Favourable effect / lower risk
Bodera et al. (2019)[563]	Animal	1800 MHz	Favourable effect / lower risk
Khadrawy et al. (2009)[564]	Animal	900 MHz GSM	Effect, not clearly favourable or unfavourable
Ahmed et al. (2018)[565]	Animal	1800 MHz	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 1 animal study no effect was found and 9 studies showed an unfavourable effect. In 1 study both favourable and unfavourable effects were found and in 3 studies effects that are not clearly favourable or unfavourable.

Table 45. Publications on the relation with brain neurotransmission in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Crouzier et al. (2007)[402]	Animal	2450 MHz pulsed with 1 kHz	No effect
Lai et al. (1990)[566]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Lai et al. (1991)[567]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Lai et al. (1992)[568]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Inaba et al. (1992)[569]	Animal	2450 MHz	Unfavourable effect / higher risk
Lai et al. (1994)[502]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Lai et al. (1996)[570]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Shtemberg et al. (2001)[408]	Animal	4200 MHz modulated with 20 Hz–20 kHz	Unfavourable effect / higher risk
Wang et al. (2015)[571]	Animal	2.856 GHz pulsed	Unfavourable effect / higher risk
Tan et al. (2017)[493]	Animal	2.856 GHz	Unfavourable effect / higher risk
Qiao et al. (2014)[508]	Animal	2.856 GHz pulsed	Favourable and unfavourable effect
Lai et al. (1992)[572]	Animal	2450 MHz pulsed	Effect, not clearly favourable or unfavourable
Li et al. (2015)[510]	Animal	2.856 GHz pulsed	Effect, not clearly favourable or unfavourable
Wang et al. (2015)[509]	Animal	2.856 GHz	Effect, not clearly favourable or unfavourable

Excluded

Table 46. Excluded publications on the relation with brain neurotransmission

Animal studies	Reason for exclusion
Wang et al. (2009)[573]	Not clear at what time points sham controls were assayed; type of microwaves not specified
Maskey et al. (2010)[574]	Whole-body SAR, assessment unclear: not calculated, no measurements of temperature or electric field
Noor et al. (2011)[575]	Units of concentration not provided and an unusual assay parameter used, the equilibrium ratio percent, which is not explained
Dogan et al. (2012)[576]	No exposure level
Jing et al. (2012)[348]	No exposure level, no frequency provided
Wang et al. (2012)[577]	No exposure source and frequency reported
Zhao et al. (2012) [537]	Not clear whether time points of neurotransmitter assays were calculated from the first or the last exposure; type of field not specified
Maaroufi et al. (2014)[541]	SAR incorrectly calculated using external electric field, which is not provided, no other information on exposure level
Maskey et al. (2014) [578]	SAR assessment unclear: not calculated, no measurements of temperature or electric field
Song et al. (2015)[579]	No dosimetry, no sham control group

Conclusion

The committee concludes that radiofrequency electromagnetic fields may have an effect on brain neurotransmission. For the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz it is concluded that an effect is possible. No statement is possible for the frequency range of 20-40 GHz.

5.5 Brain electrical activity

The brain functions using chemical and electrical processes. These are continuously influenced by all kinds of factors and behaviours. Changes in electrical processes in the brain continuously occur. The committee has

taken 80 studies into the relation between exposure to radiofrequency electromagnetic fields and brain electrical activity into account in this report, see table 47.

Table 47. Numbers of publications on the relation with brain electrical activity, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
64 experimental humans 9 experimental animals	1 experimental humans 6 experimental animals	No publications	3 experimental humans 10 experimental animals

700-2200 MHz

In 23 human experimental studies no effects on brain electrical activity were observed, and in 41 studies effects were observed that are not clearly favourable or unfavourable. In 4 animal studies no effects were found and in 5 studies effects that are not clearly favourable or unfavourable.

Table 48. Publications on the relation with brain electrical activity in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Hinrichs & Heinze (2004)[580]	Experimental humans adults event related potentials	Mobile telephone	No effect
Hamblin et al. (2006)[452]	Experimental humans adults event related potentials	Mobile telephone	No effect
Yuasa et al. (2006)[581]	Experimental humans adults event related potentials	Mobile telephone	No effect
Ferreri et al. (2006)[582]	Experimental humans adults event related potentials	Mobile telephone	No effect
Stefanics et al. (2008)[164]	Experimental humans adults event related potentials	Mobile telephone	No effect
Kleinlogel et al. (2008)[460]	Experimental humans adults event related potentials	Mobile telephone	No effect
Parazzini et al. (2009)[165]	Experimental humans adults event related potentials	Mobile telephone	No effect
Parazzini et al. (2010)[166]	Experimental humans adults event related potentials	Mobile telephone	No effect
Kwon et al. (2009)[583]	Experimental humans adults event related potentials	Mobile telephone	No effect
Trunk et al. (2014)[584]	Experimental humans adults event related potentials	Mobile telephone	No effect
Dalecki et al. (2018)[585]	Experimental humans adults event related potentials	Mobile telephone	No effect
Freude et al. (1998)[441]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Freude et al. (2000)[442]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Krause et al. (2000)[443]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Krause et al. (2000)[444]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Krause et al. (2004)[463]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Krause et al. (2007)[445]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Hamblin et al. (2004)[464]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Vecchio et al. (2012)[531]	Experimental humans adults event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Inomata-Terada et al. (2007)[586]	Experimental humans adults patient event related potentials	Mobile telephone	No effect
Jech et al. (2001)[475]	Experimental humans adults patient event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Maby et al. (2005, 2006)[587, 588]	Experimental humans adults patient event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Tombini et al. (2013)[589]	Experimental humans adults patient event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Curcio et al. (2015)[590]	Experimental humans adults patient event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Kwon et al. (2010)[591]	Experimental humans children event related potentials	Mobile telephone	No effect
Krause et al. (2006)[592]	Experimental humans children event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Leung et al. (2011)[474]	Experimental humans children event related potentials	Mobile telephone	Effect, not clearly favourable or unfavourable
Röschke & Mann (1997)[593]	Experimental humans adults EEG awake	Mobile telephone	No effect
Perentos et al. (2007)[594]	Experimental humans adults EEG awake	Mobile telephone	No effect
Kleinlogel et al. (2008)[86]	Experimental humans adults EEG awake	Mobile telephone	No effect
Hietanen et al. (2000)[595]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Huber et al. (2002)[554]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable

Reference	Type of study	Source of exposure	Effect
D'Costa et al. (2003)[596]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Curcio et al. (2005)[82]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Regel et al. (2007)[597]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Vecchio et al. (2007)[598]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Vecchio et al. (2010)[599]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Croft et al. (2008)[600]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Hountala et al. (2008)[601]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Perentos et al (2013)[602]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Ghosn et al. (2015)[226]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Lv et al. (2014)[603]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Yang et al. (2017)[604]	Experimental humans adults EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Vecchio et al. (2012)[605]	Experimental humans adults patient EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Loughran et al. (2013)[473]	Experimental humans children EEG awake	Mobile telephone	No effect
Croft et al. (2010)[97]	Experimental humans children EEG awake	Mobile telephone	Effect, not clearly favourable or unfavourable
Wagner et al. (1998)[549]	Experimental humans adults EEG sleep	Mobile telephone	No effect
Wagner et al. (2000)[550]	Experimental humans adults EEG sleep	Mobile telephone	No effect
Danker-Hopfe et al. (2011)[551]	Experimental humans adults EEG sleep	Mobile telephone	No effect
Lustenberger et al. (2015)[552]	Experimental humans adults EEG sleep	Mobile telephone	No effect
Mann & Röschke (1996)[76]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Huber et al. (2002)[554]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Loughran et al. (2005)[555]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Loughran et al. (2012)[83]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Regel et al. (2007)[470]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Hung et al. (2007)[147]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Schmid et al. (2012)[89]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Schmid et al. (2012)[90]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Lustenberger et al. (2013)[92]	Experimental humans adults EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Danker-Hopfe et al. (2010)[106]	Experimental humans adults EEG sleep	Base station	No effect
Borbély et al. (1999)[77]	Experimental humans adults EEG sleep	Base station	Effect, not clearly favourable or unfavourable
Huber et al. (2000)[78]	Experimental humans adults EEG sleep	Base station	Effect, not clearly favourable or unfavourable
Jech et al. (2001)[475]	Experimental humans adults patient EEG sleep	Mobile telephone	No effect
Lowden et al. (2011)[104]	Experimental humans adults patient EEG sleep	Mobile telephone	Effect, not clearly favourable or unfavourable
Crouzier et al. (2007)[420]	Animal	1800 MHz GSM	Unfavourable effect / higher risk
López-Martín et al. (2009)[606]	Animal	900 MHz GSM	Unfavourable effect / higher risk

Reference	Type of study	Source of exposure	Effect
Pelletier et al. (2013)[607]	Animal	900 MHz	Unfavourable effect / higher risk
Prochnow et al. (2011)[608]	Animal	2000 MHz UMTS	Unfavourable effect / higher risk
Chizhenkova & Safroshkina (1996)[609]	Animal	~800 MHz	Effect, not clearly favourable or unfavourable
Vorobyov et al. (2004)[610]	Animal	915 MHz modulated with 4 Hz	Effect, not clearly favourable or unfavourable
Vorobyov et al. (2010)[611]	Animal	915 MHz modulated with 4 Hz	Effect, not clearly favourable or unfavourable
Mohammed et al. (2013)[612]	Animal	900 MHz continuous and modulated with 8 and 16 Hz	Effect, not clearly favourable or unfavourable
Hidisoglu et al. (2016)[613]	Animal	2100 MHz GSM	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 1 human experimental study no effect on brain electrical activity was found. In 2 animal studies no effects were found and in 4 animal studies effects that are not clearly favourable or unfavourable.

Table 49. Publications on the relation with brain electrical activity in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Zentai et al. (2015)[614]	Experimental humans adults EEG awake	Mobile telephone	Unfavourable effect / higher risk
Crouzier et al. (2007)[402]	Animal EEG	2450 MHz pulsed with 1 kHz	Unfavourable effect / higher risk
Wang et al. (2013)[507]	Animal EEG	2.856 GHz pulsed	Unfavourable effect / higher risk
Thuróczy et al. (1994)[615]	Animal EEG	2450 MHz continuous	Effect, not clearly favourable or unfavourable
Sinha et al. (2008)[412]	Animal EEG	2450 MHz modulated with 1 kHz	Effect, not clearly favourable or unfavourable
Li et al. (2015)[510]	Animal EEG	2.856 GHz	Effect, not clearly favourable or unfavourable
Tan et al. (2017)[493]	Animal EEG	2.856 GHz	Effect, not clearly favourable or unfavourable

Excluded

Table 50. Excluded publications on the relation with brain electrical activity

Human experimental studies	Reason for exclusion
Lv et al. (2015)[616]	No peer-reviewed journal
Roggeveen et al. (2015)[617]	Single-blind experiments, no within-subject control of time-of-day, no clear sham exposure control condition
Roggeveen et al. (2015)[618]	Single-blind experiments, no within-subject control of time-of-day, no clear sham exposure control condition
Animal studies	
Vorobyov et al. (1997)[619]	Fixed order of exposure
Sidorenko (1999)[620]	No sham control group; exposure levels not sufficiently controlled and documented
Marino et al. (2003)[621]	Exposure not assessed
Chizhenkova (2004)[622]	Not clear whether separate animals or repeated measurements in the same animals were used; not clear whether controls were sham exposed
Barcal et al. (2005)[623]	Exposure not assessed
Petrova et al. (2005)[624]	No dosimetry
Sallam (2006)[625]	No control group
Sallam et al. (2008)[626]	No sham control group
Razavinasab et al. (2016)[356]	SAR assessment unclear, no other exposure information
Sistani et al. (2019)[627]	No dosimetry, no sham control group

Conclusion

The committee concludes that exposure to radiofrequency electromagnetic fields can have an effect on brain electrical activity. For the frequency range of 700-2200 MHz the conclusion is that an effect is likely, but it is not clear whether the effects are favourable or unfavourable. For the 2.2-5.0 GHz range the conclusion is that a (favourable or unfavourable) effect is possible. No statement is possible for the frequency range of 20-40 GHz.

5.6 Blood-brain barrier

The blood-brain barrier plays an important role in protecting the brain against harmful substances in the blood. These cannot reach the brain tissue. A decrease in the effectiveness of the blood-brain barrier may increase the risk of brain damage. The committee has taken 32 studies into the relation between exposure to radiofrequency electromagnetic fields and the blood-brain barrier into account in this report, see table 51.

Table 51. Numbers of publications on the relation with the blood-brain barrier, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
1 epidemiological 26 experimental animals	5 experimental animals	No publications	9 experimental animals

700-2200 MHz

There is 1 epidemiological study that did not find an association between exposure to electromagnetic fields between 700 and 2200 MHz and several indicators of effects on the blood-brain barrier. In addition, 18 animal studies did not show effects on the blood-brain barrier, in 2 studies an effect was found that was not clearly favourable or unfavourable, and in 6 studies an unfavourable effect: indications for an increase in the permeability of the blood-brain barrier.

Table 52. Publications on the relation with the blood-brain barrier in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Söderqvist et al. (2009)[628]	Epidemiology cross-sectional	Mobile telephone	No association
Söderqvist et al. (2009)[629]	Epidemiology cross-sectional	Mobile telephone	No association
Söderqvist et al. (2009)[630]	Epidemiology cross-sectional	Mobile telephone	No association
Finnie et al. (2001)[631]	Animal	898 MHz GSM	No effect
Finnie et al. (2002)[632], Finnie & Blumbergs (2004)[633]	Animal	900 MHz GSM	No effect
Kuribayashi et al. (2005)[634]	Animal	1439 MHz TDMA	No effect
Finnie et al. (2006)[635]	Animal	900 MHz GSM	No effect
Finnie et al. (2006)[636]	Animal	900 MHz GSM	No effect
Kumlin et al. (2007)[393]	Animal	900 MHz GSM	No effect
Masuda et al. (2007)[637]	Animal	1439 MHz TDMA pulsed	No effect
Masuda et al. (2007)[638]	Animal	1439 MHz TDMA pulsed	No effect
Ushiyama et al. (2007)[639]	Animal	1500 MHz TDMA	No effect
Grafström et al. (2008)[640]	Animal	900 MHz GSM	No effect
McQuade et al. (2009)[641]	Animal	915 MHz continuous and pulsed with 16 and 217 Hz	No effect
Masuda et al. (2009)[642]	Animal	915 MHz GSM	No effect
Poulletier de Gannes et al. (2009)[643]	Animal	915 MHz GSM	No effect
Finnie et al. (2009)[644]	Animal	900 MHz GSM	No effect
Nittby et al. (2011)[645]	Animal	900 MHz GSM	No effect
Masuda et al. (2015)[646]	Animal	1439 MHz PDC	No effect
Masuda et al. (2015)[647]	Animal	1439 MHz PDC	No effect
Poulletier de Gannes et al. (2017)[648]	Animal	1800 MHz GSM and 1960 MHz UMTS	No effect
Fritze et al. (1997)[649]	Animal	900 MHz GSM and continuous	Unfavourable effect / higher risk
Eberhardt et al. (2008)[650]	Animal	915 MHz GSM	Unfavourable effect / higher risk
Sirav & Seyhan (2009)[651]	Animal	900 en 1800 MHz continuous	Unfavourable effect / higher risk
Sirav & Seyhan (2011)[652]	Animal	900 en 1800 MHz continuous	Unfavourable effect / higher risk
Tang et al. (2015)[490]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Sirav & Seyhan (2016)[653]	Animal	900 and 1800 MHz GSM	Unfavourable effect / higher risk
Belyaev et al. (2006)[562]	Animal	915 MHz GSM	Effect, not clearly favourable or unfavourable
Nittby et al. (2008)[654]	Animal	1800 MHz GSM	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 3 animal studies no effect was found on the blood-brain barrier, in 2 other studies an unfavourable effect was found.

Table 53. Publications on the relation with the blood-brain barrier in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Moriyama et al. (1991)[655]	Animal	2450 MHz continuous	No effect
Lin et al. (1998)[656]	Animal	2450 MHz continuous	No effect
Cosquer et al. (2005)[500]	Animal	2450 MHz pulsed	No effect
Neubauer et al. (1990)[657]	Animal	2450 MHz pulsed	Unfavourable effect / higher risk
Lange & Sedmak (1991)[658]	Animal	2450 MHz continuous	Unfavourable effect / higher risk

Excluded

Table 54. Excluded publications on the relation with the blood-brain barrier

Animal studies	Reason for exclusion
Persson et al. (1992)[659]	No dosimetry; insufficient description of experimental protocols and exposure
Salford et al. (1993)[660]	SAR incorrectly calculated from external electric field.
Salford et al. (1994)[661]	No dosimetry
Persson et al. (1997)[662]	Incomplete dosimetry, insufficient information about exposure level
Tsurita et al. (2000)[663]	No dosimetry
Salford et al. (2003)[664]	Incomplete dosimetry; SAR variations due to animal size, position and age not analysed; peak power density given, but no information on brain exposure
Persson et al. (2005)[665]	No dosimetry
Vojtisek et al. (2005)[666]	No dosimetry
Nittby et al. (2009)[667]	No data on neurodegeneration; incomplete dosimetry; SAR assessment unclear

Conclusion

The committee concludes that no unambiguous effects of exposure to radiofrequency electromagnetic fields on the blood-brain barrier have been found. For the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz the conclusion is that an effect is possible. No statement is possible for the frequency range of 20-40 GHz.

5.7 Neurodegeneration

Neurodegeneration is the gradual decline of nerve cell functions and an increase of their death. This can lead to diseases such as ALS and Alzheimer. The committee has taken 13 studies into the relation between exposure to radiofrequency electromagnetic fields and neurodegeneration in brain tissue into account in this report, see table 55. In these studies, various endpoints have been investigated: death of nerve cells – occurring as a normal biological process (apoptosis) –, nerve cell activity, blood circulation in the brain and changes in the number of glial cells and the density of neurotransmitter vesicles.

Table 55. Numbers of publications on the relation with neurodegeneration of brain tissue, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
13 experimental animals	No publications	No publications	13 experimental animals

700-2200 MHz

In 4 out of 13 animal studies no effect was found on neurodegeneration of brain tissue. In 8 studies an increase in neurodegeneration was found and in 1 study both favourable and unfavourable effects.

Table 56. Publications on the relation with neurodegeneration of brain tissue in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Masuda et al. (2009)[642]	Animal	900 MHz GSM	No effect
Poulletier de Gannes et al. (2009)[643]	Animal	915 MHz GSM	No effect
De Pomerai et al. (2016)[668]	Animal	1800 MHz	No effect
Zhang et al. (2017)[391]	Animal	1800 MHz	No effect
Eberhardt et al. (2008)[650]	Animal	915 MHz GSM	Unfavourable effect / higher risk
Mori & Arendash (2011)[482]	Animal	918 MHz GSM	Unfavourable effect / higher risk
Arendash et al. (2012)[483]	Animal	918 MHz GSM	Unfavourable effect / higher risk
Barthélémy et al. (2016)[381]	Animal	900 MHz	Unfavourable effect / higher risk
Kim et al. (2017)[394]	Animal	835 MHz	Unfavourable effect / higher risk
Kim et al. (2017)[492]	Animal	83 MHz	Unfavourable effect / higher risk
Gökçek-Saraç et al. (2017)[669]	Animal	900 and 2100 MHz	Unfavourable effect / higher risk
Kim et al. (2018)[670]	Animal	835 MHz	Unfavourable effect / higher risk
Keleş et al. (2019)[671]	Animal	909 MHz	Favourable and unfavourable effect

Excluded

Table 57. Excluded publications on the relation with neurodegeneration of brain tissue

Animal studies	Reason for exclusion
Salford et al. (2003)[664]	Incomplete dosimetry; SAR variations due to animal size, position and age not analysed; peak power density provided, but no information on brain exposure
Seaman & Phelix (2005)[672]	Incorrect information on dosimetry; no other exposure information
Nittby et al. (2009)[667]	No data on neurodegeneration; incomplete dosimetry; assessment SAR unclear
Arendash et al. (2010)[254]	Assessment SAR unclear, no other exposure information
Dragicevic et al. (2011)[255]	SAR calculated incorrectly from external electric field
Dasdag et al. (2012)[673]	SAR calculated incorrectly from external electric field
Celikozlu et al. (2012)[674]	No exposure level; no frequency
Aldad et al. (2012)[347]	Mobile telephone on cage; no dosimetry, no exposure level
Banaceur et al. (2013)[256]	No information on SAR assessment
Kopani et al. (2017)[675]	Incomplete dosimetry
Obajuluwa et al. (2017)[411]	No dosimetry; no exposure level
Fragopoulou et al. (2018)[676]	Exposure by mobile phone; no exposure level
Seymen et al. (2019)[677]	No sham control group, incorrect dosimetry

Conclusion

The committee concludes that in some studies an increased level of neurodegeneration was found, but that the endpoints used are widely varying. The conclusion for the frequency range of 700-2200 MHz is that effects are possible. No statement is possible for the frequency ranges of 2.2-5.0 GHz and 20-40 GHz.

5.8 Brain gene expression

Studies on gene expression aim to investigate which parts of the DNA are expressed, i.e., which parts will produce proteins. Gene expression studies generally do not focus on specific genes, but investigate the expression of hundreds of genes simultaneously. Changes in gene expression occur continuously in response to many internal and external stimuli. They express the ability of an organism to adapt to changing circumstances. Information on gene expression may provide data on the formation of proteins that are involved in processes that are unfavourable for the organism. The committee has taken 51 studies into the relation between exposure to radiofrequency electromagnetic fields and gene expression in the brain into consideration in this report, see table 58.

Table 58. Numbers of publications on the relation with gene expression in brain, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
38 experimental animals	13 experimental animals	No publications	36 experimental animals

700-2200 MHz

No effect on gene expression in brain tissue was found in 17 animal studies. In 16 studies a possible unfavourable effect was found, in 3 studies an effect that is not clearly favourable or unfavourable and in 2 studies effects that can be both favourable and unfavourable.

Table 59. Publications on the relation with gene expression in brain in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Fritze et al. (1997)[678]	Animal	900 MHz GSM and continuous	No effect
Stagg et al. (2001)[679]	Animal	1600 MHz pulsed with 11 Hz	No effect
Finnie (2005)[680]	Animal	900 MHz GSM	No effect
Belyaev et al. (2006)[562]	Animal	915 MHz GSM	No effect
Finnie et al. (2006)[681]	Animal	900 MHz GSM	No effect
Finnie et al. (2007)[682]	Animal	900 MHz GSM	No effect
Paparini et al. (2008)[683]	Animal	1800 MHz GSM	No effect
Finnie et al. (2009)[684]	Animal	900 MHz GSM	No effect
Finnie et al. (2009)[644]	Animal	900 MHz GSM	No effect
Finnie et al. (2010)[685]	Animal	900 MHz GSM	No effect
Watilliaux et al. (2011)[686]	Animal	1800 MHz GSM	No effect
Bouji et al. (2012)[377]	Animal	900 MHz GSM	No effect

Reference	Type of study	Source of exposure	Effect
Court-Kowalski et al. (2015)[687]	Animal	900 MHz GSM	No effect
McNamee et al. (2016)[688]	Animal	1900 MHz continuous and pulsed with 50 Hz	No effect
Bouij et al. (2016)[484]	Animal	900 MHz GSM	No effect
Petitdant et al. (2016)[382]	Animal	900 MHz GSM	No effect
Lameth et al. (2017)[689]	Animal	1800 MHz	No effect
Morrissey et al. (1999)[690]	Animal	1600 MHz continuous and pulsed with 11 Hz	Unfavourable effect / higher risk
Mausset-Bonnefont et al. (2004)[375]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Kuribayashi et al. (2005)[634]	Animal	1439 MHz TDMA	Unfavourable effect / higher risk
Brillaud et al. (2007)[691]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Nittby et al. (2008)[654]	Animal	1800 MHz GSM	Unfavourable effect / higher risk
Ammari et al. (2008)[692]	Animal	900 MHz GSM	Unfavourable effect / higher risk
López-Martín et al. (2009)[606]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Ammari et al. (2010)[693]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Carballo-Quintás et al. (2011)[423]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Jeong et al. (2015)[488]	Animal	1950 MHz	Unfavourable effect / higher risk
Daşdağ et al. (2015)[694]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Megha et al. (2015)[560]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Deshmukh et al. (2015)[489]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Deshmukh et al. (2016)[491]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Xu et al. (2017)[695]	Animal	1800 MHz	Unfavourable effect / higher risk
Kumar et al. (2019)[696]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Zhao et al. (2015)[697]	Animal	2100 MHz	Favourable and unfavourable effect
Barthélémy et al. (2016)[381]	Animal	900 MHz GSM	Favourable and unfavourable effect
Fragopoulou et al. (2012)[698]	Animal	900 MHz GSM	Effect, not clearly favourable or unfavourable
Gökcek-Sarac et al. (2017)[669]	Animal	900 and 2100 MHz	Effect, not clearly favourable or unfavourable
Fragopoulou et al. (2018)[676]	Animal	1800 MHz	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 3 animal studies no effect on gene expression was found, in 8 studies a possibly unfavourable effect, in 1 study an effect not clearly favourable or unfavourable and in 1 study an effect that can be both favourable and unfavourable. It mostly concerns the expression of genes involved in stress responses.

Table 60. Publications on the relation with gene expression in brain in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Xiong et al. (2015)[699]	Animal	2.856 GHz pulsed	No effect
Wang et al. (2015)[571]	Animal	2.856 GHz pulsed	No effect
Wang et al. (2017)[512]	Animal	2.856 GHz pulsed	No effect
Paulraj & Behari (2006)[700]	Animal	2540 MHz	Unfavourable effect / higher risk
Jorge-Mora et al. (2011)[701]	Animal	2450 MHz	Unfavourable effect / higher risk
Daşdağ et al. (2015)[694]	Animal	2.4 GHz Wi-Fi	Unfavourable effect / higher risk
Deshmukh et al. (2015)[489]	Animal	2450 MHz	Unfavourable effect / higher risk
Deshmukh et al. (2016)[491]	Animal	2450 MHz	Unfavourable effect / higher risk
Ohtani et al. (2016)[702]	Animal	2240 MHz WCDMA	Unfavourable effect / higher risk
Obajuluwa et al. (2017)[411]	Animal	2.5 GHz	Unfavourable effect / higher risk
Kumar et al. (2019)[696]	Animal	2450 MHz	Unfavourable effect / higher risk
Wang et al. (2015)[509]	Animal	2.856 GHz pulsed	Favourable and unfavourable effect
Yang et al. (2012)[703]	Animal	2540 MHz pulsed	Effect, not clearly favourable or unfavourable

Excluded

Table 61. Excluded publications on the relation with gene expression in brain

Animal studies	Reason for exclusion
Singh et al. (1994)[704]	No statistical analysis; incomplete dosimetry
Daşdağ et al. (2004)[705]	No dosimetry
El-Swefy et al. (2008)[706]	No dosimetry
Kim et al. (2008)[707]	No statistical analysis, only descriptive
Lee et al. (2008)[708]	SAR assessment unclear; no sham control group
Yilmaz et al. (2008)[709]	No statistical analysis, only descriptive
Guler et al. (2010)[710]	Experimental procedures unclear: stated that after exposure during pregnancy, animals were left until the end of pregnancy, but also that animals were killed the day after the exposure
Maskey et al. (2010)[711]	SAR assessment unclear: not calculated, no measurements of temperature or electric field
Maskey et al. (2010)[574]	SAR assessment unclear: not calculated, no measurements of temperature or electric field
Aryal et al. (2011)[712]	From Maskey et al. (2010)[711]: SAR assessment unclear: not calculated, no measurements of temperature or electric field
Dogan et al. (2012)[576]	No exposure level
Jing et al. (2012)[348]	No exposure level, no frequency reported

Animal studies	Reason for exclusion
Maskey et al. (2012)[713]	From Maskey et al. (2010)[711]: SAR assessment unclear: not calculated, no measurements of temperature or electric field
Tsybulin et al. (2012)[714]	Incomplete and incorrect dosimetry
Eser et al. (2013)[715]	Incomplete dosimetry, SAR incorrectly calculated from external electric field; power density assessed, but not indicated at which location
Kesari et al. (2014)[716]	SAR calculated using external electric field, which is not provided
Motawi et al. (2014)[717]	No exposure level, no sham control
Saikhedkar et al. (2014)[429]	Incomplete and incorrect dosimetry
Yilmaz et al. (2014)[718]	Incomplete dosimetry, SAR incorrectly calculated from external electric field
Saili et al. (2015)[719]	No dosimetry
Sangun et al. (2015)[339]	Exposure of foetus and newborns not provided; quoted SAR levels for adults; exposure head-on, so variation over body
Song et al. (2015)[579]	No exposure level, no sham control
Tohidi et al. (2015)[720]	No dosimetry
Guler et al. (2016)[721]	Incomplete dosimetry
Hussein et al. (2016)[722]	No dosimetry
Kerimoğlu et al. (2016)[723]	No dosimetry
Kim et al. (2016)[724]	Incomplete dosimetry
Wang et al. (2016)[544]	Source of exposure not provided; incomplete dosimetry
Hassanshahi et al. (2017)[432]	No dosimetry
Kim et al. (2017)[725]	Incomplete dosimetry
Othman et al. (2017)[359]	No dosimetry, no exposure level
Othman et al. (2017)[358]	No dosimetry, no exposure level
Varghese et al. (2017)[411]	Incomplete dosimetry
Ghatei et al. (2017)[726]	No dosimetry
Gohari et al. (2017)[727]	No dosimetry
Ibitayo et al. (2017)[728]	No dosimetry

Conclusion

The committee concludes that for the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz effects on the expression of genes in brain tissue that may result in unfavourable health effects are possible. No statement is possible for the frequency range of 20-40 GHz.

5.9 Immune system

The immune system consists of many components in blood, bone marrow and other tissues. An effect on one of these components does not necessarily mean that the entire immune system is compromised.
A reduced immune system can lead to a greater susceptibility to infections and other diseases. On the other hand, an over-functioning immune system can also be involved in the development of diseases, such as autoimmunity. The committee has taken 23 studies into the relation between exposure to radiofrequency electromagnetic fields and the immune system into account in this report, see table 62.

Table 62. Numbers of publications on the relation with the immune system, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
3 experimental humans 9 experimental animals	10 experimental animals	No publications	1 epidemiological 5 experimental animals

700-2200 MHz

In 3 human experimental studies and 7 animal studies no effects on the immune system have been found. In 2 other animal studies unfavourable effects on the immune system were observed.

Table 63. Publications on the relation with the immune system in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Radon et al. (2001)[729]	Experimental humans adults	Mobile telephone	No effect
Johansson et al. (2008)[87]	Experimental humans electrosensitive	Mobile telephone	No effect
Augner et al. (2010)[730]	Experimental humans adults	Base station	No effect
Chagnaud & Veyret (1999)[731]	Animal	900 MHz GSM	No effect
Gatta et al. (2003)[732]	Animal	900 MHz GSM	No effect
Nasta et al. (2006)[733]	Animal	900 MHz GSM	No effect
Prisco et al. (2008)[734]	Animal	900 MHz GSM	No effect
Watilliaux et al. (2011)[686]	Animal	1800 MHz GSM	No effect
Jin et al. (2012)[735]	Animal	849 MHz CDMA and 1900 MHz WCDMA	No effect
Rosado et al. (2014)[736]	Animal	900 MHz GSM	No effect
Bouji et al. (2012)[377]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Megha et al. (2012)[737]	Animal	900 en 1800 MHz GSM	Unfavourable effect / higher risk

2.2-5.0 GHz

In 6 animal studies no effects on the immune system were found and in 4 studies unfavourable effects were found.

Table 64. Publications on the relation with the immune system in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Chou et al. (1992)[406]	Animal	2450 MHz pulsed	No effect
Elekes et al. (1996)[738]	Animal	2450 MHz continuous and modulated	No effect
Poulletier de Gannes et al. (2009)[739]	Animal	2450 MHz	No effect
Sambucci et al. (2010)[740]	Animal	2450 MHz Wi-Fi	No effect
Laudisi et al. (2012)[741]	Animal	2450 MHz Wi-Fi	No effect
Aït-Aïssa et al. (2012)[334]	Animal	2450 MHz Wi-Fi	No effect
Nakamura et al. (1997)[742]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Nakamura et al. (1998)[743]	Animal	2450 MHz	Unfavourable effect / higher risk
Grigoriev et al. (2010)[744]	Animal	2450 MHz	Unfavourable effect / higher risk
Sambucci et al. (2011)[745]	Animal	2450 MHz Wi-Fi	Unfavourable effect / higher risk

Excluded

Table 65. Excluded publications on the relation with the immune system

Epidemiological studies	Reason for exclusion
Møllerløkken & Moen (2008)[48]	Radar frequencies outside ranges (9.1-9.4 GHz)
Animal studies	
Fesenko et al. (1999)[746]	Presentation of results and assessment of significance of differences unclear
Novoselova et al. (1999)[747]	Presentation of results and assessment of significance of differences unclear
Moustafa et al. (2001)[748]	No sham control group; no control of exposure level
Kimata (2005)[749]	No control of exposure level, fixed order of exposure conditions; no statistical comparison between sham and real exposure
Eser et al. (2013)[715]	Incomplete dosimetry; SAR assessed incorrectly using external electric field; power density assessed, but not indicated at which location

Conclusion

The committee concludes that for the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz no unfavourable effects of exposure to radiofrequency electromagnetic fields on the immune system have been found. No statement is possible for the frequency range of 20-40 GHz.

5.10 Blood

Blood has a vital function in transporting oxygen and nutrients to tissues and to remove waste products. It also contains components of the immune system and it transports hormones. Disturbance of one or more of these functions may adversely affect health. The committee has taken 7 studies into the relation between exposure to radiofrequency electromagnetic fields and blood into account in this report, see table 66.

Table 66. Numbers of publications on the relation with blood, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
3 experimental animals	4 experimental animals	No publications	1 epidemiological 7 experimental animals

700-2200 MHz

In 2 of the 3 animal studies into effects of exposure to electromagnetic fields on components of the blood an unfavourable effect has been found, in the third one a favourable effect.

Table 67. Publications on the relation with blood in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Jin et al. (2011)[750]	Animal	850 MHz CDMA and 1950 MHz WCDMA	Unfavourable effect / higher risk
Kismali et al. (2012)[751]	Animal	1800 MHz GSM	Unfavourable effect / higher risk
Cao et al. (2011)[752]	Animal	900 MHz continuous	Favourable effect / lower risk

2.2-5.0 GHz

In 1 animal study no effect was found on components of the blood, in 3 studies unfavourable effects were found.

Table 68. Publications on the relation with blood in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Braithwaite et al. (1991)[753]	Animal	2450 MHz continuous	No effect
Trošić et al. (2004)[754]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Trošić & Busljeta (2006)[755]	Animal	2450 MHz continuous	Unfavourable effect / higher risk
Shahin et al. (2013)[304]	Animal	2450 MHz continuous	Unfavourable effect / higher risk

Excluded

Table 69. Excluded publications on the relation with blood

Epidemiological studies	Reason for exclusion
Goldoni et al. (1993)[756]	Non-specified radar
Animal studies	
Nakamura et al. (2003)[343]	No sham control group
Busljeta et al. (2004)[757]	No sham control group
Adang et al. (2009)[758]	Methodological deficiencies and flawed data analysis[759]
Achudume et al. (2010)[760]	No dosimetry, SAR incorrectly indicated in µV/m.
Mortavazi et al. (2012)[761]	No dosimetry
Shojaeifard et al. (2018)[762]	No exposure level; no frequency
El-Maleky & Ebrahim (2019)[763]	No dosimetry

Conclusion

The committee concludes that both favourable and unfavourable effects of exposure to radiofrequency electromagnetic fields on blood have been found. For the frequency ranges of 700-2200 MHz and 2.2-5.0 GHz the conclusion is that an effect is possible. No statement is possible for the frequency range of 20-40 GHz.

5.11 Hormones

Hormones transmit signals and regulate many processes in the body. Disturbance of hormone levels may lead to adverse health effects.
The committee has taken 7 studies into the relation between exposure to radiofrequency electromagnetic fields and hormones into account in this report, see table 70.

Table 70. Numbers of publications on the relation with hormones, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
7 experimental humans	No publications	No publications	1 epidemiological 8 experimental animals

700-2200 MHz

In 7 human experimental studies no effects on hormone levels have been found.

Table 71. Publications on the relation with hormones in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Mann et al. (1998)[764]	Experimental humans adults	Mobile telephone	No effect
Radon et al. (2001)[729]	Experimental humans adults	Mobile telephone	No effect
Wood et al. (2006)[765]	Experimental humans adults	Mobile telephone	No effect
Braune et al. (2002)[222]	Experimental humans adults	Mobile telephone	No effect
Barker et al. (2007)[223]	Experimental humans adults	Mobile telephone	No effect
Ghosn et al. (2015)[226]	Experimental humans adults	Mobile telephone	No effect
Augner et al. (2010)[730]	Experimental humans adults	Base station	No effect

Excluded

Table 72. Excluded publications on the relation with hormones

Epidemiological studies	Reason for exclusion
Singh & Kapoor 2015[766]	Radar frequencies outside ranges (8-18 GHz)
Animal studies	
Bortkiewicz et al. (2002)[140]	No control of exposure level
de Sèze et al. (1999)[767]	No blinding
de Sèze et al. (1998)[768]	No blinding
de Sèze et al. (2001)[178]	No blinding
Djeridane et al. (2008)[769]	No blinding
Geronikolou et al. (2015)[770]	No sham control, no blinding, no control of exposure level
Jarupat et al. (2003)[771]	No control of exposure level
Møllerløkken et al. (2012)[772]	No blinding

Conclusion

The committee concludes that for the frequency range of 700-2200 MHz no effect has been found. No statement is possible for the frequency ranges of 2.2-5.0 GHz and 20-40 GHz.

5.12 Oxidative stress

Highly reactive substances are formed in the body under the influence of normal metabolic processes and external factors. These may react with other substances and damage these or render them ineffective. An important group of such reactive substances are oxygen radicals. An increased level of oxygen radicals is called ‘oxidative stress’. There are several mechanisms in the body to neutralize oxygen radicals. When these are not sufficient, oxidative stress may increase. This may lead to disturbances of processes in the body and ultimately to adverse health effects. The committee has taken 42 studies into the relation between exposure to radiofrequency electromagnetic fields and oxidative stress into account in this report, see table 73.

Table 73. Numbers of publications on the relation with oxidative stress, by frequency range

700-2200 MHz	2.2-5.0 GHz	20-40 GHz	Excluded
31 experimental animals	10 experimental animals	No publications	19 experimental animals

700-2200 MHz

In 9 animal studies no effect on oxidative stress was found, in 22 studies an increased level of oxidative stress and in 1 study both favourable and unfavourable effects.

Table 74. Publications on the relation with oxidative stress in the frequency range 700-2200 MHz

Reference	Type of study	Source of exposure	Effect
Ferreira et al. (2006)[773]	Animal	834 MHz	No effect
Ribeiro et al. (2007)[257]	Animal	1800 MHz GSM	No effect
Lee et al. (2010)[259]	Animal	848.5 MHz CDMA	No effect
Khalil et al. (2011)[774]	Animal	900 MHz	No effect
Lee et al. (2012)[260]	Animal	849 MHz CDMA and 1950 MHz WCDMA	No effect
Daşdağ et al. (2012)[673]	Animal	900 MHz GSM	No effect
Kismali et al. (2012) [751]	Animal	1800 MHz GSM	No effect
Kerimoğlu et al. (2016)[775]	Animal	900 MHz	No effect
Jeong et al. (2018)[392]	Animal	1950 MHz	No effect
Köylü et al. (2006)[776]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Ozguner et al. (2006)[777]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Sokolovic et al. (2008)[778]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Daşdağ et al. (2009)[779]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Aydin and Akar (2011)[780]	Animal	900 MHz GSM	Unfavourable effect / higher risk
Kerman & Senol (2012)[781]	Animal	900 MHz	Unfavourable effect / higher risk
Megha et al. (2012)[737]	Animal	900 and 1800 MHz GSM	Unfavourable effect / higher risk
Jelodar et al. (2013)[782]	Animal	900 MHz base station	Unfavourable effect / higher risk
Akbari et al. (2014)[783]	Animal	900 MHz	Unfavourable effect / higher risk
Tang et al. (2015)[490]	Animal	900 MHz	Unfavourable effect / higher risk
Megha et al. (2015)[784]	Animal	900 and 1800 MHz GSM	Unfavourable effect / higher risk
Furtado-Filho et al. (2015)[785]	Animal	950 MHz	Unfavourable effect / higher risk
Bodera et al. (2015)[786]	Animal	1800 MHz	Unfavourable effect / higher risk
Sahin et al. (2016)[787]	Animal	2100 MHz GSM	Unfavourable effect / higher risk
Hidisoglu et al. (2016)[613]	Animal	2100 MHz	Unfavourable effect / higher risk

Reference	Type of study	Source of exposure	Effect
Bodera et al. (2017)[788]	Animal	1800 MHz	Unfavourable effect / higher risk
Kim et al. (2017)[725]	Animal	835 MHz	Unfavourable effect / higher risk
Kim et al. (2018)[670]	Animal	835 MHz	Unfavourable effect / higher risk
Ertilav et al. (2018)[789]	Animal	900 and 1800 MHz	Unfavourable effect / higher risk
Alkis et al. (2019)[790]	Animal	900, 1800 and 2100 MHz	Unfavourable effect / higher risk
Sharma et al. (2019)[495]	Animal	2100 MHz	Unfavourable effect / higher risk
Hidisoglu et al. (2018)[174]	Animal	2100 MHz 217 Hz modulated	Unfavourable effect / higher risk
Ahmed et al. (2017)[791]	Animal	900 MHz 217 Hz modulated	Effect, not clearly favourable or unfavourable

2.2-5.0 GHz

In 2 animal studies no effect on oxidative stress was found and in 8 studies an increased oxidative stress level.

Table 75. Publications on the relation with oxidative stress in the frequency range 2.2-5.0 GHz

Reference	Type of study	Source of exposure	Effect
Naziroğlu & Gümral (2009)[792]	Animal	2450 MHz	No effect
Aït-Aïssa et al. (2013)[793]	Animal	2450 MHz	No effect
Meena et al. (2014)[271]	Animal	2450 MHz modulated with 50 Hz	Unfavourable effect / higher risk
Saygin et al. (2016)[275]	Animal	2450 MHz	Unfavourable effect / higher risk
Shahin et al. (2014)[272]	Animal	2450 MHz	Unfavourable effect / higher risk
Megha et al. (2015)[784]	Animal	2450 MHz	Unfavourable effect / higher risk
Kuybulu et al. (2016)[340]	Animal	2450 MHz	Unfavourable effect / higher risk
Tan et al. (2017)[493]	Animal	2.856 GHz	Unfavourable effect / higher risk
Chauhan et al. (2017)[794]	Animal	2450 MHz	Unfavourable effect / higher risk
Shahin et al. (2018)[278]	Animal	2450 MHz	Unfavourable effect / higher risk

Excluded

Table 76. Excluded publications on the relation with oxidative stress

Animal studies	Reason for exclusion
Irmak et al. (2002)[795]	No exposure level and dosimetry
Ilhan et al. (2004)[796]	Exposure level not clear: likely derived from mobile phone specifications
Meral et al. (2007)[797]	Exposure level not clear: SAR likely derived from mobile phone specifications
Imge et al. (2010)[798]	No dosimetry
Kesari et al. (2011)[799]	Assessment SAR unclear
Avci et al. (2012)[800]	SAR calculated incorrectly using external electric field; power density assessed, but not indicated at which location; electric field assessed, but exposure inhomogeneous with head pointed to source, so field at head unknown
Naziroğlu et al. (2012)[801]	Incorrect dosimetry
Ben Salah et al. (2013)[802]	No dosimetry
Bilgici et al. (2013)[803]	SAR calculated incorrectly using external electric field; power density assessed, but not indicated at which location; electric field assessed, but exposure inhomogeneous with head pointed to source, so field at head unknown
Çetin et al. (2014)[804]	Exposure of foetus and newborns not provided; quoted SAR levels are for adults; exposure inhomogeneous with head pointed to source, so variation over body.
Gürler et al. (2014)[805]	SAR calculated incorrectly using external electric field; power density assessed, but not indicated at which location; electric field assessed, but exposure inhomogeneous with head pointed to source, so field at head unknown
Hu et al. (2014)[806]	Exposure source and duration not provided
Maaroufi et al. (2014)[541]	SAR calculated incorrectly using external electric field, field strength not provided, no other exposure information
Narayanan et al. (2014)[807]	Exposure by phone in cage: inhomogeneous field over cage; actual exposure of animals not known
Ragy (2014)[808]	No exposure level, no sham control
An et al. (2015)[809]	Incorrect dosimetry
Nirwane et al. (2016)[543]	No dosimetry
Shehu et al. (2016)[431]	Mobile telephone in cage, no dosimetry
Kamali et al. (2018)[810]	No exposure level

Conclusion

The committee concludes that for the frequency ranges of 700-2200 MHz and 2.2.-5.0 GHz an increased level of oxidative stress after exposure to radiofrequency electromagnetic fields is possible. No statement is possible for the frequency range of 20-40 GHz.

references

1 WHO - World Health Organization. *Radiofrequency fields*. Geneva: WHO, 2014; Public consultation document.

2 SSM - Swedish Radiation Safety Authority - Scientific Council on Electromagnetic Fields. *Recent Research on EMF and Health Risk. Eleventh report from SSM's Scientific Council on Electromagnetic Fields, 2016. Including Thirteen years of electromagnetic field research monitored by SSM's Scientific Council on EMF and health: How has the evidence changed over time?* Stockholm: Swedish Radiation Safety Authority, 2016; SSM Report 2016:15.

3 SSM - Swedish Radiation Safety Authority - Scientific Council on Electromagnetic Fields. *Recent Research on EMF and Health Risk. Twelfth report from SSM's Scientific Council on Electromagnetic Fields, 2017*. Stockholm: Swedish Radiation Safety Authority, 2018; SSM Report 2018:09.

4 SSM - Swedish Radiation Safety Authority - Scientific Council on Electromagnetic Fields. *Recent Research on EMF and Health Risk - Thirteenth report from SSM's Scientific Council on Electromagnetic Fields, 2018*. Stockholm: Swedish Radiation Safety Authority, 2019; SSM Report 2019:08.

5 Simkó M and Mattsson MO. *5G Wireless communication and health effects - a pragmatic review based on available studies regarding 6 to 100 GHz*. Int J Environ Res Public Health 2019; 16(18): E3406.

6 ANSES - Agence nationale de sécurité sanitaire de l'alimentation de l'environnement et du travail. *Exposition de la population aux champs électromagnétiques liée au déploiement de la technologie de communication « 5G » et effets sanitaires associés*. Maisons-Alfort: ANSES, 2019; Saisine n° 2019-SA-0006.

7 Hansson Mild K, Bach Andersen J and Pedersen GF. *Is there any exposure from a mobile phone in stand-by mode?* Electromagn Biol Med 2012; 31(1): 52-6.

8 Schulz KF, Altman DG, Moher D and Group C. *CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials*. BMJ 2010; 340: c332.

9 Hooijmans C, de Vries R, Leenaars M and Ritskes-Hoitinga M. *The Gold Standard Publication Checklist (GSPC) for improved design, reporting and scientific quality of animal studies GSPC versus ARRIVE guidelines*. Lab Anim 2011; 45(1): 61.

10 Samaras T, Kuster N and Negovetic S. Deliverable D36: Recommendations on engineering requirements/aspects for experimental research in Bioelectromagnetics; Deliverable D37: Recommendations on quality assurance in Bioelectromagnetics research http://ihcp.jrc.ec.europa.eu/our_activities/public-health/exposure_health_impact_met/emf-net/docs/reports/Report%20on%20Reccomendation%20in%20Bioelectromagnetcs%20Aug2006.pdf, accessed 26 September 2014.

11 Zeni O and Scarfi MR. *Experimental requirements for in vitro studies aimed to evaluate the biological effects of radiofrequency radiation*. Costanzo Ss. Microwave Materials Characterization. InTech; 2012.

www.intechopen.com/books/microwave-materials-characterization/experimental-requirements-for-in-vitro-studies-aimed-to-evaluate-the-biological-effects-of-radiofreq. Consulted: 26 September 2014

[12] HCN - Health Council of the Netherlands. *Mobile phones and cancer. Part 3: Update and overall conclusions from epidemiological and animal studies*. The Hague: Health Council of the Netherlands, 2016; publication nr 2016/06.

[13] Vila J, Turner MC, Gracia-Lavedan E, Figuerola J, Bowman JD, Kincl L, et al. *Occupational exposure to high-frequency electromagnetic fields and brain tumor risk in the INTEROCC study: An individualized assessment approach*. Environ Int 2018; 119: 353-65.

[14] Luo J, Deziel NC, Huang H, Chen Y, Ni X, Ma S, et al. *Cell phone use and risk of thyroid cancer: a population-based case-control study in Connecticut*. Ann Epidemiol 2019; 29: 39-45.

[15] Al-Qahtani K. *Mobile phone use and the risk of parotid gland tumors: a retrospective case-control study*. Gulf J Oncolog 2016; 1(20): 71-8.

[16] Balekouzou A, Yin P, Afewerky HK, Bekolo C, Pamatika CM, Nambei SW, et al. *Behavioral risk factors of breast cancer in Bangui of Central African Republic: A retrospective case-control study*. PLoS One 2017; 12(2): e0171154.

[17] Shrestha M, Raitanen J, Salminen T, Lahkola A and Auvinen A. *Pituitary tumor risk in relation to mobile phone use: A case-control study*. Acta Oncol 2015; 54(8): 1159-65.

[18] Sato Y, Kojimahara N and Yamaguchi N. *Analysis of mobile phone use among young patients with brain tumors in Japan*. Bioelectromagnetics 2017; 38(5): 349-55.

[19] Satta G, Mascia N, Serra T, Salis A, Saba L, Sanna S, et al. *Estimates of environmental exposure to radiofrequency electromagnetic fields and risk of lymphoma subtypes*. Radiat Res 2018; 189(5): 541-7.

[20] Dabouis V, Arvers P, Debouzy JC, Sebbah C, Crouzier D and Perrin A. *First epidemiological study on occupational radar exposure in the French Navy: a 26-year cohort study*. Int J Environ Health Res 2016; 26(2): 131-44.

[21] Degrave E, Meeusen B, Grivegnée AR, Boniol M and Autier P. *Causes of death among Belgian professional military radar operators: a 37-year retrospective cohort study*. Int J Cancer 2009; 124(4): 945-51.

[22] Kim SJH, Ioannides SJ and Elwood JM. *Trends in incidence of primary brain cancer in New Zealand, 1995 to 2010*. Aust N Z J Public Health 2015; 39(2): 148-52.

[23] Sato Y, Kiyohara K, Kojimahara N and Yamaguchi N. *Time trend in incidence of malignant neoplasms of the central nervous system in relation to mobile phone use among young people in Japan*. Bioelectromagnetics 2016; 37(5): 282-9.

[24] Chapman S, Azizi L, Luo Q and Sitas F. *Has the incidence of brain cancer risen in Australia since the introduction of mobile phones 29 years ago?* Cancer Epidemiol 2016; 42: 199-205.

[25] Gonzalez-Rubio J, Arribas E, Ramirez-Vazquez R and Najera A. *Radiofrequency electromagnetic fields and some cancers of unknown etiology: An ecological study*. Sci Total Environ 2017; 599-600: 834-43.

[26] Karipidis K, Elwood M, Benke G, Sanagou M, Tjong L and Croft RJ. *Mobile phone use and incidence of brain tumour histological types, grading or anatomical location: a population-based ecological study*. BMJ Open 2018; 8(12): e024489.

[27] Keinan-Boker L, Friedman E and Silverman BG. *Trends in the incidence of primary brain, central nervous system and intracranial tumors in Israel, 1990-2015*. Cancer Epidemiol 2018; 56: 6-13.

[28] Nilsson J, Järås J, Henriksson R, Holgersson G, Bergström S, Estenberg J, et al. *No evidence for increased brain tumour incidence in the Swedish national cancer register between years 1980-2012*. Anticancer Res 2019; 39(2): 791-6.

[29] Natukka T, Raitanen J, Haapasalo H and Auvinen A. *Incidence trends of adult malignant brain tumors in Finland, 1990-2016*. Acta Oncol 2019; 58(7): 990-6.

[30] Carlberg M, Hedendahl L, Ahonen M, Koppel T and Hardell L. *Increasing incidence of thyroid cancer in the Nordic countries with main focus on Swedish data*. BMC Cancer 2016; 16: 426.

[31] Hardell L and Carlberg M. *Mobile phones, cordless phones and rates of brain tumors in different age groups in the Swedish National Inpatient Register and the Swedish Cancer Register during 1998-2015*. PLoS One 2017; 12(10): e0185461.

[32] Smith-Roe SL, Wyde ME, Stout MD, Winters JW, Hobbs CA, Shepard KG, et al. *Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure*. Environ Mol Mutagen 2019.

[33] NTP - National Toxicology Program. *Toxicology and carcinogenesis studies in Hsd:Sprague Dawley SD rats exposed to wholebody radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones*. Research Triangle Park, NC, 2018; NTP TR-595.

[34] Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, et al. *Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8GHz GSM base station environmental emission*. Environ Res 2018; 165: 496-503.

[35] Kryukova OV, Pyankov VF, Kopylov AF and Khlebopros RG. *Effect of electromagnetic microwave radiation on the growth of Ehrlich ascites carcinoma*. Dokl Biol Sci 2016; 470(1): 237-9.

[36] HCN - Health Council of the Netherlands. *Mobile phones and cancer. Part 2: Animal studies on carcinogenesis*. The Hague: Health Council of the Netherlands, 2014; publication nr 2014/22.

[37] Baumgardt-Elms C, Ahrens W, Bromen K, Boikat U, Stang A, Jahn I, et al. *Testicular cancer and electromagnetic fields (EMF) in the workplace: results of a population-based case-control study in Germany*. Cancer Causes Control 2002; 13(10): 895-902.

[38] Finkelstein MM. *Cancer incidence among Ontario police officers*. Am J Ind Med 1998; 34(2): 157-62.

[39] Lester JR and Moore DF. *Cancer mortality and air force bases*. J Bioelectricity 1982; 1(1): 77-82.

[40] Polson P and Merrit JH. *Cancer mortality and Air Force bases: A reevaluation*. J Bioelec 1985; 4: 121-7.

[41] Hayes RB, Brown LM, Pottern LM, Gomez M, Kardaun JW, Hoover RN, et al. *Occupation and risk for testicular cancer: a case-control study*. Int J Epidemiol 1990; 19(4): 825-31.

[42] Garland FC, Gorham ED and Garland CF. *Hodgkin's disease in the US Navy*. Int J Epidemiol 1987; 16(3): 367-72.

[43] Garland FC, Shaw E, Gorham ED, Garland CF, White MR and Sinsheimer PJ. *Incidence of leukemia in occupations with potential electromagnetic field exposure in United States Navy personnel*. Am J Epidemiol 1990; 132(2): 293-303.

[44] Hardell L, Nasman A, Ohlson CG and Fredrikson M. *Case-control study on risk factors for testicular cancer*. Int J Oncol 1998; 13(6): 1299-303.

[45] Smulevich VB, Solionova LG and Belyakova SV. *Parental occupation and other factors and cancer risk in children: II. Occupational factors*. Int J Cancer 1999; 83(6): 718-22.

[46] Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N and Jöckel KH. *The possible role of radiofrequency radiation in the development of uveal melanoma*. Epidemiology 2001; 12(1): 7-12.

[47] Groves FD, Page WF, Gridley G, Lisimaque L, Stewart PA, Tarone RE, et al. *Cancer in Korean war navy technicians: mortality survey after 40 years*. Am J Epidemiol 2002; 155(9): 810-8.

[48] Møllerløkken OJ and Moen BE. *Is fertility reduced among men exposed to radiofrequency fields in the Norwegian Navy?* Bioelectromagnetics 2008; 29(5): 345-52.

[49] Peleg M, Nativ O and Richter ED. *Radio frequency radiation-related cancer: assessing causation in the occupational/military setting*. Environ Res 2018; 163: 123-33.

[50] Shen SY, Wang WH, Liang R, Pan GQ and Qian YM. *Clinicopathologic analysis of 2736 salivary gland cases over a 11-year period in Southwest China*. Acta Otolaryngol 2018; 138(8): 746-9.

[51] Sato Y, Kojimahara N and Yamaguchi N. *Simulation of the incidence of malignant brain tumors in birth cohorts that started using mobile phones when they first became popular in Japan*. Bioelectromagnetics 2019; 40(3): 143-9.

[52] Olsson A, Bouaoun L, Auvinen A, Feychting M, Johansen C, Mathiesen T, et al. *Survival of glioma patients in relation to mobile phone use in Denmark, Finland and Sweden*. J Neurooncol 2019; 141(1): 139-49.

[53] Mohler E, Frei P, Fröhlich J, Braun-Fahrländer C, Röösli M and Qualifex team t. *Exposure to radiofrequency electromagnetic fields and sleep quality: a prospective cohort study*. PLoS One 2012; 7(5): e37455.

54 Cho YM, Lim HJ, Jang H, Kim K, Choi JW, Shin C, et al. *A follow-up study of the association between mobile phone use and symptoms of ill health*. Environ Health Toxicol 2016; 32: e2017001.

55 Schoeni A, Roser K and Röösli M. *Symptoms and the use of wireless communication devices: A prospective cohort study in Swiss adolescents*. Environ Res 2017; 154: 275-83.

56 Frei P, Mohler E, Braun-Fahrlander C, Fröhlich J, Neubauer G, Röösli M, et al. *Cohort study on the effects of everyday life radio frequency electromagnetic field exposure on non-specific symptoms and tinnitus*. Environ Int 2012; 38(1): 29-36.

57 Chia SE, Chia HP and Tan JS. *Prevalence of headache among handheld cellular telephone users in Singapore: a community study*. Environ Health Perspect 2000; 108(11): 1059-62.

58 Wilén J, Sandström M and Hansson Mild K. *Subjective symptoms among mobile phone users--a consequence of absorption of radiofrequency fields?* Bioelectromagnetics 2003; 24(3): 152-9.

59 Söderqvist F, Carlberg M and Hardell L. *Use of wireless telephones and self-reported health symptoms: a population-based study among Swedish adolescents aged 15-19 years*. Environ Health 2008; 7: 18.

60 Heinrich S, Thomas S, Heumann C, von Kries R and Radon K. *Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study*. Environ Health 2010; 9: 75.

61 Heinrich S, Thomas S, Heumann C, von Kries R and Radon K. *The impact of exposure to radio frequency electromagnetic fields on chronic well-being in young people--a cross-sectional study based on personal dosimetry*. Environ Int 2011; 37(1): 26-30.

62 Sudan M, Kheifets L, Arah O, Olsen J and Zeltzer L. *Prenatal and Postnatal Cell Phone Exposures and Headaches in Children*. Open Pediatr Med Journal 2012; 6(2012): 46-52.

63 Redmayne M, Smith E and Abramson MJ. *The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study*. Environ Health 2013; 12: 90.

64 Chiu CT, Chang YH, Chen CC, Ko MC and Li CY. *Mobile phone use and health symptoms in children*. J Formos Med Assoc 2014.

65 Zheng F, Gao P, He M, Li M, Tan J, Chen D, et al. *Association between mobile phone use and self-reported well-being in children: a questionnaire-based cross-sectional study in Chongqing, China*. BMJ Open 2015; 5(5): e007302.

66 Cho YM, Lim HJ, Jang H, Kim K, Choi JW, Shin C, et al. *A cross-sectional study of the association between mobile phone use and symptoms of ill health*. Environ Health Toxicol 2016; 31: e2016022.

67 Stalin P, Abraham SB, Kanimozhy K, Prasad RV, Singh Z and Purty AJ. *Mobile Phone Usage and its Health Effects Among Adults in a Semi-Urban Area of Southern India*. J Clin Diagn Res 2016; 10(1): Lc14-6.

68 Durusoy R, Hassoy H, Ozkurt A and Karababa AO. *Mobile phone use, school electromagnetic field levels and related symptoms: a cross-*

sectional survey among 2150 high school students in Izmir. Environ Health 2017; 16(1): 51.

69 Baliatsas C, van Kamp I, Bolte J, Kelfkens G, van Dijk C, Spreeuwenberg P, et al. *Clinically defined non-specific symptoms in the vicinity of mobile phone base stations: A retrospective before-after study*. Sci Total Environ 2016; 565: 714-20.

70 Schoeni A, Roser K, Bürgi A and Röösli M. *Symptoms in Swiss adolescents in relation to exposure from fixed site transmitters: a prospective cohort study*. Environ Health 2016; 15(1): 77.

71 Thomas S, Kühnlein A, Heinrich S, Praml G, Nowak D, von Kries R, et al. *Personal exposure to mobile phone frequencies and well-being in adults: a cross-sectional study based on dosimetry*. Bioelectromagnetics 2008; 29(6): 463-70.

72 Berg-Beckhoff G, Blettner M, Kowall B, Breckenkamp J, Schlehofer B, Schmiedel S, et al. *Mobile phone base stations and adverse health effects: phase 2 of a cross-sectional study with measured radio frequency electromagnetic fields*. Occup Environ Med 2009; 66(2): 124-30.

73 Baliatsas C, Bolte J, Yzermans J, Kelfkens G, Hooiveld M, Lebret E, et al. *Actual and perceived exposure to electromagnetic fields and non-specific physical symptoms: an epidemiological study based on self-reported data and electronic medical records*. Int J Hyg Environ Health 2015; 218(3): 331-44.

74 Martens AL, Slottje P, Timmermans DRM, Kromhout H, Reedijk M, Vermeulen RCH, et al. *Modeled and Perceived Exposure to Radiofrequency Electromagnetic Fields From Mobile-Phone Base Stations and the Development of Symptoms Over Time in a General Population Cohort*. Am J Epidemiol 2017; 186(2): 210-9.

75 Hutter HP, Moshammer H, Wallner P and Kundi M. *Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations*. Occup Environ Med 2006; 63(5): 307-13.

76 Mann K and Röschke J. *Effects of pulsed high-frequency electromagnetic fields on human sleep*. Neuropsychobiology 1996; 33(1): 41-7.

77 Borbély AA, Huber R, Graf T, Fuchs B, Gallmann E and Achermann P. *Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram*. Neurosci Lett 1999; 275(3): 207-10.

78 Huber R, Graf T, Cote KA, Wittmann L, Gallmann E, Matter D, et al. *Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG*. Neuroreport 2000; 11(15): 3321-5.

79 Huber R, Schuderer J, Graf T, Jutz K, Borbély AA, Kuster N, et al. *Radio frequency electromagnetic field exposure in humans: Estimation of SAR distribution in the brain, effects on sleep and heart rate*. Bioelectromagnetics 2003; 24(4): 262-76.

80 Koivisto M, Haarala C, Krause CM, Revonsuo A, Laine M and Hämäläinen H. *GSM phone signal does not produce subjective symptoms*. Bioelectromagnetics 2001; 22(3): 212-5.

81 Tahvanainen K, Nino J, Halonen P, Kuusela T, Laitinen T, Lansimies E, et al. *Cellular phone use does not acutely affect blood pressure or heart rate of humans*. Bioelectromagnetics 2004; 25(2): 73-83.

82 Curcio G, Ferrara M, Moroni F, D'Inzeo G, Bertini M and De Gennaro L. *Is the brain influenced by a phone call? An EEG study of resting wakefulness*. Neuroscience Research 2005; 53(3): 265-70.

83 Loughran SP, McKenzie RJ, Jackson ML, Howard ME and Croft RJ. *Individual differences in the effects of mobile phone exposure on human sleep: rethinking the problem*. Bioelectromagnetics 2012; 33(1): 86-93.

84 Fritzer G, Goder R, Friege L, Wachter J, Hansen V, Hinze-Selch D, et al. *Effects of short- and long-term pulsed radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy subjects*. Bioelectromagnetics 2007; 28(4): 316-25.

85 Cinel C, Russo R, Boldini A and Fox E. *Exposure to mobile phone electromagnetic fields and subjective symptoms: a double-blind study*. Psychosom Med 2008; 70(3): 345-8.

86 Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A and Berz R. *Effects of weak mobile phone - electromagnetic fields (GSM, UMTS) on well-being and resting EEG*. Bioelectromagnetics 2008; 29(6): 479-87.

87 Johansson A, Forsgren S, Stenberg B, Wilen J, Kaiezic N and Sandstrom M. *No effect of mobile phone-like RF exposure on patients with atopic dermatitis*. Bioelectromagnetics 2008; 29(5): 353-62.

88 Curcio G, Ferrara M, Limongi T, Tempesta D, Di Sante G, De Gennaro L, et al. *Acute mobile phones exposure affects frontal cortex hemodynamics as evidenced by functional near-infrared spectroscopy*. J Cereb Blood Flow Metab 2009; 29(5): 903-10.

89 Schmid MR, Loughran SP, Regel SJ, Murbach M, Bratic Grunauer A, Rusterholz T, et al. *Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields*. J Sleep Res 2012; 21(1): 50-8.

90 Schmid MR, Murbach M, Lustenberger C, Maire M, Kuster N, Achermann P, et al. *Sleep EEG alterations: effects of pulsed magnetic fields versus pulse-modulated radio frequency electromagnetic fields*. J Sleep Res 2012; 21(6): 620-9.

91 Spichtig S, Scholkmann F, Chin L, Lehmann H and Wolf M. *Assessment of intermittent UMTS electromagnetic field effects on blood circulation in the human auditory region using a near-infrared system*. Bioelectromagnetics 2012; 33(1): 40-54.

92 Lustenberger C, Murbach M, Durr R, Schmid MR, Kuster N, Achermann P, et al. *Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement*. Brain Stimul 2013; 6(5): 805-11.

[93] Vecsei Z, Csatho A, Thuroczy G and Hernadi I. *Effect of a single 30 min UMTS mobile phone-like exposure on the thermal pain threshold of young healthy volunteers*. Bioelectromagnetics 2013; 34(7): 530-41.

[94] Verrender A, Loughran SP, Dalecki A, McKenzie R and Croft RJ. *Pulse modulated radiofrequency exposure influences cognitive performance*. Int J Radiat Biol 2016; 92(10): 603-10.

[95] Verrender A, Loughran SP, Dalecki A, Freudenstein F and Croft RJ. *Can explicit suggestions about the harmfulness of EMF exposure exacerbate a nocebo response in healthy controls?* Environ Res 2018; 166: 409-17.

[96] Lowden A, Nagai R, Akerstedt T, Hansson Mild K and Hillert L. *Effects of evening exposure to electromagnetic fields emitted by 3G mobile phones on health and night sleep EEG architecture*. J Sleep Res 2019; 28(4): e12813.

[97] Croft RJ, Leung S, McKenzie RJ, Loughran SP, Iskra S, Hamblin DL, et al. *Effects of 2G and 3G mobile phones on human alpha rhythms: Resting EEG in adolescents, young adults, and the elderly*. Bioelectromagnetics 2010; 31(6): 434-44.

[98] Choi SB, Kwon MK, Chung JW, Park JS, Chung K and Kim DW. *Effects of short-term radiation emitted by WCDMA mobile phones on teenagers and adults*. BMC Public Health 2014; 14: 438.

[99] Hietanen M, Hämäläinen AM and Husman T. *Hypersensitivity symptoms associated with exposure to cellular telephones: no causal link*. Bioelectromagnetics 2002; 23(4): 264-70.

[100] Rubin GJ, Hahn G, Everitt BS, Cleare AJ and Wessely S. *Are some people sensitive to mobile phone signals? Within participants double blind randomised provocation study*. British Medical Journal 2006; 332(7546): 886-9.

[101] Wilén J, Johansson A, Kalezic N, Lyskov E and Sandström M. *Psychophysiological tests and provocation of subjects with mobile phone related symptoms*. Bioelectromagnetics 2006; 27(3): 204-14.

[102] Oftedal G, Straume A, Johnsson A and Stovner LJ. *Mobile phone headache: a double blind, sham-controlled provocation study*. Cephalalgia 2007; 27(5): 447-55.

[103] Nam KC, Lee JH, Noh HW, Cha EJ, Kim NH and Kim DW. *Hypersensitivity to RF Fields Emitted From CDMA Cellular Phones: A Provocation Study*. Bioelectromagnetics 2009; 30(8): 641-50.

[104] Lowden A, Åkerstedt T, Ingre M, Wiholm C, Hillert L, Kuster N, et al. *Sleep after mobile phone exposure in subjects with mobile phone-related symptoms*. Bioelectromagnetics 2011; 32(1): 4-14.

[105] Kwon MK, Choi JY, Kim SK, Yoo TK and Kim DW. *Effects of radiation emitted by WCDMA mobile phones on electromagnetic hypersensitive subjects*. Environmental Health 2012; 11.

[106] Danker-Hopfe H, Dorn H, Bornkessel C and Sauter C. *Do Mobile Phone Base Stations Affect Sleep of Residents? Results from an Experimental Double-Blind Sham-Controlled Field Study*. American Journal of Human Biology 2010; 22(5): 613-8.

[107] Augner C, Florian M, Pauser G, Oberfeld G and Hacker GW. *GSM base stations: short-term effects on well-being*. Bioelectromagnetics 2009; 30(1): 73-80.

[108] Riddervold IS, Pedersen GF, Andersen NT, Pedersen AD, Andersen JB, Zachariae R, et al. *Cognitive function and symptoms in adults and adolescents in relation to rf radiation from UMTS base stations*. Bioelectromagnetics 2008; 29(4): 257-67.

[109] Regel SJ, Negovetic S, Röösli M, Berdinas V, Schuderer J, Huss A, et al. *UMTS base station-like exposure, well-being, and cognitive performance*. Environ Health Perspect 2006; 114(8): 1270-5.

[110] Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, et al. *Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study*. Environ Health Perspect 2007; 115(11): 1603-8.

[111] Leitgeb N, Schröttner J, Cech R and Kerbl R. *EMF-protection sleep study near mobile phone base stations*. Somnologie 2008; 12: 234-43.

[112] Furubayashi T, Ushiyama A, Terao Y, Mizuno Y, Shirasawa K, Pongpaibool P, et al. *Effects of Short-Term W-CDMA Mobile Phone Base Station Exposure on Women With or Without Mobile Phone Related Symptoms*. Bioelectromagnetics 2009; 30(2): 100-13.

[113] Bolte JFB, Clahsen S, Vercruijsse W, Houtveen JH, Schipper CMA, van Kamp I, et al. *Ecological momentary assessment study of exposure to radiofrequency electromagnetic fields and non-specific physical symptoms with self-declared electrosensitives*. Environ Int 2019; 131: 104948.

[114] Robinette CD, Silverman C and Jablon S. *Effects upon health of occupational exposure to microwave radiation (radar)*. Am J Epidemiol 1980; 112(1): 39-53.

[115] Cao Z, Zhao X, Tao Y and Wan C. *[Effects of electromagnetic radiation from cellular telephone handsets on symptoms of neurasthenia]*. Wei Sheng Yan Jiu 2000; 29(6): 366-8.

[116] Santini R, Seigne M, Bonhomme-Faivre L, Bouffet S, Defrasne E and Sage M. *[Symptoms reported by mobile cellular telephone users]*. Pathol Biol (Paris) 2001; 49(3): 222-6.

[117] Navarro EA, Segura J, Portoles M and Gomez-Peretta C. *The microwave syndrome: a preliminary study in Spain*. Electro Magn Biol 2003; 22: 161-9.

[118] Santini R, Santini P, Danze JM, Le Ruz P and Seigne M. *[Investigation on the health of people living near mobile telephone relay stations: I/Incidence according to distance and sex]*. Pathol Biol (Paris) 2002; 50(6): 369-73.

[119] Santini R, Santini P, Danze JM, Le Ruz P and Seigne M. *[Symptoms experienced by people in vicinity of base stations: II/ Incidences of age, duration of exposure, location of subjects in relation to the antennas and other electromagnetic factors]*. Pathol Biol (Paris) 2003; 51(7): 412-5.

[120] Al-Khlaiwi T and Meo SA. *Association of mobile phone radiation with fatigue, headache, dizziness, tension and sleep disturbance in Saudi population*. Saudi Med J 2004; 25(6): 732-6.

[121] Wilén J, Hornsten R, Sandström M, Bjerle P, Wiklund U, Stensson O, et al. *Electromagnetic field exposure and health among RF plastic sealer operators*. Bioelectromagnetics 2004; 25(1): 5-15.

[122] Balikci K, Cem Ozcan I, Turgut-Balik D and Balik HH. *A survey study on some neurological symptoms and sensations experienced by long term users of mobile phones*. Pathol Biol (Paris) 2005; 53(1): 30-4.

[123] Meo SA and Al-Drees AM. *Mobile phone related-hazards and subjective hearing and vision symptoms in the Saudi population*. Int J Occup Med Environ Health 2005; 18(1): 53-7.

[124] Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, El-Batanouny M, et al. *Neurobehavioral effects among inhabitants around mobile phone base stations*. Neurotoxicology 2007; 28(2): 434-40.

[125] Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, et al. *Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany*. Occup Environ Med 2009; 66(2): 118-23.

[126] Eger H and Jahn M. *Spezifische Symptome und Mobilfunkstrahlung in Selbitz (Bayern) - Evidenz für eine Dosiswirkungsbeziehung*. umwelt-medizin-gesellschaft 2010; 23(2): 130-9.

[127] Baliatsas C, van Kamp I, Kelfkens G, Schipper M, Bolte J, Yzermans J, et al. *Non-specific physical symptoms in relation to actual and perceived proximity to mobile phone base stations and powerlines*. BMC Public Health 2011; 11: 421.

[128] Bortkiewicz A, Gadzicka E, Szyjkowska A, Politanski P, Mamrot P, Szymczak W, et al. *Subjective complaints of people living near mobile phone base stations in Poland*. Int J Occup Med Environ Health 2012; 25(1): 31-40.

[129] Liu H, Chen G, Pan Y, Chen Z, Jin W, Sun C, et al. *Occupational electromagnetic field exposures associated with sleep quality: a cross-sectional study*. PLoS One 2014; 9(10): e110825.

[130] Lamech F. *Self-reporting of symptom development from exposure to radiofrequency fields of wireless smart meters in Victoria, Australia: a case series*. Altern Ther Health Med 2014; 20(6): 28-39.

[131] Silva DF, Barros WR, Almeida Mda C and Rego MA. *Exposure to non-ionizing electromagnetic radiation from mobile telephony and the association with psychiatric symptoms*. Cad Saude Publica 2015; 31(10): 2110-26.

[132] Singh K, Nagaraj A, Yousuf A, Ganta S, Pareek S and Vishnani P. *Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function*. J Int Soc Prev Community Dent 2016; 6(1): 54-9.

[133] Hegazy AA, Alkhail BA, Awadalla NJ, Qadi M and Al-Ahmadi J. *Mobile phone use and risk of adverse health impacts among medical students in Jeddah, Saudi Arabia*. Br J Med Med Res 2016; 15(1): 1-11.

[134] Adair ER, Kelleher SA, Mack GW and Morocco TS. *Thermophysiological responses of human volunteers during controlled whole-body radio frequency exposure at 450 MHz*. Bioelectromagnetics 1998; 19(4): 232-45.

[135] Braune S, Wrocklage C, Raczek J, Gailus T and Lucking CH. *Resting blood pressure increase during exposure to a radio-frequency electromagnetic field*. Lancet 1998; 351(9119): 1857-8.

[136] Zhang J, Clement D and Taunton J. *The efficacy of Farabloc, an electromagnetic shield, in attenuating delayed-onset muscle soreness*. Clinical Journal of Sport Medicine 2000; 10(1): 15-21.

[137] Barth A, Maritczak L, Valic E, Konnaris C and Wolf C. *[Pseudostenocardia due to exposure to "electrosmog"]*. Dtsch Med Wochenschr 2000; 125(27): 830-2.

[138] Adair ER, Mylacraine KS and Cobb BL. *Human exposure to 2450 MHz CW energy at levels outside the IEEE C95.1 standard does not increase core temperature*. Bioelectromagnetics 2001; 22(6): 429-39.

[139] Adair ER, Mylacraine KS and Cobb BL. *Partial-body exposure of human volunteers to 2450 MHz pulsed or CW fields provokes similar thermoregulatory responses*. Bioelectromagnetics 2001; 22(4): 246-59.

[140] Bortkiewicz A, Pilacik B, Gadzicka E and Szymczak W. *The excretion of 6-hydroxymelatonin sulfate in healthy young men exposed to electromagnetic fields emitted by cellular phone -- an experimental study*. Neuro Endocrinol Lett 2002; 23 Suppl 1: 88-91.

[141] Hocking B and Westerman R. *Neurological changes induced by a mobile phone*. Occup Med (Lond) 2002; 52(7): 413-5.

[142] Adair ER, Mylacraine KS and Allen SJ. *Thermophysiological consequences of whole body resonant RF exposure (100 MHz) in human volunteers*. Bioelectromagnetics 2003; 24(7): 489-501.

[143] Uloziene I, Uloza V, Gradauskiene E and Saferis V. *Assessment of potential effects of the electromagnetic fields of mobile phones on hearing*. BMC Public Health 2005; 5: 39.

[144] Adair ER, Blick DW, Allen SJ, Mylacraine KS, Ziriax JM and Scholl DM. *Thermophysiological responses of human volunteers to whole body RF exposure at 220 MHz*. Bioelectromagnetics 2005; 26(6): 448-61.

[145] Eliyahu I, Luria R, Hareuveny R, Margaliot M, Meiran N and Shani G. *Effects of radiofrequency radiation emitted by cellular telephones on the cognitive functions of humans*. Bioelectromagnetics 2006; 27(2): 119-26.

[146] Bachmann M, Hinrikus H, Adamasoo K, Võhma Ü, Lass J, Rubljova J, et al. *Modulated microwave effects on individuals with depressive disorder*. The Environmentalist 2007; 27: 505-10.

[147] Hung CS, Anderson C, Horne JA and McEvoy P. *Mobile phone 'talk-mode' signal delays EEG-determined sleep onset*. Neurosci Lett 2007; 421(1): 82-6.

[148] Luria R, Eliyahu I, Hareuveny R, Margaliot M and Meiran N. *Cognitive effects of radiation emitted by cellular phones: the influence of exposure side and time*. Bioelectromagnetics 2009; 30(3): 198-204.

[149] Mortazavi SM, Mahbudi A, Atefi M, Bagheri S, Bahaedini N and Besharati A. *An old issue and a new look: electromagnetic hypersensitivity caused by radiations emitted by GSM mobile phones*. Technol Health Care 2011; 19(6): 435-43.

[150] Alsanosi AA, Al-Momani MO, Hagr AA, Almomani FM, Shami IM and Al-Habeeb SF. *The acute auditory effects of exposure for 60 minutes to mobile`s electromagnetic field*. Saudi Med J 2013; 34(2): 142-6.

[151] Havas M and Marrongelle J. *Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings*. Electromagn Biol Med 2013; 32(2): 253-66.

[152] Trunk A, Stefanics G, Zentai N, Kovacs-Balint Z, Thuroczy G and Hernadi I. *No effects of a single 3G UMTS mobile phone exposure on spontaneous EEG activity, ERP correlates, and automatic deviance detection*. Bioelectromagnetics 2013; 34(1): 31-42.

[153] Hutter HP, Moshammer H, Wallner P, Cartellieri M, Denk-Linnert DM, Katzinger M, et al. *Tinnitus and mobile phone use*. Occup Environ Med 2010; 67(12): 804-8.

[154] Mortazavi SM, Ahmadi J and Shariati M. *Prevalence of subjective poor health symptoms associated with exposure to electromagnetic fields among university students*. Bioelectromagnetics 2007; 28(4): 326-30.

[155] Sudan M, Kheifets L, Arah OA and Olsen J. *Cell phone exposures and hearing loss in children in the Danish National Birth Cohort*. Paediatr Perinat Epidemiol 2013; 27(3): 247-57.

[156] Gupta N, Goyal D, Sharma R and Arora KS. *Effect of prolonged use of mobile phone on brainstem auditory evoked potentials*. J Clin Diagn Res 2015; 9(5): CC07-9.

[157] Bhagat S, Varshney S, Bist SS, Goel D, Mishra S and Jha VK. *Effects on auditory function of chronic exposure to electromagnetic fields from mobile phones*. Ear Nose Throat J 2016; 95(8): E18-22.

[158] Janssen T, Boege P, von Mikusch-Buchberg J and Raczek J. *Investigation of potential effects of cellular phones on human auditory function by means of distortion product otoacoustic emissions*. J Acoust Soc Am 2005; 117(3 Pt 1): 1241-7.

[159] Parazzini M, Bell S, Thuróczy G, Molnar F, Tognola G, Lutman ME, et al. *Influence on the mechanisms of generation of distortion product otoacoustic emissions of mobile phone exposure*. Hear Res 2005; 208(1-2): 68-78.

[160] Parazzini M, Brazzale AR, Paglialonga A, Tognola G, Collet L, Moulin A, et al. *Effects of GSM cellular phones on human hearing: The European project "GUARD"*. Radiation Research 2007; 168(5): 608-13.

[161] Paglialonga A, Tognola G, Parazzini M, Lutman ME, Bell SL, Thuroczy G, et al. *Effects of mobile phone exposure on time frequency fine structure of transiently evoked otoacoustic emissions*. J Acoust Soc Am 2007; 122(4): 2174-82.

[162] Bamiou DE, Ceranic B, Cox R, Watt H, Chadwick P and Luxon LM. *Mobile telephone use effects an peripheral audiovestibular function: A case-control study*. Bioelectromagnetics 2008; 29(2): 108-17.

[163] Bamiou DE, Ceranic B, Vickers D, Zamyslowska-Szmytke E, Cox R, Chadwick P, et al. *Mobile telephone use effects on perception of verticality*. Bioelectromagnetics 2015; 36(1): 27-34.

[164] Stefanics G, Thuróczy G, Kellényi L and Hernádi I. *Effects of twenty-minute 3G mobile phone irradiation on event related potential components and early gamma synchronization in auditory oddball paradigm*. Neuroscience 2008; 157(2): 453-62.

[165] Parazzini M, Sibella F, Lutman ME, Mishra S, Moulin A, Sliwinska-Kowalska M, et al. *Effects of UMTS cellular phones on human hearing: results of the European project EMFnEAR*. Radiat Res 2009; 172(2): 244-51.

[166] Parazzini M, Lutman ME, Moulin A, Barnel C, Sliwinska-Kowalska M, Zmyslony M, et al. *Absence of short-term effects of UMTS exposure on the human auditory system*. Radiat Res 2010; 173(1): 91-7.

[167] Kwon MS, Jaaskelainen SK, Toivo T and Hämäläinen H. *No effects of mobile phone electromagnetic field on auditory brainstem response*. Bioelectromagnetics 2010; 31(1): 48-55.

[168] Marino C, Cristalli G, Galloni P, Pasqualetti P, Piscitelli M and Lovisolo GA. *Effects of microwaves (900 MHz) on the cochlear receptor: exposure systems and preliminary results*. Radiat Environ Biophys 2000; 39(2): 131-6.

[169] Aran JM, Carrere N, Chalan Y, Dulou PE, Larrieu S, Letenneur L, et al. *Effects of exposure of the ear to GSM microwaves: in vivo and in vitro experimental studies*. Int J Audiol 2004; 43(9): 545-54.

[170] Galloni P, Lovisolo GA, Mancini S, Parazzini M, Pinto R, Piscitelli M, et al. *Effects of 900 MHz electromagnetic fields exposure on cochlear cells' functionality in rats: evaluation of distortion product otoacoustic emissions*. Bioelectromagnetics 2005; 26(7): 536-47.

[171] Galloni P, Parazzini M, Piscitelli M, Pinto R, Lovisolo GA, Tognola G, et al. *Electromagnetic fields from mobile phones do not affect the inner auditory system of Sprague-Dawley rats*. Radiat Res 2005; 164(6): 798-804.

[172] Parazzini M, Galloni P, Piscitelli M, Pinto R, Lovisolo GA, Tognola G, et al. *Possible combined effects of 900 MHz continuous-wave electromagnetic fields and gentamicin on the auditory system of rats*. Radiat Res 2007; 167(5): 600-5.

[173] Galloni P, Lopresto V, Parazzini M, Pinto R, Piscitelli M, Ravazzani P, et al. *No effects of UMTS exposure on the function of rat outer hair cells*. Bioelectromagnetics 2009; 30(5): 385-92.

[174] Hidisoglu E, Kantar-Gok D, Ozen S and Yargicoglu P. *Short-term 2.1 GHz radiofrequency radiation treatment induces significant changes on the auditory evoked potentials in adult rats*. Int J Radiat Biol 2018; 94(9): 858-71.

[175] Kim JH, Huh YH, Lee JH, Jung JY, Ahn SC and Kim HR. *Early exposure to radiofrequency electromagnetic fields at 1850 MHz affects auditory circuits in early postnatal mice*. Sci Rep 2019; 9(1): 377.

[176] Sagiv D, Migirov L, Madgar O, Nakache G, Wolf M and Shapira Y. *Mobile phone usage does not affect sudden sensorineural hearing loss*. J Laryngol Otol 2018; 132(1): 29-32.

[177] Kellenyi L, Thuróczy G, Faludy B and Lenard L. *Effects of mobile GSM radiotelephone exposure on the auditory brainstem response (ABR)*. Neurobiology (Bp) 1999; 7(1): 79-81.

[178] de Sèze R, Mausset AL, Ayoub J, Pina G and Miro L. *Evaluation of the health impact of the radio-frequency fields from mobile telephones*. Indoor Built Environ 2001; 10(5): 284-90.

[179] Ozturan O, Erdem T, Miman MC, Kalcioglu MT and Oncel S. *Effects of the electromagnetic field of mobile telephones on hearing*. Acta Otolaryngol 2002; 122(3): 289-93.

[180] Arai N, Enomoto H, Okabe S, Yuasa K, Kamimura Y and Ugawa Y. *Thirty minutes mobile phone use has no short-term adverse effects on central auditory pathways*. Clin Neurophysiol 2003; 114(8): 1390-4.

[181] Bak M, Sliwinska-Kowalska M, Zmyslony M and Dudarewicz A. *No effects of acute exposure to the electromagnetic field emitted by mobile phones on brainstem auditory potentials in young volunteers*. Int J Occup Med Environ Health 2003; 16(3): 201-8.

[182] Monnery PM, Srouji EI and Bartlett J. *Is cochlear outer hair cell function affected by mobile telephone radiation?* Clin Otolaryngol Allied Sci 2004; 29(6): 747-9.

[183] Pau HW, Sievert U, Eggert S and Wild W. *Can electromagnetic fields emitted by mobile phones stimulate the vestibular organ?* Otolaryngol Head Neck Surg 2005; 132(1): 43-9.

[184] Sievert U, Eggert S and Pau HW. *Can mobile phone emissions affect auditory functions of cochlea or brain stem?* Otolaryngol Head Neck Surg 2005; 132(3): 451-5.

[185] Oysu C, Topak M, Celik O, Yilmaz HB and Sahin AA. *Effects of the acute exposure to the electromagnetic field of mobile phones on human auditory brainstem responses*. Eur Arch Otorhinolaryngol 2005; 262(10): 839-43.

[186] Mora R, Crippa B, Mora F and Dellepiane M. *A study of the effects of cellular telephone microwave radiation on the auditory system in healthy men*. Ear Nose Throat J 2006; 85(3): 160, 2-3.

[187] Sievert U, Eggert S, Goltz S and Pau HW. *[Effects of electromagnetic fields emitted by cellular phone on auditory and vestibular labyrinth]*. Laryngorhinootologie 2007; 86(4): 264-70.

[188] Stefanics G, Kellényi L, Molnar F, Kubinyi G, Thuróczy G and Hernádi I. *Short GSM mobile phone exposure does not alter human auditory brainstem response*. BMC Public Health 2007; 7: 325.

[189] Colletti V, Mandala M, Manganotti P, Ramat S, Sacchetto L and Colletti L. *Intraoperative observation of changes in cochlear nerve action*

potentials during exposure to electromagnetic fields generated by mobile phones. Journal of Neurology Neurosurgery and Psychiatry 2011; 82(7): 766-71.

[190] Balachandran R, Prepageran N, Rahmat O, Zulkiflee AB and Hufaida KS. *Effects of Bluetooth device electromagnetic field on hearing: pilot study*. J Laryngol Otol 2012; 126(4): 345-8.

[191] Mandala M, Colletti V, Sacchetto L, Manganotti P, Ramat S, Marcocci A, et al. *Effect of Bluetooth headset and mobile phone electromagnetic fields on the human auditory nerve*. Laryngoscope 2014; 124(1): 255-9.

[192] Singh K. *Effect of electromagnetic waves emitted from mobile phone on brain stem auditory evoked potential in adult males*. Indian J Physiol Pharmacol 2015; 59(4): 402-6.

[193] Kizilay A, Ozturan O, Erdem T, Kalcioglu MT and Miman MC. *Effects of chronic exposure of electromagnetic fields from mobile phones on hearing in rats*. Auris Nasus Larynx 2003; 30(3): 239-45.

[194] Budak GG, Muluk NB, Budak B, Ozturk GG, Apan A and Seyhan N. *Effects of intrauterine and extrauterine exposure to GSM-like radiofrequency on distortion product otoacoustic emissions in infant male rabbits*. Int J Pediatr Otorhinolaryngol 2009; 73(3): 391-9.

[195] Budak GG, Muluk NB, Budak B, Ozturk GG, Apan A and Seyhan N. *Effects of GSM-like radiofrequency on distortion product otoacoustic emissions of rabbits: comparison of infants versus adults*. Int J Pediatr Otorhinolaryngol 2009; 73(8): 1143-7.

[196] Budak GG, Muluk NB, Ozturk GG, Budak B, Apan A, Seyhan N, et al. *Effects of GSM-like radiofrequency on distortion product otoacoustic emissions in pregnant adult rabbits*. Clin Invest Med 2009; 32(2): E112-E6.

[197] Kayabasoglu G, Sezen OS, Eraslan G, Aydin E, Coskuner T and Unver S. *Effect of chronic exposure to cellular telephone electromagnetic fields on hearing in rats*. J Laryngol Otol 2011; 125(4): 348-53.

[198] Kaprana AE, Chimona TS, Papadakis CE, Velegrakis SG, Vardiambasis IO, Adamidis G, et al. *Auditory brainstem response changes during exposure to GSM-900 radiation: an experimental study*. Audiol Neurootol 2011; 16(4): 270-6.

[199] Seckin E, Suren Basar F, Atmaca S, Kaymaz FF, Suzer A, Akar A, et al. *The effect of radiofrequency radiation generated by a Global System for Mobile Communications source on cochlear development in a rat model*. J Laryngol Otol 2014; 128(5): 400-5.

[200] Schmid G, Sauter C, Stepansky R, Lobentanz IS and Zeitlhofer J. *No influence on selected parameters of human visual perception of 1970 MHz UMTS-like exposure*. Bioelectromagnetics 2005; 26(4): 243-50.

[201] Irlenbusch L, Bartsch B, Cooper J, Herget I, Marx B, Raczek J, et al. *Influence of a 902.4 MHz GSM signal on the human visual system: investigation of the discrimination threshold*. Bioelectromagnetics 2007; 28(8): 648-54.

[202] Unterlechner M, Sauter C, Schmid G and Zeitlhofer J. *No effect of an UMTS mobile phone-like electromagnetic field of 1.97 GHz on human attention and reaction time*. Bioelectromagnetics 2008; 29(2): 145-53.

[203] Eker ED, Arslan B, Yildirim M, Akar A and Aras N. *The effect of exposure to 1800 MHz radiofrequency radiation on epidermal growth factor, caspase-3, Hsp27 and p38MAPK gene expressions in the rat eye*. Bratisl Lek Listy 2018; 119(9): 588-92.

[204] Kamimura Y, Saito K, Saiga T and Amenmiya Y. *Effect of 2.45 GHz microwave irradiation on monkey eyes*. IEICE Trans Comm 1994; E77-B: 762-5.

[205] Lu ST, D'Andrea J, Chalfin S, Crane C, Marchello D, Garay R, et al. *Absence of corneal endothelium injury in non-human primates treated with and without ophthalmologic drugs and exposed to 2.8 GHz pulsed microwaves*. Bioelectromagnetics 2010; 31(4): 324-33.

[206] Kues HA, Monahan JC, D'Anna SA, McLeod DS, Lutty GA and Koslov S. *Increased sensitivity of the non-human primate eye to microwave radiation following ophthalmic drug pretreatment*. Bioelectromagnetics 1992; 13(5): 379-93.

[207] Ye J, Yao K, Lu D, Wu R and Jiang H. *Low power density microwave radiation induced early changes in rabbit lens epithelial cells*. Chin Med J (Engl) 2001; 114(12): 1290-4.

[208] Cleary SF, Pasternack BS and Beebe GW. *Cataract incidence in radar workers*. Arch Environ Health 1965; 11(2): 179-82.

[209] Gawit KG, Tiwari SA, Kasabe GH, Deshpande PK and Ghongane BB. *Effect of cellular mobile hone use and cetrizine on hand-eye coordination and visual acuity*. J Clin Diagn Res 2017; 11(9): FC09-FC12.

[210] Inalöz SS, Daşdağ S, Çeviz A and Bilici A. *Acceptable radiation leakage of microwave ovens on pregnant and newborn rat brains*. Clin Exp Obstet Gynecol 1997; 24(4): 215-9.

[211] Balci M, Devrim E and Durak I. *Effects of mobile phones on oxidant/antioxidant balance in cornea and lens of rats*. Curr Eye Res 2007; 32(1): 21-5.

[212] Balci M, Namuslu M, Devrim E and Durak I. *Effects of computer monitor-emitted radiation on oxidant/antioxidant balance in cornea and lens from rats*. Mol Vis 2009; 15: 2521-5.

[213] Hässig M, Jud F, Naegeli H, Kupper J and Spiess BM. *Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations*. Schweiz Arch Tierheilkd 2009; 151(10): 471-8.

[214] Zareen N, Khan MY and Minhas LA. *Derangement of chick embryo retinal differentiation caused by radiofrequency electromagnetic fields*. Congenit Anom (Kyoto) 2009; 49(1): 15-9.

[215] Demirel S, Doganay S, Turkoz Y, Dogan Z, Turan B and Firat PG. *Effects of third generation mobile phone-emitted electromagnetic radiation on oxidative stress parameters in eye tissue and blood of rats*. Cutan Ocul Toxicol 2012; 31(2): 89-94.

[216] Hässig M, Jud F and Spiess B. *[Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]*. Schweiz Arch Tierheilkd 2012; 154(2): 82-6.

[217] Beekhuizen J, Vermeulen R, Kromhout H, Burgi A and Huss A. *Geospatial modelling of electromagnetic fields from mobile phone base stations*. Sci Total Environ 2013; 445-446: 202-9.

[218] Akar A, Karayigit MO, Bolat D, Gultiken ME, Yarim M and Castellani G. *Effects of low level electromagnetic field exposure at 2.45 GHz on rat cornea*. Int J Radiat Biol 2013; 89(4): 243-9.

[219] Tök L, Naziroglu M, Dogan S, Kahya MC and Tök O. *Effects of melatonin on Wi-Fi-induced oxidative stress in lens of rats*. Indian J Ophthalmol 2014; 62(1): 12-5.

[220] Benson VS, Pirie K, Schüz J, Reeves GK, Beral V and Green J. *Mobile phone use and risk of brain neoplasms and other cancers: prospective study*. Int J Epidemiol 2013; 42(3): 792-802.

[221] Mann K, Röschke J, Connemann B and Beta H. *No effects of pulsed high-frequency electromagnetic fields on heart rate variability during human sleep*. Neuropsychobiology 1998; 38(4): 251-6.

[222] Braune S, Riedel A, Schulte-Monting J and Raczek J. *Influence of a radiofrequency electromagnetic field on cardiovascular and hormonal parameters of the autonomic nervous system in healthy individuals*. Radiat Res 2002; 158(3): 352-6.

[223] Barker AT, Jackson PR, Parry H, Coulton LA, Cook GG and Wood SM. *The effect of GSM and TETRA mobile handset signals on blood pressure, catechol levels and heart rate variability*. Bioelectromagnetics 2007; 28(6): 433-8.

[224] Atlasz T, Kellenyi L, Kovacs P, Babai N, Thuroczy G, Hejjel L, et al. *The application of surface plethysmography for heart rate variability analysis after GSM radiofrequency exposure*. J Biochem Biophys Methods 2006; 69(1-2): 233-6.

[225] Ghosn R, Thuróczy G, Loos N, Brenet-Dufour V, Liabeuf S, de Sèze R, et al. *Effects of GSM 900 MHz on middle cerebral artery blood flow assessed by transcranial Doppler sonography*. Radiat Res 2012; 178(6): 543-50.

[226] Ghosn R, Yahia-Cherif L, Hugueville L, Ducorps A, Lemarechal JD, Thuroczy G, et al. *Radiofrequency signal affects alpha band in resting electroencephalogram*. J Neurophysiol 2015; 113(7): 2753-9.

[227] Parazzini M, Ravazzani P, Thuróczy G, Molnar FB, Ardesi G, Sacchettini A, et al. *Nonlinear heart rate variability measures under electromagnetic fields produced by GSM cellular phones*. Electromagn Biol Med 2013; 32(2): 173-81.

[228] Loos N, Thuróczy G, Ghosn R, Brenet-Dufour V, Liabeuf S, Selmaoui B, et al. *Is the effect of mobile phone radiofrequency waves on human skin perfusion non-thermal?* Microcirculation 2013; 20(7): 629-36.

[229] Lindholm H, Alanko T, Rintamaki H, Kannala S, Toivonen T, Sistonen H, et al. *Thermal effects of mobile phone RF fields on children: a provocation study*. Prog Biophys Mol Biol 2011; 107(3): 399-403.

[230] Andrianome S, Gobert J, Hugueville L, Stephan-Blanchard E, Telliez F and Selmaoui B. *An assessment of the autonomic nervous system in the electrohypersensitive population: a heart rate variability and skin conductance study*. J Appl Physiol (1985) 2017; 123(5): 1055-62.

[231] Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, et al. *Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls*. Bioelectromagnetics 2009; 30(7): 556-63.

[232] Tikhonova GI. *[Epidemiological risk assessment of pathology development in occupational exposure to radiofrequency electromagnetic fields]*. Radiats Biol Radioecol 2003; 43(5): 559-64.

[233] Paredi P, Kharitonov SA, Hanazawa T and Barnes PJ. *Local vasodilator response to mobile phones*. Laryngoscope 2001; 111(1): 159-62.

[234] Monfrecola G, Moffa G and Procaccini EM. *Non-ionizing electromagnetic radiations, emitted by a cellular phone, modify cutaneous blood flow*. Dermatology 2003; 207(1): 10-4.

[235] Celik O and Hascalik S. *Effect of electromagnetic field emitted by cellular phones on fetal heart rate patterns*. Eur J Obstet Gynecol Reprod Biol 2004; 112(1): 55-6.

[236] Esen F and Esen H. *Effect of electromagnetic fields emitted by cellular phones on the latency of evoked electrodermal activity*. Int J Neurosci 2006; 116(3): 321-9.

[237] Nam KC, Kim SW, Kim SC and Kim DW. *Effects of RF exposure of teenagers and adults by CDMA cellular phones*. Bioelectromagnetics 2006; 27(7): 509-14.

[238] Ahamed VI, Karthick NG and Joseph PK. *Effect of mobile phone radiation on heart rate variability*. Comput Biol Med 2008; 38(6): 709-12.

[239] Andrzejak R, Poreba R, Poreba M, Derkacz A, Skalik R, Gac P, et al. *The influence of the call with a mobile phone on heart rate variability parameters in healthy volunteers*. Ind Health 2008; 46(4): 409-17.

[240] Rezk AY, Abdulqawi K, Mustafa RM, Abo El-Azm TM and Al-Inany H. *Fetal and neonatal responses following maternal exposure to mobile phones*. Saudi Med J 2008; 29(2): 218-23.

[241] Tamer A, Gunduz H and Ozyildirim S. *The cardiac effects of a mobile phone positioned closest to the heart*. Anadolu Kardiyol Derg 2009; 9(5): 380-4.

[242] Yilmaz D and Yildiz M. *Analysis of the mobile phone effect on the heart rate variability by using the largest Lyapunov exponent*. J Med Syst 2010; 34(6): 1097-103.

[243] Havas M, Marrongelle J, Pollner B, Kelley E, Rees CRG and Tully L. *Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system*. Eur J Oncol Libr 2010; 5: 273–300.

[244] Faust O, Acharya UR, Nergui M, Ghista DN, Chattopadhyay S, Joseph P, et al. *Effects of mobile phone radiation on cardiac health*. J Mechanics Med Biol 2011; 11(5): 1241-53.

[245] Barutcu I, Esen AM, Kaya D, Turkmen M, Karakaya O, Saglam M, et al. *Do mobile phones pose a potential risk to autonomic modulation of the heart?* Pacing Clin Electrophysiol 2011; 34(11): 1511-4.

[246] Alhusseiny A, Al-Nimer M and Majeed A. *Electromagnetic energy radiated from mobile phone alters electrocardiographic records of patients with ischemic heart disease*. Ann Med Health Sci Res 2012; 2(2): 146-51.

[247] Devasia T, Nandra A, Kareem H, Manu MK and Thakkar AS. *Acute effect of mobile phone on cardiac electrical activity in healthy volunteers*. Int J Clin Med 2014; 5(5): 167-70.

[248] Malek F, Rani KA, Rahim HA and Omar MH. *Effect of short-term mobile phone base station exposure on cognitive performance, body temperature, heart rate and blood pressure of Malaysians*. Sci Rep 2015; 5: 13206.

[249] Messina A, Russo G, Monda V, Valenzano A, Villano I, Ascione A, et al. *Effect of radiofrequency on sympathetic nervous system functioning*. Acta Medica Mediterranea 2017; 33(5): 833-40.

[250] Umar ZU, Abubakar MB, Ige J, Igbokwe UV, Mojiminiyi FB and Isezuo SA. *Effect of mobile phone radiofrequency electromagnetic fields on cardiovascular parameters in apparently healthy individuals*. Niger J Physiol Sci 2014; 29(2): 137-40.

[251] Luna J, Leleu JP, Preux PM, Corcia P, Couratier P, Marin B, et al. *Residential exposure to ultra high frequency electromagnetic fields emitted by Global System for Mobile (GSM) antennas and amyotrophic lateral sclerosis incidence: A geo-epidemiological population-based study*. Environ Res 2019; 176: 108525.

[252] Silva M and Santana VS. *[Occupation and mortality in the Brazilian Navy]*. Rev Saude Publica 2004; 38(5): 709-15.

[253] Beard JD, Engel LS, Richardson DB, Gammon MD, Baird C, Umbach DM, et al. *Military service, deployments, and exposures in relation to amyotrophic lateral sclerosis etiology*. Environ Int 2016; 91: 104-15.

[254] Arendash GW, Sanchez-Ramos J, Mori T, Mamcarz M, Lin X, Runfeldt M, et al. *Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice*. J Alzheimers Dis 2010; 19(1): 191-210.

[255] Dragicevic N, Bradshaw PC, Mamcarz M, Lin X, Wang L, Cao C, et al. *Long-term electromagnetic field treatment enhances brain mitochondrial function of both Alzheimer's transgenic mice and normal mice: a mechanism for electromagnetic field-induced cognitive benefit?* Neuroscience 2011; 185: 135-49.

[256] Banaceur S, Banasr S, Sakly M and Abdelmelek H. *Whole body exposure to 2.4 GHz WIFI signals: effects on cognitive impairment in adult triple transgenic mouse models of Alzheimer's disease (3xTg-AD)*. Behav Brain Res 2013; 240: 197-201.

[257] Ribeiro EP, Rhoden EL, Horn MM, Rhoden C, Lima LP and Toniolo L. *Effects of subchronic exposure to radio frequency from a conventional cellular telephone on testicular function in adult rats*. J Urol 2007; 177(1): 395-9.

[258] Daşdağ S, Akdağ MZ, Ulukaya E, Uzunlar AK and Yegin D. *Mobile phone exposure does not induce apoptosis on spermatogenesis in rats*. Arch Med Res 2008; 39(1): 40-4.

[259] Lee H-J, Pack J-K, Kim T-H, Kim N, Choi S-Y, Lee J-S, et al. *The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis*. Bioelectromagnetics 2010; 31(7): 528-34.

[260] Lee H-J, Jin Y-B, Kim T-H, Pack J-K, Kim N, Choi H-D, et al. *The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function*. Bioelectromagnetics 2012; 33: 356-64.

[261] Trošić I, Matausic-Pisl M, Pavicic I and Marjanovic AM. *Histological and cytological examination of rat reproductive tissue after short-time intermittent radiofrequency exposure*. Arh Hig Rada Toksikol 2013; 64(4): 513-9.

[262] Qin F, Zhang J, Cao H, Guo W, Chen L, Shen O, et al. *Circadian alterations of reproductive functional markers in male rats exposed to 1800 MHz radiofrequency field*. Chronobiol Int 2014; 31(1): 123-33.

[263] Houston BJ, Nixon B, McEwan KE, Martin JH, King BV, Aitken RJ, et al. *Whole-body exposures to radiofrequency-electromagnetic energy can cause DNA damage in mouse spermatozoa via an oxidative mechanism*. Sci Rep 2019; 9(1): 17478.

[264] Azimzadeh M and Jelodar G. *Alteration of testicular regulatory and functional molecules following long-time exposure to 900 MHz RFW emitted from BTS*. Andrologia 2019; 51(9): e13372.

[265] Yahyazadeh A, Altunkaynak BZ and Kaplan S. *Biochemical, immunohistochemical and morphometrical investigation of the effect of thymoquinone on the rat testis following exposure to a 900-MHz electromagnetic field*. Acta Histochem 2020; 122(1): 151467.

[266] Forgács Z, Somosy Z, Kubinyi G, Bakos J, Hudák A, Surjan A, et al. *Effect of whole-body 1800 MHz GSM-like microwave exposure on testicular steroidogenesis and histology in mice*. Reprod Toxicol 2006; 22(1): 111-7.

[267] Imai N, Kawabe M, Hikage T, Nojima T, Takahashi S and Shirai T. *Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones*. Syst Biol Reprod Med 2011; 57(4): 204-9.

[268] Nisbet HO, Nisbet C, Akar A, Cevik M and Karayigit MO. *Effects of exposure to electromagnetic field (1.8/0.9 GHz) on testicular function and structure in growing rats*. Res Vet Sci 2012; 93(2): 1001-5.

[269] Taş M, Daşdağ S, Akdağ MZ, Cirit U, Yegin K, Seker U, et al. *Long-term effects of 900 MHz radiofrequency radiation emitted from mobile phone on testicular tissue and epididymal semen quality*. Electromagn Biol Med 2014; 33(3): 216-22.

[270] Saygin M, Caliskan S, Karahan N, Koyu A, Gumral N and Uguz A. *Testicular apoptosis and histopathological changes induced by a 2.45 GHz electromagnetic field*. Toxicol Ind Health 2011; 27(5): 455-63.

[271] Meena R, Kumari K, Kumar J, Rajamani P, Verma HN and Kesari KK. *Therapeutic approaches of melatonin in microwave radiations-induced oxidative stress-mediated toxicity on male fertility pattern of Wistar rats*. Electromagn Biol Med 2014; 33(2): 81-91.

[272] Shahin S, Mishra V, Singh SP and Chaturvedi CM. *2.45-GHz microwave irradiation adversely affects reproductive function in male mouse, Mus musculus by inducing oxidative and nitrosative stress*. Free Radic Res 2014; 48(5): 511-25.

[273] Saygin M, Caliskan S, Ozguner MF, Gumral N, Comlekci S and Karahan N. *Impact of L-carnitine and selenium treatment on testicular apoptosis in rats exposed to 2.45 GHz microwave energy*. West Indian Med J 2015; 64(2): 55-61.

[274] Dasdag S, Tas M, Akdag MZ and Yegin K. *Effect of long-term exposure of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on testes functions*. Electromagn Biol Med 2015; 34(1): 37-42.

[275] Saygin M, Asci H, Ozmen O, Cankara FN, Dincoglu D and Ilhan I. *Impact of 2.45 GHz microwave radiation on the testicular inflammatory pathway biomarkers in young rats: The role of gallic acid*. Environ Toxicol 2016; 31(12): 1771-84.

[276] Jonwal C, Sisodia R, Saxena VK and Kesari KK. *Effect of 2.45 GHz microwave radiation on the fertility pattern in male mice*. Gen Physiol Biophys 2018; 37(4): 453-60.

[277] Bilgici B, Gun S, Avci B, Akar A and B KE. *What is adverse effect of wireless local area network, using 2.45 GHz, on the reproductive system?* Int J Radiat Biol 2018; 94(11): 1054-61.

[278] Shahin S, Singh SP and Chaturvedi CM. *2.45 GHz microwave radiation induced oxidative and nitrosative stress mediated testicular apoptosis: Involvement of a p53 dependent bax-caspase-3 mediated pathway*. Environ Toxicol 2018; 33(9): 931-45.

[279] Yu G, Tang Z, Chen H, Chen Z, Wang L, Cao H, et al. *Long-term exposure to 4G smartphone radiofrequency electromagnetic radiation diminished male reproductive potential by directly disrupting Spock3-MMP2-BTB axis in the testes of adult rats*. Sci Total Environ 2020; 698: 133860.

[280] Weyandt TB, Schrader SM, Turner TW and Simon SD. *Semen analysis of military personnel associated with military duty assignments*. Reprod Toxicol 1996; 10(6): 521-8.

[281] Schrader SM, Langford RE, Turner TW, Breitenstein MJ, Clark JC, Jenkins BL, et al. *Reproductive function in relation to duty assignments among military personnel*. Reprod Toxicol 1998; 12(4): 465-8.

[282] Ding XP, Yan SW, Zhang N, Tang J, Lu HO, Wang XL, et al. *[A cross-sectional study on nonionizing radiation to male fertility]*. Zhonghua Liu Xing Bing Xue Za Zhi 2004; 25(1): 40-3.

[283] Yan SW, Zhang N, Tang J, Lu HO and Wang XL. *[Long-term exposure to low intensity microwave radiation affects male reproductivity]*. Zhonghua Nan Ke Xue 2007; 13(4): 306-8.

[284] Baste V, Riise T and Moen BE. *Radiofrequency electromagnetic fields; male infertility and sex ratio of offspring*. Eur J Epidemiol 2008; 23(5): 369-77.

[285] Baste V, Moen BE, Oftedal G, Strand LA, Bjorge L and Hansson Mild K. *Pregnancy outcomes after paternal radiofrequency field exposure aboard fast patrol boats*. J Occup Environ Med 2012; 54(4): 431-8.

[286] Davoudi M, Brössner C and Kuber W. *Der Einfluss elektromagnetischer Wellen auf die Spermienmotilität*. J Urol Urogynäk 2002; 9(3): 18-22.

[287] Daşdağ S, Ketani MA, Akdağ Z, Ersay AR, Sari I, Demirtas OC, et al. *Whole-body microwave exposure emitted by cellular phones and testicular function of rats*. Urol Res 1999; 27(3): 219-23.

[288] Daşdağ S, Akdağ MZ, Aksen F, Yilmaz F, Bashan M, Daşdag MM, et al. *Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes*. Bioelectromagnetics 2003; 24(3): 182-8.

[289] Ozguner M, Koyu A, Cesur G, Ural M, Ozguner F, Gokcimen A, et al. *Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field*. Saudi Med J 2005; 26(3): 405-10.

[290] Yan JG, Agresti M, Bruce T, Yan YH, Granlund A and Matloub HS. *Effects of cellular phone emissions on sperm motility in rats*. Fertil Steril 2007; 88(4): 957-64.

[291] Mailankot M, Kunnath AP, Jayalekshmi H, Koduru B and Valsalan R. *Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8 GHz) mobile phones induces oxidative stress and reduces sperm motility in rats*. Clinics (Sao Paulo) 2009; 64(6): 561-5.

[292] Kesari KK, Kumar S and Behari J. *Mobile phone usage and male infertility in Wistar rats*. Indian J Exp Biol 2010; 48(10): 987-92.

[293] Meo SA, Al-Drees AM, Husain S, Khan MM and Imran MB. *Effects of mobile phone radiation on serum testosterone in Wistar albino rats*. Saudi Med J 2010; 31(8): 869-73.

[294] Otitoloju AA, Obe IA, Adewale OA, Otubanjo OA and Osunkalu VO. *Preliminary study on the induction of sperm head abnormalities in mice, Mus musculus, exposed to radiofrequency radiations from global system for mobile communication base stations*. Bull Environ Contam Toxicol 2010; 84(1): 51-4.

[295] Esmekaya MA, Ozer C and Seyhan N. *900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues*. Gen Physiol Biophys 2011; 30(1): 84-9.

[296] Kesari KK, Kumar S and Behari J. *Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats*. Appl Biochem Biotechnol 2011; 164(4): 546-59.

[297] Meo SA, Arif M, Rashied S, Khan MM, Vohra MS, Usmani AM, et al. *Hypospermatogenesis and spermatozoa maturation arrest in rats*

induced by mobile phone radiation. J Coll Physicians Surg Pak 2011; 21(5): 262-5.

[298] Sarookhani MR, Asiabanha Rezaei M, Safari A, Zaroushani V and Ziaeiha M. *The influence of 950 MHz magnetic field (mobile phone radiation) on sex organ and adrenal function of male rabbits*. Afr J Biochem Res 2011; 5(2): 77-80.

[299] Al-Damegh MA. *Rat testicular impairment induced by electromagnetic radiation from a conventional cellular telephone and the protective effects of the antioxidants vitamins C and E*. Clinics (Sao Paulo) 2012; 67(7): 785-92.

[300] Çelik S, Aridogan IA, Izol V, Erdoğan S, Polat S and Doran Ş. *An evaluation of the effects of long-term cell phone use on the testes via light and electron microscope analysis*. Urology 2012; 79(2): 346-50.

[301] Kesari KK and Behari J. *Evidence for mobile phone radiation exposure effects on reproductive pattern of male rats: role of ROS*. Electromagn Biol Med 2012; 31(3): 213-22.

[302] Atasoy HI, Gunal MY, Atasoy P, Elgun S and Bugdayci G. *Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices*. J Pediatr Urol 2013; 9(2): 223-9.

[303] Ghanbari M, Mortazavi SB, Khavanin A and Khazaei M. *The effects of cell phone waves (900 MHz-GSM band) on sperm parameters and total antioxidant capacity in rats*. Int J Fertil Steril 2013; 7(1): 21-8.

[304] Shahin S, Singh VP, Shukla RK, Dhawan A, Gangwar RK, Singh SP, et al. *2.45 GHz microwave irradiation-induced oxidative stress affects implantation or pregnancy in mice, Mus musculus*. Appl Biochem Biotechnol 2013; 169(5): 1727-51.

[305] Karaman MI, Gokce AM, Koca O, Karaman B, Ozturk MI, Yurdakul N, et al. *The effects of electromagnetic waves emitted by the cell phones on the testicular tissue*. Arch Ital Urol Androl 2014; 86(4): 274-7.

[306] Kumar S, Nirala JP, Behari J and Paulraj R. *Effect of electromagnetic irradiation produced by 3G mobile phone on male rat reproductive system in a simulated scenario*. Indian J Exp Biol 2014; 52(9): 890-7.

[307] Oksay T, Naziroglu M, Dogan S, Guzel A, Gumral N and Kosar PA. *Protective effects of melatonin against oxidative injury in rat testis induced by wireless (2.45 GHz) devices*. Andrologia 2014; 46(1): 65-72.

[308] Sepehrimanesh M, Saeb M, Nazifi S, Kazemipour N, Jelodar G and Saeb S. *Impact of 900 MHz electromagnetic field exposure on main male reproductive hormone levels: a Rattus norvegicus model*. Int J Biometeorol 2014; 58(7): 1657-63.

[309] Azadi Oskouyi E, Rajaei F, Safari Variani A, Sarokhani MR and Javadi A. *Effects of microwaves (950 MHZ mobile phone) on morphometric and apoptotic changes of rabbit epididymis*. Andrologia 2015; 47(6): 700-5.

[310] Bin-Meferij MM and El-Kott AF. *The radioprotective effects of Moringa oleifera against mobile phone electromagnetic radiation-induced infertility in rats*. Int J Clin Exp Med 2015; 8(8): 12487-97.

311 Tumkaya L, Kalkan Y, Bas O and Yilmaz A. *Mobile phone radiation during pubertal development has no effect on testicular histology in rats*. Toxicol Ind Health 2016; 32(2): 328-36.

312 Cetkin M, Kizilkan N, Demirel C, Bozdag Z, Erkilic S and Erbagci H. *Quantitative changes in testicular structure and function in rat exposed to mobile phone radiation*. Andrologia 2017.

313 Pandey N, Giri S, Das S and Upadhaya P. *Radiofrequency radiation (900 MHz)-induced DNA damage and cell cycle arrest in testicular germ cells in swiss albino mice*. Toxicol Ind Health 2017; 33(4): 373-84.

314 Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S and Davis DL. *Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure*. Environ Sci Pollut Res Int 2017; 24(15): 13666-73.

315 Shahin S, Singh SP and Chaturvedi CM. *Mobile phone (1800MHz) radiation impairs female reproduction in mice, Mus musculus, through stress induced inhibition of ovarian and uterine activity*. Reprod Toxicol 2017; 73: 41-60.

316 Oyewopo AO, Olaniyi SK, Oyewopo CI and Jimoh AT. *Radiofrequency electromagnetic radiation from cell phone causes defective testicular function in male Wistar rats*. Andrologia 2017; 49(10).

317 Narayanan SN, Lukose ST, Arun G, Mohapatra N, Pamala J, Concessao PL, et al. *Modulatory effect of 900 MHz radiation on biochemical and reproductive parameters in rats*. Bratisl Lek Listy 2018; 119(9): 581-7.

318 Oh JJ, Byun SS, Lee SE, Choe G and Hong SK. *Effect of Electromagnetic Waves from Mobile Phones on Spermatogenesis in the Era of 4G-LTE*. Biomed Res Int 2018; 2018: 1801798.

319 Shahin S, Singh SP and Chaturvedi CM. *1800 MHz mobile phone irradiation induced oxidative and nitrosative stress leads to p53 dependent Bax mediated testicular apoptosis in mice, Mus musculus*. J Cell Physiol 2018; 233(9): 7253-67.

320 Hu HX, Sun J, Gao YJ, Fang H, Xu SQ, Dong J, et al. *Effect of modified Wuzi Yanzong Pill () on Tip60-mediated apoptosis in testis of male rats after microwave radiation*. Chin J Integr Med 2019; 25(5): 342-7.

321 Yahyazadeh A and Altunkaynak BZ. *Protective effects of luteolin on rat testis following exposure to 900 MHz electromagnetic field*. Biotech Histochem 2019; 94(4): 298-307.

322 Gautam R, Singh KV, Nirala J, Murmu NN, Meena R and Rajamani P. *Oxidative stress-mediated alterations on sperm parameters in male Wistar rats exposed to 3G mobile phone radiation*. Andrologia 2019; 51(3): e13201.

323 Tsarna E, Reedijk M, Birks LE, Guxens M, Ballester F, Ha M, et al. *Associations of maternal cell-phone use during pregnancy with pregnancy duration and fetal growth in 4 birth cohorts*. Am J Epidemiol 2019; 188(7): 1270-80.

[324] Bornhausen M and Scheingraber H. *Prenatal exposure to 900 MHz, cell-phone electromagnetic fields had no effect on operant-behavior performances of adult rats*. Bioelectromagnetics 2000; 21(8): 566-74.

[325] Ferreira AR, Knakievicz T, Pasquali MA, Gelain DP, Dal-Pizzol F, Fernandez CE, et al. *Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring*. Life Sci 2006; 80(1): 43-50.

[326] Sommer AM, Grote K, Reinhardt T, Streckert J, Hansen V and Lerchl A. *Effects of radiofrequency electromagnetic fields (UMTS) on reproduction and development of mice: a multi-generation study*. Radiat Res 2009; 171(1): 89-95.

[327] Ogawa K, Nabae K, Wang J, Wake K, Watanabe S, Kawabe M, et al. *Effects of gestational exposure to 1.95-GHz W-CDMA signals for IMT-2000 cellular phones: lack of embryotoxicity and teratogenicity in rats*. Bioelectromagnetics 2009; 30(3): 205-12.

[328] Lee H-J, Lee J-S, Pack J-K, Choi H-D, Kim N, Kim S-H, et al. *Lack of teratogenicity after combined exposure of pregnant mice to CDMA and WCDMA radiofrequency electromagnetic fields*. Radiat Res 2009; 172(5): 648-52.

[329] Fragopoulou AF, Koussoulakos SL and Margaritis LH. *Cranial and postcranial skeletal variations induced in mouse embryos by mobile phone radiation*. Pathophysiology 2010; 17(3): 169-77.

[330] Shirai T, Wang J, Kawabe M, Wake K, Watanabe SI, Takahashi S, et al. *No adverse effects detected for simultaneous whole-body exposure to multiple-frequency radiofrequency electromagnetic fields for rats in the intrauterine and pre- and post-weaning periods*. J Radiat Res 2017; 58(1): 48-58.

[331] Nisbet HO, Akar A, Nisbet C, Gulbahar MY, Ozak A, Yardimci C, et al. *Effects of electromagnetic field (1.8/0.9 GHz) exposure on growth plate in growing rats*. Res Vet Sci 2016; 104: 24-9.

[332] Abad M, Malekafzali H, Simbar M, Seyed Mosaavi H and Merghati Khoei E. *Association between electromagnetic field exposure and abortion in pregnant women living in Tehran*. Int J Reprod Biomed (Yazd) 2016; 14(5): 347-54.

[333] Takahashi S, Imai N, Nabae K, Wake K, Kawai H, Wang J, et al. *Lack of adverse effects of whole-body exposure to a mobile telecommunication electromagnetic field on the rat fetus*. Radiat Res 2010; 173(3): 362-72.

[334] Aït-Aïssa S, Billaudel B, Poulletier de Gannes F, Ruffie G, Duleu S, Hurtier A, et al. *In utero and early-life exposure of rats to a Wi-Fi signal: screening of immune markers in sera and gestational outcome*. Bioelectromagnetics 2012; 33(5): 410-20.

[335] Poulletier de Gannes F, Haro E, Hurtier A, Taxile M, Athane A, Ait-Aissa S, et al. *Effect of in utero Wi-Fi exposure on the pre- and postnatal development of rats*. Birth Defects Res B Dev Reprod Toxicol 2012; 95(2): 130-6.

[336] Poulletier de Gannes F, Billaudel B, Haro E, Taxile M, Le Montagner L, Hurtier A, et al. *Rat fertility and embryo fetal development: influence of exposure to the Wi-Fi signal*. Reprod Toxicol 2013; 36: 1-5.

[337] Shirai T, Imai N, Wang J, Takahashi S, Kawabe M, Wake K, et al. *Multigenerational effects of whole body exposure to 2.14 GHz W-CDMA cellular phone signals on brain function in rats*. Bioelectromagnetics 2014; 35(7): 497-511.

[338] Woelders H, de Wit A, Lourens A, Stockhofe N, Engel B, Hulsegge I, et al. *Study of potential health effects of electromagnetic fields of telephony and Wi-Fi, using chicken embryo development as animal model*. Bioelectromagnetics 2017; 38(3): 186-203.

[339] Sangun O, Dundar B, Darici H, Comlekci S, Doguc DK and Çelik S. *The effects of long-term exposure to a 2450 MHz electromagnetic field on growth and pubertal development in female Wistar rats*. Electromagn Biol Med 2015; 34(1): 63-71.

[340] Kuybulu AE, Oktem F, Ciris IM, Sutcu R, Ormeci AR, Comlekci S, et al. *Effects of long-term pre- and post-natal exposure to 2.45 GHz wireless devices on developing male rat kidney*. Ren Fail 2016; 38(4): 571-80.

[341] Magras IN and Xenos TD. *RF radiation-induced changes in the prenatal development of mice*. Bioelectromagnetics 1997; 18(6): 455-61.

[342] Nakamura H, Nagase H, Ogino K, Hatta K and Matsuzaki I. *Uteroplacental circulatory disturbance mediated by prostaglandin f2alpha in rats exposed to microwaves*. Reprod Toxicol 2000; 14(3): 235-40.

[343] Nakamura H, Matsuzaki I, Hatta K, Nobukuni Y, Kambayashi Y and Ogino K. *Nonthermal effects of mobile-phone frequency microwaves on uteroplacental functions in pregnant rats*. Reprod Toxicol 2003; 17(3): 321-6.

[344] Bas O, Odaci E, Mollaoglu H, Ucok K and Kaplan S. *Chronic prenatal exposure to the 900 megahertz electromagnetic field induces pyramidal cell loss in the hippocampus of newborn rats*. Toxicol Ind Health 2009; 25(6): 377-84.

[345] Gul A, Celebi H and Uğraş S. *The effects of microwave emitted by cellular phones on ovarian follicles in rats*. Arch Gynecol Obstet 2009; 280(5): 729-33.

[346] Rağbetli MÇ, Aydinlioğlu A, Koyun N, Rağbetli C and Karayel M. *Effect of prenatal exposure to mobile phone on pyramidal cell numbers in the mouse hippocampus: a stereological study*. Int J Neurosci 2009; 119(7): 1031-41.

[347] Aldad TS, Gan G, Gao XB and Taylor HS. *Fetal radiofrequency radiation exposure from 800-1900 MHz-rated cellular telephones affects neurodevelopment and behavior in mice*. Sci Rep 2012; 2: 312.

[348] Jing J, Yuhua Z, Xiao-qian Y, Rongping J, Dong-mei G and Xi C. *The influence of microwave radiation from cellular phone on fetal rat brain*. Electromagn Biol Med 2012; 31(1): 57-66.

[349] Haghani M, Shabani M and Moazzami K. *Maternal mobile phone exposure adversely affects the electrophysiological properties of Purkinje neurons in rat offspring*. Neuroscience 2013; 250: 588-98.

[350] Köktürk S, Yardimoglu M, Celikozlu SD, Dolanbay EG and Cimbiz A. *Effect of Lycopersicon esculentum extract on apoptosis in the rat cerebellum, following prenatal and postnatal exposure to an electromagnetic field*. Exp Ther Med 2013; 6(1): 52-6.

[351] Bedir R, Tumkaya L, Sehitoglu I, Kalkan Y, Yilmaz A and Sahin OZ. *The effect of exposure of rats during prenatal period to radiation spreading from mobile phones on renal development*. Ren Fail 2015; 37(2): 305-9.

[352] Odaci E, Unal D, Mercantepe T, Topal Z, Hanci H, Turedi S, et al. *Pathological effects of prenatal exposure to a 900 MHz electromagnetic field on the 21-day-old male rat kidney*. Biotech Histochem 2015; 90(2): 93-101.

[353] Türedi S, Hanci H, Topal Z, Unal D, Mercantepe T, Bozkurt I, et al. *T he effects of prenatal exposure to a 900-MHz electromagnetic field on* the 21-day-old male rat heart. Electromagn Biol Med 2015; 34(4): 390-7.

[354] Zhang Y, Li Z, Gao Y and Zhang C. *Effects of fetal microwave radiation* exposure on offspring behavior in mice. J Radiat Res 2015; 56(2): 261-8.

[355] Erkut A, Tumkaya L, Balik MS, Kalkan Y, Guvercin Y, Yilmaz A, et al. *The effect of prenatal exposure to 1800 MHz electromagnetic field on calcineurin and bone development in rats*. Acta Cir Bras 2016; 31(2): 74-83.

[356] Razavinasab M, Moazzami K and Shabani M. *Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal neurons in rat offspring*. Toxicol Ind Health 2016; 32(6): 968-79.

[357] Turedi S, Hanci H, Colakoglu S, Kaya H and Odaci E. *Disruption of the ovarian follicle reservoir of prepubertal rats following prenatal exposure to a continuous 900-MHz electromagnetic field*. Int J Radiat Biol 2016; 92(6): 329-37.

[358] Othman H, Ammari M, Rtibi K, Bensaid N, Sakly M and Abdelmelek H. *Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices*. Environ Toxicol Pharmacol 2017; 52: 239-47.

[359] Othman H, Ammari M, Sakly M and Abdelmelek H. *Effects of repeated restraint stress and WiFi signal exposure on behavior and oxidative stress in rats*. Metab Brain Dis 2017; 32(5): 1459-69.

[360] Yilmaz A, Tumkaya L, Akyildiz K, Kalkan Y, Bodur AF, Sargin F, et al. *Lasting hepatotoxic effects of prenatal mobile phone exposure*. J Matern Fetal Neonatal Med 2017; 30(11): 1355-9.

[361] Alimohammadi I, Ashtarinezhad A, Asl BM, Masruri B and Moghadasi N. *The effects of radiofrequency radiation on mice fetus weight, length and tissues*. Data Brief 2018; 19: 2189-94.

[362] Tumkaya L, Yilmaz A, Akyildiz K, Mercantepe T, Yazici ZA and Yilmaz H. *Prenatal effects of a 1,800-MHz electromagnetic field on rat livers*. Cells Tissues Organs 2019; 207(3-4): 187-96.

[363] Amandokht Saghezchi S, Azad N, Heidari R, Jajarmi V, Abdi S, Abaszadeh HA, et al. *The effect of prenatal exposure to 2.4 GHz radio frequency on the histology and expression of the osteocalcin and RUNX2 gene of the forelimb in an NMRI mouse*. J Lasers Med Sci 2019; 10(4): 283-9.

[364] Guxens M, Vermeulen R, Steenkamer I, Beekhuizen J, Vrijkotte TGM, Kromhout H, et al. *Radiofrequency electromagnetic fields, screen time, and emotional and behavioural problems in 5-year-old children*. Int J Hyg Environ Health 2019; 222(2): 188-94.

[365] Divan HA, Kheifets L, Obel C and Olsen J. *Prenatal and postnatal exposure to cell phone use and behavioral problems in children*. Epidemiology 2008; 19(4): 523-9.

[366] Divan HA, Kheifets L, Obel C and Olsen J. *Cell phone use and behavioural problems in young children*. J Epidemiol Community Health 2012; 66(6): 524-9.

[367] Byun YH, Ha M, Kwon HJ, Hong YC, Leem JH, Sakong J, et al. *Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study*. PLoS One 2013; 8(3): e59742.

[368] Sudan M, Olsen J, Arah OA, Obel C and Kheifets L. *Prospective cohort analysis of cellphone use and emotional and behavioural difficulties in children*. J Epidemiol Community Health 2016; 70(12): 1207-13.

[369] Roser K, Schoeni A and Röösli M. *Mobile phone use, behavioural problems and concentration capacity in adolescents: a prospective study.* International Journal of Hygiene and Environmental Health 2016; 219: 759–69.

[370] Zheng F, Gao P, He M, Li M, Wang C, Zeng Q, et al. *Association between mobile phone use and inattention in 7102 Chinese adolescents: a population-based cross-sectional study*. BMC Public Health 2014; 14: 1022.

[371] Thomas S, Heinrich S, von Kries R and Radon K. *Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents*. Eur J Epidemiol 2010; 25(2): 135-41.

[372] D'Andrea JA, Cobb BL and De Lorge JO. *Lack of behavioral effects in the rhesus monkey: high peak microwave pulses at 1.3 GHz*. Bioelectromagnetics 1989; 10(1): 65-76.

[373] Quock RM, Klauenberg BJ, Hurt WD and Merritt JH. *Influence of microwave exposure on chlordiazepoxide effects in the mouse staircase test*. Pharmacol Biochem Behav 1994; 47(4): 845-9.

[374] Dubreuil D, Jay T and Edeline JM. *Head-only exposure to GSM 900-MHz electromagnetic fields does not alter rat's memory in spatial and non-spatial tasks*. Behav Brain Res 2003; 145(1-2): 51-61.

[375] Mausset-Bonnefont AL, Hirbec H, Bonnefont X, Privat A, Vignon J and de Sèze R. *Acute exposure to GSM 900-MHz electromagnetic fields induces glial reactivity and biochemical modifications in the rat brain*. Neurobiol Dis 2004; 17(3): 445-54.

[376] Nittby H, Grafström G, Tian DP, Malmgren L, Brun A, Persson BR, et al. *Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation*. Bioelectromagnetics 2008; 29(3): 219-32.

[377] Bouji M, Lecomte A, Hode Y, de Sèze R and Villégier AS. *Effects of 900 MHz radiofrequency on corticosterone, emotional memory and neuroinflammation in middle-aged rats*. Exp Gerontol 2012; 47(6): 444-51.

[378] Klose M, Grote K, Spathmann O, Streckert J, Clemens M, Hansen VW, et al. *Effects of early-onset radiofrequency electromagnetic field exposure (GSM 900 MHz) on behavior and memory in rats*. Radiat Res 2014; 182(4): 435-47.

[379] Huss A, van Eijsden M, Guxens M, Beekhuizen J, van Strien R, Kromhout H, et al. *Environmental Radiofrequency Electromagnetic Fields Exposure at Home, Mobile and Cordless Phone Use, and Sleep Problems in 7-Year-Old Children*. PLoS One 2015; 10(10): e0139869.

[380] Son Y, Jeong YJ, Kwon JH, Choi HD, Pack JK, Kim N, et al. *1950 MHz radiofrequency electromagnetic fields do not aggravate memory deficits in 5xFAD mice*. Bioelectromagnetics 2016; 37(6): 391-9.

[381] Barthélémy A, Mouchard A, Bouji M, Blazy K, Puigsegur R and Villegier AS. *Glial markers and emotional memory in rats following acute cerebral radiofrequency exposures*. Environ Sci Pollut Res Int 2016; 23(24): 25343-55.

[382] Petitdant N, Lecomte A, Robidel F, Gamez C, Blazy K and Villegier AS. *Cerebral radiofrequency exposures during adolescence: Impact on astrocytes and brain functions in healthy and pathologic rat models*. Bioelectromagnetics 2016; 37(5): 338-50.

[383] Gupta SK, Mesharam MK and Krishnamurthy S. *Electromagnetic radiation 2450 MHz exposure causes cognition deficit with mitochondrial dysfunction and activation of intrinsic pathway of apoptosis in rats*. J Biosci 2018; 43(2): 263-76.

[384] Gupta SK, Patel SK, Tomar MS, Singh SK, Mesharam MK and Krishnamurthy S. *Long-term exposure of 2450 MHz electromagnetic radiation induces stress and anxiety like behavior in rats*. Neurochem Int 2019; 128: 1-13.

[385] Lebovitz RM. *Prolonged microwave irradiation of rats: effects on concurrent operant behavior*. Bioelectromagnetics 1981; 2(2): 169-85.

[386] Lebovitz RM. *Pulse modulated and continuous wave microwave radiation yield equivalent changes in operant behavior of rodents*. Physiol Behav 1983; 30(6): 891-8.

[387] Akyel Y, Hunt EL, Gambrill C and Vargas C, Jr. *Immediate post-exposure effects of high-peak-power microwave pulses on operant behavior of Wistar rats*. Bioelectromagnetics 1991; 12(3): 183-95.

[388] Daniels WM, Pitout IL, Afullo TJ and Mabandla MV. *The effect of electromagnetic radiation in the mobile phone range on the behaviour of the rat*. Metab Brain Dis 2009; 24(4): 629-41.

[389] Khirazova EE, Baizhumanov AA, Trofimova LK, Deev LI, Maslova MV, Sokolova NA, et al. *Effects of GSM-Frequency Electromagnetic*

Radiation on Some Physiological and Biochemical Parameters in Rats. Bull Exp Biol Med 2012; 153(6): 816-9.

[390] Schneider J and Stangassinger M. *Nonthermal effects of lifelong high-frequency electromagnetic field exposure on social memory performance in rats*. Behav Neurosci 2014; 128(5): 633-7.

[391] Zhang JP, Zhang KY, Guo L, Chen QL, Gao P, Wang T, et al. *Effects of 1.8 GHz radiofrequency fields on the emotional behavior and spatial memory of adolescent mice*. Int J Environ Res Public Health 2017; 14(11).

[392] Jeong YJ, Son Y, Han NK, Choi HD, Pack JK, Kim N, et al. *Impact of Long-Term RF-EMF on Oxidative Stress and Neuroinflammation in Aging Brains of C57BL/6 Mice*. Int J Mol Sci 2018; 19(7).

[393] Kumlin T, Iivonen H, Miettinen P, Juvonen A, van Groen T, Puranen L, et al. *Mobile phone radiation and the developing brain: behavioral and morphological effects in juvenile rats*. Radiat Res 2007; 168(4): 471-9.

[394] Kim JH, Yu DH, Huh YH, Lee EH, Kim HG and Kim HR. *Long-term exposure to 835 MHz RF-EMF induces hyperactivity, autophagy and demyelination in the cortical neurons of mice*. Sci Rep 2017; 7: 41129.

[395] Wang K, Lu JM, Xing ZH, Zhao QR, Hu LQ, Xue L, et al. *Effect of 1.8 GHz radiofrequency electromagnetic radiation on novel object associative recognition memory in mice*. Sci Rep 2017; 7: 44521.

[396] Son Y, Kim JS, Jeong YJ, Jeong YK, Kwon JH, Choi HD, et al. *Long-term RF exposure on behavior and cerebral glucose metabolism in 5xFAD mice*. Neurosci Lett 2018; 666: 64-9.

[397] Broom KA, Findlay R, Addison DS, Goiceanu C and Sienkiewicz Z. *Early-life exposure to pulsed LTE radiofrequency fields causes persistent changes in activity and behavior in C57BL/6 J mice*. Bioelectromagnetics 2019; 40(7): 498-511.

[398] Quock RM, Kouchich FJ, Ishii TK and Lange DG. *Microwave facilitation of domperidone antagonism of apomorphine-induced stereotypic climbing in mice*. Bioelectromagnetics 1987; 8(1): 45-55.

[399] Mitchell CL, McRee DI, Peterson NJ, Tilson HA, Shandala MG, Rudnev MI, et al. *Results of a United States and Soviet Union joint project on nervous system effects of microwave radiation*. Environ Health Perspect 1989; 81: 201-9.

[400] Kemerov S, Marinkev M and Getova D. *Effects of low-intensity electromagnetic fields on behavioral activity of rats*. Folia Med (Plovdiv) 1999; 41(3): 75-80.

[401] Cosquer B, Galani R, Kuster N and Cassel JC. *Whole-body exposure to 2.45 GHz electromagnetic fields does not alter anxiety responses in rats: a plus-maze study including test validation*. Behav Brain Res 2005; 156(1): 65-74.

[402] Crouzier D, Testylier G, Perrin A and Debouzy JC. *[Which neurophysiologic effects at low level 2.45 GHz RF exposure?] Quels effets neurophysiologiques pour un champ electromagnetique de faible puissance a 2,45 GHz?* Pathol Biol (Paris) 2007; 55(5): 235-41.

[403] Thomas JR, Schrot J and Banvard RA. *Comparative effects of pulsed and continuous-wave 2.8-GHz microwaves on temporally defined behavior*. Bioelectromagnetics 1982; 3(2): 227-35.

[404] Lai H, Horita A, Chou CK and Guy AW. *Psychoactive-drug response is affected by acute low-level microwave irradiation*. Bioelectromagnetics 1983; 4(3): 205-14.

[405] D'Andrea JA, DeWitt JR, Portuguez LM and Gandhi OP. *Reduced exposure to microwave radiation by rats: frequency specific effects*. Prog Clin Biol Res 1988; 257: 289-308.

[406] Chou CK, Guy AW, Kunz LL, Johnson RB, Crowley JJ and Krupp JH. *Long-term, low-level microwave irradiation of rats*. Bioelectromagnetics 1992; 13(6): 469-96.

[407] Raslear TG, Akyel Y, Bates F, Belt M and Lu ST. *Temporal bisection in rats: the effects of high-peak-power pulsed microwave irradiation*. Bioelectromagnetics 1993; 14(5): 459-78.

[408] Shtemberg AS, Uzbekov MG, Shikhov SN, Bazyan AS and Chernyakov GM. *Some neurotropic effects of low-intensity electromagnetic waves in rats with different typological characteristics of higher nervous activity*. Neurosci Behav Physiol 2001; 31(5): 547-53.

[409] Chaturvedi CM, Singh VP, Singh P, Basu P, Shukla RK, Dhawan A, et al. *2.45 GHz (CW) microwave irradiation alters circadian organization, spatial memory, DNA structure in the brain cells and blood cell counts of male mice, Mus musculus*. Prog Electromagn Res B 2011; 29: 23-42.

[410] Kumar M, Singh SP and Chaturvedi CM. *Chronic nonmodulated microwave radiations in mice produce anxiety-like and depression-like behaviours and calcium- and NO-related biochemical changes in the brain*. Exp Neurobiol 2016; 25(6): 318-27.

[411] Obajuluwa AO, Akinyemi AJ, Afolabi OB, Adekoya K, Sanya JO and Ishola AO. *Exposure to radio-frequency electromagnetic waves alters acetylcholinesterase gene expression, exploratory and motor coordination-linked behaviour in male rats*. Toxicol Rep 2017; 4: 530-4.

[412] Sinha RK, Aggarwal Y, Upadhyay PK, Dwivedi A, Keshri AK and Das BN. *Neural network-based evaluation of chronic non-thermal effects of modulated 2450 MHz microwave radiation on electroencephalogram*. Ann Biomed Eng 2008; 36(5): 839-51.

[413] Sinha RK. *Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats*. Int J Radiat Biol 2008; 84(6): 505-13.

[414] Calvente I, Perez-Lobato R, Nunez MI, Ramos R, Guxens M, Villalba J, et al. *Does exposure to environmental radiofrequency electromagnetic fields cause cognitive and behavioral effects in 10-year-old boys?* Bioelectromagnetics 2016; 37(1): 25-36.

[415] Galloway WD. *Microwave dose-response relationships on two behavioral tasks*. Ann N Y Acad Sci 1975; 247: 410-6.

[416] Mattsson JL and Oliva SA. *Effect of electromagnetic pulse on avoidance behavior and electroencephalogram of a rhesus monkey*. Aviat Space Environ Med 1976; 47(6): 644-8.

[417] Thomas JR, Schrot J and Banvard RA. *Behavioral effects of chlorpromazine and diazepam combined with low-level microwaves*. Neurobehav Toxicol 1980; 2(2): 131-5.

[418] Carratalá F and Moya M. *Febrile convulsions induced by microwaves and the alteration in behavior of albino mouse OF1*. Biol Neonate 1991; 60(1): 62-8.

[419] Jensh RP. *Behavioral teratologic studies using microwave radiation: is there an increased risk from exposure to cellular phones and microwave ovens?* Reprod Toxicol 1997; 11(4): 601-11.

[420] Crouzier D, Debouzy JC, Bourbon F, Collin A, Perrin A and Testylier G. *Neurophysiologic effects at low level 1.8 GHz radiofrequency field exposure: a multiparametric approach on freely moving rats*. Pathol Biol (Paris) 2007; 55(3-4): 134-42.

[421] Narayanan SN, Kumar RS, Potu BK, Nayak S and Mailankot M. *Spatial memory performance of Wistar rats exposed to mobile phone*. Clinics (Sao Paulo) 2009; 64(3): 231-4.

[422] Narayanan SN, Kumar RS, Potu BK, Nayak S, Bhat PG and Mailankot M. *Effect of radio-frequency electromagnetic radiations (RF-EMR) on passive avoidance behaviour and hippocampal morphology in Wistar rats*. Ups J Med Sci 2010; 115(2): 91-6.

[423] Carballo-Quintás M, Martínez-Silva I, Cadarso-Suárez C, Álvarez-Figueiras M, Ares-Pena FJ and López-Martín E. *A study of neurotoxic biomarkers, c-fos and GFAP after acute exposure to GSM radiation at 900 MHz in the picrotoxin model of rat brains*. Neurotoxicology 2011; 32(4): 478-94.

[424] Ntzouni MP, Stamatakis A, Stylianopoulou F and Margaritis LH. *Short-term memory in mice is affected by mobile phone radiation*. Pathophysiology 2011; 18(3): 193-9.

[425] El Kholy SE and El Husseiny EM. *Effect of 60 minutes exposure to electromagnetic field on fecundity, learning and memory, speed of movement and whole body protein of the fruit fly Drosophila melanogaster*. J Egypt Soc Parasitol 2012; 42(3): 639-48.

[426] Sokolovic D, Djordjevic B, Kocic G, Babovic P, Ristic G, Stanojkovic Z, et al. *The effect of melatonin on body mass and behaviour of rats during an exposure to microwave radiation from mobile phone*. Bratisl Lek Listy 2012; 113(5): 265-9.

[427] Ntzouni MP, Skouroliakou A, Kostomitsopoulos N and Margaritis LH. *Transient and cumulative memory impairments induced by GSM 1.8 GHz cell phone signal in a mouse model*. Electromagn Biol Med 2013; 32(1): 95-120.

[428] de Caires Júnior LC, Guimarães Eda S, Musso CM, Stabler CT, González Garcia RM, Mourão-Júnior CA, et al. *Behavior and memory evaluation of Wistar rats exposed to 1.8 GHz radiofrequency electromagnetic radiation*. Neurol Res 2014; 36(9): 800-3.

[429] Saikhedkar N, Bhatnagar M, Jain A, Sukhwal P, Sharma C and Jaiswal N. *Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain*. Neurol Res 2014; 36(12): 1072-9.

[430] Chiu CT, Chang YH, Chen CC, Ko MC and Li CY. *Mobile phone use and health symptoms in children*. J Formos Med Assoc 2015; 114(7): 598-604.

[431] Shehu A, Mohammed A, Magaji RA and Muhammad MS. *Exposure to mobile phone electromagnetic field radiation, ringtone and vibration affects anxiety-like behaviour and oxidative stress biomarkers in albino wistar rats*. Metab Brain Dis 2016; 31(2): 355-62.

[432] Hassanshahi A, Shafeie SA, Fatemi I, Hassanshahi E, Allahtavakoli M, Shabani M, et al. *The effect of Wi-Fi electromagnetic waves in unimodal and multimodal object recognition tasks in male rats*. Neurol Sci 2017; 38(6): 1069-76.

[433] Thomas S, Benke G, Dimitriadis C, Inyang I, Sim MR, Wolfe R, et al. *Use of mobile phones and changes in cognitive function in adolescents*. Occup Environ Med 2010; 67(12): 861-6.

[434] Foerster M, Thielens A, Joseph W, Eeftens M and Roosli M. *A prospective cohort study of adolescents' memory performance and individual brain dose of microwave radiation from wireless communication*. Environ Health Perspect 2018; 126(7): 077007.

[435] Ng TP, Lim ML, Niti M and Collinson S. *Long-term digital mobile phone use and cognitive decline in the elderly*. Bioelectromagnetics 2012; 33: 176-85.

[436] Brzozek C, Benke KK, Zeleke BM, Croft RJ, Dalecki A, Dimitriadis C, et al. *Uncertainty analysis of mobile phone use and its effect on cognitive function: the application of Monte Carlo simulation in a cohort of australian primary school children*. Int J Environ Res Public Health 2019; 16(13).

[437] Redmayne M, Smith CL, Benke G, Croft RJ, Dalecki A, Dimitriadis C, et al. *Use of mobile and cordless phones and cognition in Australian primary school children: a prospective cohort study*. Environ Health 2016; 15: 26.

[438] Abramson MJ, Benke GP, Dimitriadis C, Inyang IO, Sim MR, Wolfe RS, et al. *Mobile telephone use is associated with changes in cognitive function in young adolescents*. Bioelectromagnetics 2009; 30(8): 678-86.

[439] Lee TM, Ho SM, Tsang LY, Yang SH, Li LS, Chan CC, et al. *Effect on human attention of exposure to the electromagnetic field emitted by mobile phones*. Neuroreport 2001; 12(4): 729-31.

[440] Guxens M, Vermeulen R, van Eijsden M, Beekhuizen J, Vrijkotte TG, van Strien RT, et al. *Outdoor and indoor sources of residential radiofrequency electromagnetic fields, personal cell phone and cordless phone use, and cognitive function in 5-6 years old children*. Environ Res 2016; 150: 364-74.

[441] Freude G, Ullsperger P, Eggert S and Ruppe I. *Effects of microwaves emitted by cellular phones on human slow brain potentials*. Bioelectromagnetics 1998; 19(6): 384-7.

[442] Freude G, Ullsperger P, Eggert S and Ruppe I. *Microwaves emitted by cellular telephones affect human slow brain potentials*. Eur J Appl Physiol 2000; 81(1-2): 18-27.

[443] Krause CM, Sillanmaki L, Koivisto M, Haggqvist A, Saarela C, Revonsuo A, et al. *Effects of electromagnetic fields emitted by cellular phones on the electroencephalogram during a visual working memory task*. Int J Radiat Biol 2000; 76(12): 1659-67.

[444] Krause CM, Sillanmaki L, Koivisto M, Haggqvist A, Saarela C, Revonsuo A, et al. *Effects of electromagnetic field emitted by cellular phones on the EEG during a memory task*. Neuroreport 2000; 11(4): 761-4.

[445] Krause CM, Pesonen M, Haarala Björnberg C and Hämäläinen H. *Effects of pulsed and continuous wave 902 MHz mobile phone exposure on brain oscillatory activity during cognitive processing*. Bioelectromagnetics 2007; 28(4): 296-308.

[446] Haarala C, Björnberg L, Ek M, Laine M, Revonsuo A, Koivisto M, et al. *Effect of a 902 MHz electromagnetic field emitted by mobile phones on human cognitive function: A replication study*. Bioelectromagnetics 2003; 24(4): 283-8.

[447] Haarala C, Ek M, Björnberg L, Laine M, Revonsuo A, Koivisto M, et al. *902 MHz mobile phone does not affect short term memory in humans*. Bioelectromagnetics 2004; 25(6): 452-6.

[448] Haarala C, Aalto S, Hautzel H, Julkunen L, Rinne JO, Laine M, et al. *Effects of a 902 MHz mobile phone on cerebral blood flow in humans: a PET study*. Neuroreport 2003; 14(16): 2019-23.

[449] Aalto S, Haarala C, Bruck A, Sipila H, Hämäläinen H and Rinne JO. *Mobile phone affects cerebral blood flow in humans*. J Cereb Blood Flow Metab 2006; 26(7): 885-90.

[450] Kwon MS, Vorobyev V, Kannala S, Laine M, Rinne JO, Toivonen T, et al. *GSM mobile phone radiation suppresses brain glucose metabolism*. J Cereb Blood Flow Metab 2011; 31(12): 2293-301.

[451] Kwon MS, Vorobyev V, Kannala S, Laine M, Rinne JO, Toivonen T, et al. *No effects of short-term GSM mobile phone radiation on cerebral blood flow measured using positron emission tomography*. Bioelectromagnetics 2012; 33(3): 247-56.

[452] Hamblin DL, Croft RJ, Wood AW, Stough C and Spong J. *The sensitivity of human event-related potentials and reaction time to mobile phone emitted electromagnetic fields*. Bioelectromagnetics 2006; 27(4): 265-73.

[453] Besset A, Espa F, Dauvilliers Y, Billiard M and de Seze R. *No effect on cognitive function from daily mobile phone use*. Bioelectromagnetics 2005; 26(2): 102-8.

[454] Curcio G, Valentini E, Moroni F, Ferrara M, De Gennaro L and Bertini M. *Psychomotor performance is not influenced by brief repeated exposures to mobile phones*. Bioelectromagnetics 2008; 29(3): 237-41.

[455] Terao Y, Okano T, Furubayashi T and Ugawa Y. *Effects of thirty-minute mobile phone use on visuo-motor reaction time*. Clinical Neurophysiology 2006; 117(11): 2504-11.

[456] Terao Y, Okano T, Furubayashi T, Yugeta A, Inomata-Terada S and Ugawa Y. *Effects of thirty-minute mobile phone exposure on saccades*. Clin Neurophysiol 2007; 118(7): 1545-56.

[457] Russo R, Fox E, Cinel C, Boldini A, Defeyter MA, Mirshekar-Syahkal D, et al. *Does acute exposure to mobile phones affect human attention?* Bioelectromagnetics 2006; 27(3): 215-20.

[458] Cinel C, Boldini A, Russo R and Fox E. *Effects of mobile phone electromagnetic fields on an auditory order threshold task*. Bioelectromagnetics 2007; 28(6): 493-6.

[459] Haarala C, Takio F, Rintee T, Laine M, Koivisto M, Revonsuo A, et al. *Pulsed and continuous wave mobile phone exposure over left versus right hemisphere: effects on human cognitive function*. Bioelectromagnetics 2007; 28(4): 289-95.

[460] Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A and Berz R. *Effects of weak mobile phone - electromagnetic fields (GSM, UMTS) on event related potentials and cognitive functions*. Bioelectromagnetics 2008; 29(6): 488-97.

[461] Sauter C, Dorn H, Bahr A, Hansen ML, Peter A, Bajbouj M, et al. *Effects of exposure to electromagnetic fields emitted by GSM 900 and WCDMA mobile phones on cognitive function in young male subjects*. Bioelectromagnetics 2011; 32(3): 179-90.

[462] Curcio G, Nardo D, Perrucci MG, Pasqualetti P, Chen TL, Del Gratta C, et al. *Effects of mobile phone signals over BOLD response while performing a cognitive task*. Clin Neurophysiol 2012; 123(1): 129-36.

[463] Krause CM, Haarala C, Sillanmaki L, Koivisto M, Alanko K, Revonsuo A, et al. *Effects of electromagnetic field emitted by cellular phones on the EEG during an auditory memory task: a double blind replication study*. Bioelectromagnetics 2004; 25(1): 33-40.

[464] Hamblin DL, Wood AW, Croft RJ and Stough C. *Examining the effects of electromagnetic fields emitted by GSM mobile phones on human event-related potentials and performance during an auditory task*. Clin Neurophysiol 2004; 115(1): 171-8.

[465] Keetley V, Wood AW, Spong J and Stough C. *Neuropsychological sequelae of digital mobile phone exposure in humans*. Neuropsychologia 2006; 44(10): 1843-8.

[466] Preece AW, Iwi G, Davies-Smith A, Wesnes K, Butler S, Lim E, et al. *Effect of a 915-MHz simulated mobile phone signal on cognitive function in man*. Int J Radiat Biol 1999; 75(4): 447-56.

[467] Koivisto M, Revonsuo A, Krause C, Haarala C, Sillanmaki L, Laine M, et al. *Effects of 902 MHz electromagnetic field emitted by cellular telephones on response times in humans*. Neuroreport 2000; 11(2): 413-5.

[468] Koivisto M, Krause CM, Revonsuo A, Laine M and Hämäläinen H. *The effects of electromagnetic field emitted by GSM phones on working memory*. Neuroreport 2000; 11(8): 1641-3.

[469] Curcio G, Ferrara M, De Gennaro L, Cristiani R, D'Inzeo G and Bertini M. *Time-course of electromagnetic field effects on human performance and tympanic temperature*. Neuroreport 2004; 15(1): 161-4.

[470] Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt HP, et al. *Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance*. J Sleep Res 2007; 16(3): 253-8.

[471] Preece AW, Goodfellow S, Wright MG, Butler SR, Dunn EJ, Johnson Y, et al. *Effect of 902 MHz mobile phone transmission on cognitive function in children*. Bioelectromagnetics 2005; Suppl 7: S138-43.

[472] Haarala C, Bergman M, Laine M, Revonsuo A, Koivisto M and Hämäläinen H. *Electromagnetic field emitted by 902 MHz mobile phones shows no effects on children's cognitive function*. Bioelectromagnetics 2005; Suppl 7: S144-50.

[473] Loughran SP, Benz DC, Schmid MR, Murbach M, Kuster N and Achermann P. *No increased sensitivity in brain activity of adolescents exposed to mobile phone-like emissions*. Clin Neurophysiol 2013; 124(7): 1303-8.

[474] Leung S, Croft RJ, McKenzie RJ, Iskra S, Silber B, Cooper NR, et al. *Effects of 2G and 3G mobile phones on performance and electrophysiology in adolescents, young adults and older adults*. Clin Neurophysiol 2011; 122(11): 2203-16.

[475] Jech R, Sonka K, Ruzicka E, Nebuzelsky A, Bohm J, Juklickova M, et al. *Electromagnetic field of mobile phones affects visual event related potential in patients with narcolepsy*. Bioelectromagnetics 2001; 22(7): 519-28.

[476] Wiholm C, Lowden A, Kuster N, Hillert L, Arnetz BB, Åkerstedt T, et al. *Mobile phone exposure and spatial memory*. Bioelectromagnetics 2009; 30(1): 59-65.

[477] Maier R, Greter SE, Schaller G and Hommel G. *[The effects of pulsed low-level EM fields on memory processes]*. Z Med Phys 2004; 14(2): 105-12.

[478] Sienkiewicz ZJ, Blackwell RP, Haylock RG, Saunders RD and Cobb BL. *Low-level exposure to pulsed 900 MHz microwave radiation does not cause deficits in the performance of a spatial learning task in mice*. Bioelectromagnetics 2000; 21(3): 151-8.

[479] Dubreuil D, Jay T and Edeline JM. *Does head-only exposure to GSM-900 electromagnetic fields affect the performance of rats in spatial learning tasks?* Behav Brain Res 2002; 129(1-2): 203-10.

[480] Yamaguchi H, Tsurita G, Ueno S, Watanabe S, Wake K, Taki M, et al. *1439 MHz pulsed TDMA fields affect performance of rats in a T-maze task only when body temperature is elevated*. Bioelectromagnetics 2003; 24(4): 223-30.

[481] Ammari M, Jacquet A, Lecomte A, Sakly M, Abdelmelek H and de Seze R. *Effect of head-only sub-chronic and chronic exposure to 900-MHz GSM electromagnetic fields on spatial memory in rats*. Brain Inj 2008; 22(13-14): 1021-9.

[482] Mori T and Arendash GW. *Long-term electromagnetic field treatment increases brain neuronal activity: linkage to cognitive benefit and*

therapeutic implications for Alzheimer's disease. J Alzheimers Dis 2011; 1(2): 102-5.

[483] Arendash GW, Mori T, Dorsey M, Gonzalez R, Tajiri N and Borlongan C. *Electromagnetic treatment to old Alzheimer's mice reverses beta-amyloid deposition, modifies cerebral blood flow, and provides selected cognitive benefit*. PLoS One 2012; 7(4): e35751.

[484] Bouji M, Lecomte A, Gamez C, Blazy K and Villegier AS. *Neurobiological effects of repeated radiofrequency exposures in male senescent rats*. Biogerontology 2016; 17(5-6): 841-57.

[485] Keles AI, Yildirim M, Gedikli O, Colakoglu S, Kaya H, Bas O, et al. *The effects of a continuous 1-h a day 900-MHz electromagnetic field applied throughout early and mid-adolescence on hippocampus morphology and learning behavior in late adolescent male rats*. J Chem Neuroanat 2018; 94: 46-53.

[486] Bouji M, Lecomte A, Gamez C, Blazy K and Villegier AS. *Impact of cerebral radiofrequency exposures on oxidative stress and corticosterone in a rat model of Alzheimer's disease*. J Alzheimers Dis 2020; 73(2): 467-76.

[487] Deshmukh PS, Banerjee BD, Abegaonkar MP, Megha K, Ahmed RS, Tripathi AK, et al. *Effect of low level microwave radiation exposure on cognitive function and oxidative stress in rats*. Indian J Biochem Biophys 2013; 50(2): 114-9.

[488] Jeong YJ, Kang GY, Kwon JH, Choi HD, Pack JK, Kim N, et al. *1950 MHz electromagnetic fields ameliorate Ab pathology in Alzheimer's disease mice*. Curr Alzheimer Res 2015; 12(5): 481-92.

[489] Deshmukh PS, Nasare N, Megha K, Banerjee BD, Ahmed RS, Singh D, et al. *Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation*. Int J Toxicol 2015; 34(3): 284-90.

[490] Tang J, Zhang Y, Yang L, Chen Q, Tan L, Zuo S, et al. *Exposure to 900 MHz electromagnetic fields activates the mkp-1/ERK pathway and causes blood-brain barrier damage and cognitive impairment in rats*. Brain Res 2015; 1601: 92-101.

[491] Deshmukh PS, Megha K, Nasare N, Banerjee BD, Ahmed RS, Abegaonkar MP, et al. *Effect of low level subchronic microwave radiation on rat brain*. Biomed Environ Sci 2016; 29(12): 858-67.

[492] Kim JH, Kim HJ, Yu DH, Kweon HS, Huh YH and Kim HR. *Changes in numbers and size of synaptic vesicles of cortical neurons induced by exposure to 835 MHz radiofrequency-electromagnetic field*. PLoS One 2017; 12(10): e0186416.

[493] Tan S, Wang H, Xu X, Zhao L, Zhang J, Dong J, et al. *Study on dose-dependent, frequency-dependent, and accumulative effects of 1.5 GHz and 2.856 GHz microwave on cognitive functions in Wistar rats*. Sci Rep 2017; 7(1): 10781.

[494] Ahmadi S, Alavi SS, Jadidi M and Ardjmand A. *Exposure to GSM 900-MHz mobile radiation impaired inhibitory avoidance memory*

consolidation in rat: Involvements of opioidergic and nitrergic systems. Brain Res 2018; 1701: 36-45.

[495] Sharma A, Sharma S, Shrivastava S, Singhal PK and Shukla S. *Mobile phone induced cognitive and neurochemical consequences*. J Chem Neuroanat 2019; 102: 101684.

[496] Hosseini MA, Hosseini A, Jarideh S, Argasi H, Shekoohi-Shooli F, Zamani A, et al. *Evaluating short-term exposure to Wi-Fi signals on students' reaction time, short-term memory and reasoning ability*. Radiat Prot Dosimetry 2019.

[497] Bamdad K, Adel Z and Esmaeili M. *Complications of nonionizing radiofrequency on divided attention*. J Cell Biochem 2019; 120(6): 10572-5.

[498] Cobb BL, Jauchem JR and Adair ER. *Radial arm maze performance of rats following repeated low level microwave radiation exposure*. Bioelectromagnetics 2004; 25(1): 49-57.

[499] Cassel JC, Cosquer B, Galani R and Kuster N. *Whole-body exposure to 2.45 GHz electromagnetic fields does not alter radial-maze performance in rats*. Behav Brain Res 2004; 155(1): 37-43.

[500] Cosquer B, Vasconcelos AP, Fröhlich J and Cassel JC. *Blood-brain barrier and electromagnetic fields: effects of scopolamine methylbromide on working memory after whole-body exposure to 2.45 GHz microwaves in rats*. Behav Brain Res 2005; 161(2): 229-37.

[501] Cosquer B, Kuster N and Cassel JC. *Whole-body exposure to 2.45 GHz electromagnetic fields does not alter 12-arm radial-maze with reduced access to spatial cues in rats*. Behav Brain Res 2005; 161(2): 331-4.

[502] Lai H, Horita A and Guy AW. *Microwave irradiation affects radial-arm maze performance in the rat*. Bioelectromagnetics 1994; 15(2): 95-104.

[503] Wang B and Lai H. *Acute exposure to pulsed 2450-MHz microwaves affects water-maze performance of rats*. Bioelectromagnetics 2000; 21(1): 52-6.

[504] Lai H. *Interaction of microwaves and a temporally incoherent magnetic field on spatial learning in the rat*. Physiol Behav 2004; 82(5): 785-9.

[505] Li M, Wang Y, Zhang Y, Zhou Z and Yu Z. *Elevation of plasma corticosterone levels and hippocampal glucocorticoid receptor translocation in rats: a potential mechanism for cognition impairment following chronic low-power-density microwave exposure*. J Radiat Res 2008; 49(2): 163-70.

[506] Lu Y, Xu S, He M, Chen C, Zhang L, Liu C, et al. *Glucose administration attenuates spatial memory deficits induced by chronic low-power-density microwave exposure*. Physiol Behav 2012; 106(5): 631-7.

[507] Wang H, Peng R, Zhou H, Wang S, Gao Y, Wang L, et al. *Impairment of long-term potentiation induction is essential for the disruption of spatial memory after microwave exposure*. Int J Radiat Biol 2013; 89(12): 1100-7.

[508] Qiao S, Peng R, Yan H, Gao Y, Wang C, Wang S, et al. *Reduction of phosphorylated synapsin I (ser-553) leads to spatial memory*

impairment by attenuating GABA release after microwave exposure in Wistar rats. PLoS One 2014; 9(4): e95503.

[509] Wang H, Peng R, Zhao L, Wang S, Gao Y, Wang L, et al. *The relationship between NMDA receptors and microwave-induced learning and memory impairment: a long-term observation on Wistar rats*. Int J Radiat Biol 2015; 91(3): 262-9.

[510] Li HJ, Peng RY, Wang CZ, Qiao SM, Yong Z, Gao YB, et al. *Alterations of cognitive function and 5-HT system in rats after long term microwave exposure*. Physiol Behav 2015; 140: 236-46.

[511] Shahin S, Banerjee S, Singh SP and Chaturvedi CM. *2.45 GHz microwave radiation impairs learning and spatial memory via oxidative/nitrosative stress induced p53-dependent/independent hippocampal apoptosis: molecular basis and underlying mechanism*. Toxicol Sci 2015; 148(2): 380-99.

[512] Wang H, Tan S, Xu X, Zhao L, Zhang J, Yao B, et al. *Long term impairment of cognitive functions and alterations of NMDAR subunits after continuous microwave exposure*. Physiol Behav 2017; 181: 1-9.

[513] Shahin S, Banerjee S, Swarup V, Singh SP and Chaturvedi CM. *From the cover: 2.45-GHz microwave radiation impairs hippocampal learning and spatial memory: involvement of local stress mechanism-induced suppression of iGluR/ERK/CREB signaling*. Toxicol Sci 2018; 161(2): 349-74.

[514] Karimi N, Bayat M, Haghani M, Saadi HF and Ghazipour GR. *2.45 GHz microwave radiation impairs learning, memory, and hippocampal* synaptic plasticity in the rat. Toxicol Ind Health 2018: 748233718798976.

[515] Arns M, Van Luijtelaar G, Sumich A, Hamilton R and Gordon E. *Electroencephalographic, personality, and executive function measures associated with frequent mobile phone use*. Int J Neurosci 2007; 117(9): 1341-60.

[516] Mortazavi SMJ, Taeb S and Dehghan N. *Alterations of visual reaction time and short term memory in military radar personnel*. Iran J Public Health 2013; 42(4): 428-35.

[517] Jarideh S, Taeb S, Pishva SM, Haghani M, Sina S, Mortazavi SA, et al. *Does occupational exposure of Shahid Dastghieb International Airport workers to radiofrequency radiation affect their short term memory and reaction time?* J Biomed Phys Eng 2015; 5(3): 143-50.

[518] Mohan M, Khaliq F, Panwar A and Vaney N. *Does chronic exposure to mobile phones affect cognition?* Funct Neurol 2016; 31(1): 47-51.

[519] Meo SA, Almahmoud M, Alsultan Q, Alotaibi N, Alnajashi I and Hajjar WM. *Mobile phone base station tower settings adjacent to school buildings: impact on students' cognitive health*. Am J Mens Health 2019; 13(1): 1557988318816914.

[520] Eibert TF, Hansen V, Kammerer H, Vaupel T, Spittler JF, Calabrese P, et al. *Investigation of cerebro-biological effects in low-frequency pulsed RF fields*. Frequenz 1997; 51(11-12): 276-9.

[521] Hladky A, Musil J, Roth Z, Urban P and Blazkova V. *Acute effects of using a mobile phone on CNS functions*. Cent Eur J Public Health 1999; 7(4): 165-7.

[522] Croft RJ, Chandler JS, Burgess AP, Barry RJ, Williams JD and Clarke AR. *Acute mobile phone operation affects neural function in humans*. Clin Neurophysiol 2002; 113(10): 1623-32.

[523] Edelstyn N and Oldershaw A. *The acute effects of exposure to the electromagnetic field emitted by mobile phones on human attention*. Neuroreport 2002; 13(1): 119-21.

[524] Lee TM, Lam PK, Yee LT and Chan CC. *The effect of the duration of exposure to the electromagnetic field emitted by mobile phones on human attention*. Neuroreport 2003; 14(10): 1361-4.

[525] Smythe JW and Costall B. *Mobile phone use facilitates memory in male, but not female, subjects*. Neuroreport 2003; 14(2): 243-6.

[526] Maier R, Greter SE and Maier N. *Effects of pulsed electromagnetic fields on cognitive processes - a pilot study on pulsed field interference with cognitive regeneration*. Acta Neurol Scand 2004; 110(1): 46-52.

[527] Papageorgiou CC, Nanou ED, Tsiafakis VG, Capsalis CN and Rabavilas AD. *Gender related differences on the EEG during a simulated mobile phone signal*. Neuroreport 2004; 15(16): 2557-60.

[528] Papageorgiou CC, Nanou ED, Tsiafakis VG, Kapareliotis E, Kontoangelos KA, Capsalis CN, et al. *Acute mobile phone effects on pre-attentive operation*. Neurosci Lett 2006; 397(1-2): 99-103.

[529] Hareuveny R, Eliyahu I, Luria R, Meiran N and Margaliot M. *Cognitive effects of cellular phones: a possible role of non-radiofrequency radiation factors*. Bioelectromagnetics 2011; 32(7): 585-8.

[530] Mortazavi SM, Rouintan MS, Taeb S, Dehghan N, Ghaffarpanah AA, Sadeghi Z, et al. *Human short-term exposure to electromagnetic fields emitted by mobile phones decreases computer-assisted visual reaction time*. Acta Neurol Belg 2012; 112(2): 171-5.

[531] Vecchio F, Buffo P, Sergio S, Iacoviello D, Rossini PM and Babiloni C. *Mobile phone emission modulates event-related desynchronization of alpha rhythms and cognitive-motor performance in healthy humans*. Clin Neurophysiol 2012; 123(1): 121-8.

[532] Movvahedi MM, Tavakkoli-Golpayegani A, Mortazavi SA, Haghani M, Razi Z, Shojaie-Fard MB, et al. *Does exposure to GSM 900 MHz mobile phone radiation affect short-term memory of elementary school students?* J Pediatr Neurosci 2014; 9(2): 121-4.

[533] Kalafatakis F, Bekiaridis-Moschou D, Gkioka E and Tsolaki M. *Mobile phone use for 5 minutes can cause significant memory impairment in humans*. Hell J Nucl Med 2017; 20 Suppl: 146-54.

[534] Altuntas G, Sadoglu D, Ardic S, Yilmaz H, Imamoglu M and Turedi S. *Acute effects of the electromagnetic waves emitted by mobile phones on attention in emergency physicians*. Am J Emerg Med 2018; 36(3): 455-60.

[535] Kumar RS, Sareesh NN, Nayak S and Mailankot M. *Hypoactivity of Wistar rats exposed to mobile phone on elevated plus maze*. Indian J Physiol Pharmacol 2009; 53(3): 283-6.

[536] Fragopoulou AF, Miltiadous P, Stamatakis A, Stylianopoulou F, Koussoulakos SL and Margaritis LH. *Whole body exposure with GSM 900MHz affects spatial memory in mice*. Pathophysiology 2010; 17(3): 179-87.

[537] Zhao L, Peng RY, Wang SM, Wang LF, Gao YB, Dong J, et al. *Relationship between cognition function and hippocampus structure after long-term microwave exposure*. Biomed Environ Sci 2012; 25(2): 182-8.

[538] Hao D, Yang L, Chen S, Tian Y and Wu S. *916 MHz electromagnetic field exposure affects rat behavior and hippocampal neuronal discharge*. Neural Regen Res 2012; 7(19): 1488-92.

[539] Hao D, Yang L, Chen S, Tong J, Tian Y, Su B, et al. *Effects of long-term electromagnetic field exposure on spatial learning and memory in rats*. Neurol Sci 2013; 34(2): 157-64.

[540] Ikinci A, Odaci E, Yildirim M, Kaya H, Akca M, Hanci H, et al. *The effects of prenatal exposure to a 900 megahertz electromagnetic field on hippocampus morphology and learning behavior in rat pups*. Neuroquantology 2013; 11(4): 582-90.

[541] Maaroufi K, Had-Aissouni L, Melon C, Sakly M, Abdelmelek H, Poucet B, et al. *Spatial learning, monoamines and oxidative stress in rats exposed to 900 MHz electromagnetic field in combination with iron overload*. Behav Brain Res 2014; 258: 80-9.

[542] Narayanan SN, Kumar RS, Karun KM, Nayak SB and Bhat PG. *Possible cause for altered spatial cognition of prepubescent rats exposed to chronic radiofrequency electromagnetic radiation*. Metab Brain Dis 2015; 30(5): 1193-206.

[543] Nirwane A, Sridhar V and Majumdar A. *Neurobehavioural changes and brain oxidative stress induced by acute exposure to GSM900 mobile phone radiations in zebrafish (Danio rerio)*. Toxicol Res 2016; 32(2): 123-32.

[544] Wang LF, Tian DW, Li HJ, Gao YB, Wang CZ, Zhao L, et al. *Identification of a novel rat NR2B subunit gene promoter region variant and its association with microwave-induced neuron impairment*. Mol Neurobiol 2016; 53(4): 2100-11.

[545] Nasser M, Chedid P, Salami A, Khalifeh M, El Shamieh S and Joumaa WH. *Dataset on significant role of Candesartan on cognitive functions in rats having memory impairment induced by electromagnetic waves*. Data Brief 2018; 21: 2390-4.

[546] Cabré-Riera A, Torrent M, Donaire-Gonzalez D, Vrijheid M, Cardis E and Guxens M. *Telecommunication devices use, screen time and sleep in adolescents*. Environ Res 2019; 171: 341-7.

[547] Tettamanti G, Auvinen A, Akerstedt T, Kojo K, Ahlbom A, Heinavaara S, et al. *Long-term effect of mobile phone use on sleep quality: Results*

from the cohort study of mobile phone use and health (COSMOS). Environ Int 2020: 105687.

548 Röösli M, Mohler E and Frei P. *Sense and sensibility in the context of radiofrequency electromagnetic field exposure*. Comptes Rend Phys 2010; 11(9-10): 576-84.

549 Wagner P, Röschke J, Mann K, Hiller W and Frank C. *Human sleep under the influence of pulsed radiofrequency electromagnetic fields: A polysomnographic study using standardized conditions*. Bioelectromagnetics 1998; 19(3): 199-202.

550 Wagner P, Röschke J, Mann K, Fell J, Hiller W, Frank C, et al. *Human sleep EEG under the influence of pulsed radio frequency electromagnetic fields - Results from polysomnographies using submaximal high power flux densities*. Neuropsychobiology 2000; 42(4): 207-12.

551 Danker-Hopfe H, Dorn H, Bahr A, Anderer P and Sauter C. *Effects of electromagnetic fields emitted by mobile phones (GSM 900 and WCDMA/UMTS) on the macrostructure of sleep*. J Sleep Res 2011; 20(1 Pt 1): 73-81.

552 Lustenberger C, Murbach M, Tushaus L, Wehrle F, Kuster N, Achermann P, et al. *Inter-individual and intra-individual variation of the effects of pulsed RF EMF exposure on the human sleep EEG*. Bioelectromagnetics 2015; 36(3): 169-77.

553 Nakatani-Enomoto S, Furubayashi T, Ushiyama A, Groiss SJ, Ueshima K, Sokejima S, et al. *Effects of electromagnetic fields emitted from W-CDMA-like mobile phones on sleep in humans*. Bioelectromagnetics 2013; 34(8): 589-98.

554 Huber R, Treyer V, Borbély AA, Schuderer J, Gottselig JM, Landolt HP, et al. *Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG*. J Sleep Res 2002; 11(4): 289-95.

555 Loughran SP, Wood AW, Barton JM, Croft RJ, Thompson B and Stough C. *The effect of electromagnetic fields emitted by mobile phones on human sleep*. Neuroreport 2005; 16(17): 1973-6.

556 Danker-Hopfe H, Dorn H, Bolz T, Peter A, Hansen ML, Eggert T, et al. *Effects of mobile phone exposure (GSM 900 and WCDMA/UMTS) on polysomnography based sleep quality: An intra- and inter-individual perspective*. Environ Res 2016; 145: 50-60.

557 Hata K, Yamaguchi H, Tsurita G, Watanabe S, Wake K, Taki M, et al. *Short term exposure to 1439 MHz pulsed TDMA field does not alter melatonin synthesis in rats*. Bioelectromagnetics 2005; 26(1): 49-53.

558 Mausset AL, de Sèze R, Montpeyroux F and Privat A. *Effects of radiofrequency exposure on the GABAergic system in the rat cerebellum: clues from semi-quantitative immunohistochemistry*. Brain Res 2001; 912(1): 33-46.

559 Aboul Ezz HS, Khadrawy YA, Ahmed NA, Radwan NM and El Bakry MM. *The effect of pulsed electromagnetic radiation from mobile phone on the levels of monoamine neurotransmitters in four different areas of rat brain*. Eur Rev Med Pharmacol Sci 2013; 17(13): 1782-8.

[560] Megha K, Deshmukh PS, Ravi AK, Tripathi AK, Abegaonkar MP and Banerjee BD. *Effect of Low-Intensity Microwave Radiation on Monoamine Neurotransmitters and Their Key Regulating Enzymes in Rat Brain*. Cell Biochem Biophys 2015; 73(1): 93-100.

[561] Kim JH, Huh YH and Kim HR. *Trafficking of synaptic vesicles is changed at the hypothalamus by exposure to an 835 MHz radiofrequency electromagnetic field*. Gen Physiol Biophys 2019; 38(5): 379-88.

[562] Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, W HS, et al. *Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation*. Bioelectromagnetics 2006; 27(4): 295-306.

[563] Bodera P, Antkowiak B, Paluch M, Sirav B, Siwicki AK and Stankiewicz W. *The effects of radio-frequency radiation (RFR) exposure on the analgesic efficacy of morphine in healthy rats and rats with inflammation*. Int J Occup Med Environ Health 2019; 32(4): 465-74.

[564] Khadrawy YA, Ahmed NA, Aboul Ezz HS, Rad NM and Wan C. *Effect of electromagnetic radiation from mobile phone on the level of amino acid neurotransmitters in adult and young rats*. Romanian J Biophys 2009; 19: 295-305.

[565] Ahmed NA, Radwan NM, Aboul Ezz HS, Khadrawy YA and Salama NA. *The chronic effect of pulsed 1800 MHz electromagnetic radiation on amino acid neurotransmitters in three different areas of juvenile and young adult rat brain*. Toxicol Ind Health 2018: 748233718798975.

[566] Lai H, Carino MA, Horita A and Guy AW. *Corticotropin-releasing factor antagonist blocks microwave-induced decreases in high-affinity choline uptake in the rat brain*. Brain Res Bull 1990; 25(4): 609-12.

[567] Lai H, Carino MA, Wen YF, Horita A and Guy AW. *Naltrexone pretreatment blocks microwave-induced changes in central cholinergic receptors*. Bioelectromagnetics 1991; 12(1): 27-33.

[568] Lai H, Carino MA, Horita A and Guy AW. *Opioid receptor subtypes that mediate a microwave-induced decrease in central cholinergic activity in the rat*. Bioelectromagnetics 1992; 13(3): 237-46.

[569] Inaba R, Shishido K, Okada A and Moroji T. *Effects of whole body microwave exposure on the rat brain contents of biogenic amines*. Eur J Appl Physiol Occup Physiol 1992; 65(2): 124-8.

[570] Lai H, Carino MA, Horita A and Guy AW. *Intraseptal microinjection of beta-funaltrexamine blocked a microwave-induced decrease of hippocampal cholinergic activity in the rat*. Pharmacol Biochem Behav 1996; 53(3): 613-6.

[571] Wang LF, Wei L, Qiao SM, Gao XN, Gao YB, Wang SM, et al. *Microwave-Induced Structural and Functional Injury of Hippocampal and PC12 Cells Is Accompanied by Abnormal Changes in the NMDAR-PSD95-CaMKII Pathway*. Pathobiology 2015; 82(5): 181-94.

[572] Lai H, Carino MA, Horita A and Guy AW. *Single vs. repeated microwave exposure: effects on benzodiazepine receptors in the brain of the rat*. Bioelectromagnetics 1992; 13(1): 57-66.

[573] Wang L, Peng R, Hu X, Gao Y, Wang S, Zhao L, et al. *Abnormality of synaptic vesicular associated proteins in cerebral cortex and hippocampus after microwave exposure*. Synapse 2009; 63(11): 1010-6.

[574] Maskey D, Pradhan J, Aryal B, Lee CM, Choi IY, Park KS, et al. *Chronic 835-MHz radiofrequency exposure to mice hippocampus alters the distribution of calbindin and GFAP immunoreactivity*. Brain Res 2010; 1346: 237-46.

[575] Noor NA, Mohammed HS, Ahmed NA and Radwan NM. *Variations in amino acid neurotransmitters in some brain areas of adult and young male albino rats due to exposure to mobile phone radiation*. Eur Rev Med Pharmacol Sci 2011; 15(7): 729-42.

[576] Dogan M, Turtay MG, Oguzturk H, Samdanci E, Turkoz Y, Tasdemir S, et al. *Effects of electromagnetic radiation produced by 3G mobile phones on rat brains: magnetic resonance spectroscopy, biochemical, and histopathological evaluation*. Hum Exp Toxicol 2012; 31(6): 557-64.

[577] Wang LF, Hu XJ, Peng RY, Wang SM, Gao YB, Dong J, et al. *Application of 1H-NMR-based metabolomics for detecting injury induced by long-term microwave exposure in Wistar rats' urine*. Anal Bioanal Chem 2012; 404(1): 69-78.

[578] Maskey D, Kim HG, Suh MW, Roh GS and Kim MJ. *Alteration of glycine receptor immunoreactivity in the auditory brainstem of mice following three months of exposure to radiofrequency radiation at SAR 4.0 W/kg*. Int J Mol Med 2014; 34(2): 409-19.

[579] Song B, Wang F and Wang W. *Effect of aqueous extract from Morinda officinalis F. C. How on microwave-induced hypothalamic-pituitary-testis axis impairment in male Sprague-Dawley rats*. Evid Based Complement Alternat Med 2015; 2015: 360730.

[580] Hinrichs H and Heinze HJ. *Effects of GSM electromagnetic field on the MEG during an encoding-retrieval task*. Neuroreport 2004; 15(7): 1191-4.

[581] Yuasa K, Arai N, Okabe S, Tarusawa Y, Nojima T, Hanajima R, et al. *Effects of thirty minutes mobile phone use on the human sensory cortex*. Clinical Neurophysiology 2006; 117(4): 900-5.

[582] Ferreri F, Curcio G, Pasqualetti P, De Gennaro L, Fini R and Rossini PM. *Mobile phone emissions and human brain excitability*. Ann Neurol 2006; 60(2): 188-96.

[583] Kwon MS, Kujala T, Huotilainen M, Shestakova A, Naatanen R and Hämäläinen H. *Preattentive auditory information processing under exposure to the 902 MHz GSM mobile phone electromagnetic field: a mismatch negativity (MMN) study*. Bioelectromagnetics 2009; 30(3): 241-8.

[584] Trunk A, Stefanics G, Zentai N, Bacskay I, Felinger A, Thuroczy G, et al. *Lack of interaction between concurrent caffeine and mobile phone*

exposure on visual target detection: an ERP study. Pharmacol Biochem Behav 2014; 124: 412-20.

[585] Dalecki A, Loughran SP, Verrender A, Burdon CA, Taylor NAS and Croft RJ. *Does acute radio-frequency electromagnetic field exposure affect visual event-related potentials in healthy adults?* Clin Neurophysiol 2018; 129(5): 901-8.

[586] Inomata-Terada S, Okabe S, Arai N, Hanajima R, Terao Y, Frubayashi T, et al. *Effects of high frequency electromagnetic field (EMF) emitted by mobile phones on the human motor cortex*. Bioelectromagnetics 2007; 28(7): 553-61.

[587] Maby E, Le Bouquin Jeannes R and Faucon G. *Scalp localization of human auditory cortical activity modified by GSM electromagnetic fields*. Int J Radiat Biol 2006; 82(7): 465-72.

[588] Maby E, Le Bouquin Jeannes R, Faucon G, Liegeois-Chauvel C and De Seze R. *Effects of GSM signals on auditory evoked responses*. Bioelectromagnetics 2005; 26(5): 341-50.

[589] Tombini M, Pellegrino G, Pasqualetti P, Assenza G, Benvenga A, Fabrizio E, et al. *Mobile phone emissions modulate brain excitability in patients with focal epilepsy*. Brain Stimul 2013; 6(3): 448-54.

[590] Curcio G, Mazzucchi E, Della Marca G, Vollono C and Rossini PM. *Electromagnetic fields and EEG spiking rate in patients with focal epilepsy*. Clin Neurophysiol 2015; 126(4): 659-66.

[591] Kwon MS, Huotilainen M, Shestakova A, Kujala T, Naatanen R and Hämäläinen H. *No effects of mobile phone use on cortical auditory change-detection in children: an ERP study*. Bioelectromagnetics 2010; 31(3): 191-9.

[592] Krause CM, Björnberg CH, Pesonen M, Hulten A, Liesivuori T, Koivisto M, et al. *Mobile phone effects on children's event-related oscillatory EEG during an auditory memory task*. Int J Radiat Biol 2006; 82(6): 443-50.

[593] Röschke J and Mann K. *No short-term effects of digital mobile radio telephone on the awake human electroencephalogram*. Bioelectromagnetics 1997; 18(2): 172-6.

[594] Perentos N, Croft RJ, McKenzie RJ, Cvetkovic D and Cosic I. *Comparison of the effects of continuous and pulsed mobile phone like RF exposure on the human EEG*. Australas Phys Eng Sci Med 2007; 30(4): 274-80.

[595] Hietanen M, Kovala T and Hämäläinen AM. *Human brain activity during exposure to radiofrequency fields emitted by cellular phones*. Scand J Work Environ Health 2000; 26(2): 87-92.

[596] D'Costa H, Trueman G, Tang L, Abdel-rahman U, Abdel-rahman W, Ong K, et al. *Human brain wave activity during exposure to radiofrequency field emissions from mobile phones*. Australas Phys Eng Sci Med 2003; 26(4): 162-7.

[597] Regel SJ, Gottselig JM, Schuderer J, Tinguely G, Retey JV, Kuster N, et al. *Pulsed radio frequency radiation affects cognitive performance and the waking electroencephalogram*. Neuroreport 2007; 18(8): 803-7.

[598] Vecchio F, Babiloni C, Ferreri F, Curcio G, Fini R, Del Percio C, et al. *Mobile phone emission modulates interhemispheric functional coupling of EEG alpha rhythms*. Eur J Neurosci 2007; 25(6): 1908-13.

[599] Vecchio F, Babiloni C, Ferreri F, Buffo P, Cibelli G, Curcio G, et al. *Mobile phone emission modulates inter-hemispheric functional coupling of EEG alpha rhythms in elderly compared to young subjects*. Clin Neurophysiol 2010; 121(2): 163-71.

[600] Croft RJ, Hamblin DL, Spong J, Wood AW, McKenzie RJ and Stough C. *The effect of mobile phone electromagnetic fields on the alpha rhythm of human electroencephalogram*. Bioelectromagnetics 2008; 29(1): 1-10.

[601] Hountala CD, Maganioti AE, Papageorgiou CC, Nanou ED, Kyprianou MA, Tsiafakis VG, et al. *The spectral power coherence of the EEG under different EMF conditions*. Neurosci Lett 2008; 441(2): 188-92.

[602] Perentos N, Croft RJ, McKenzie RJ and Cosic I. *The alpha band of the resting electroencephalogram under pulsed and continuous radio frequency exposures*. IEEE Trans Biomed Eng 2013; 60(6): 1702-10.

[603] Lv B, Chen Z, Wu T, Shao Q, Yan D, Ma L, et al. *The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure*. Clin Neurophysiol 2014; 125(2): 277-86.

[604] Yang L, Chen Q, Lv B and Wu T. *Long-Term Evolution Electromagnetic Fields Exposure Modulates the Resting State EEG on Alpha and Beta Bands*. Clin EEG Neurosci 2017; 48(3): 168-75.

[605] Vecchio F, Tombini M, Buffo P, Assenza G, Pellegrino G, Benvenga A, et al. *Mobile phone emission increases inter-hemispheric functional coupling of electroencephalographic alpha rhythms in epileptic patients*. Int J Psychophysiol 2012; 84(2): 164-71.

[606] López-Martín E, Bregains J, Relova-Quinteiro JL, Cadarso-Suárez C, Jorge-Barreiro FJ and Ares-Pena FJ. *The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical areas in a rat model of picrotoxin-induced seizure proneness*. J Neurosci Res 2009; 87(6): 1484-99.

[607] Pelletier A, Delanaud S, Decima P, Thuroczy G, de Seze R, Cerri M, et al. *Effects of chronic exposure to radiofrequency electromagnetic fields on energy balance in developing rats*. Environ Sci Pollut Res Int 2013; 20(5): 2735-46.

[608] Prochnow N, Gebing T, Ladage K, Krause-Finkeldey D, El Ouardi A, Bitz A, et al. *Electromagnetic field effect or simply stress? Effects of UMTS exposure on hippocampal longterm plasticity in the context of procedure related hormone release*. PLoS One 2011; 6(5): e19437.

[609] Chizhenkova RA and Safroshkina AA. *Electrical reactions of brain to microwave irradiation*. Electro Magnetobiol 1996; 15(3): 253-8.

[610] Vorobyov V, Pesic V, Janac B and Prolic Z. *Repeated exposure to low-level extremely low frequency-modulated microwaves affects baseline and scopolamine-modified electroencephalograms in freely moving rats*. Int J Radiat Biol 2004; 80(9): 691-8.

611 Vorobyov V, Janac B, Pesic V and Prolic Z. *Repeated exposure to low-level extremely low frequency-modulated microwaves affects cortex-hypothalamus interplay in freely moving rats: EEG study*. Int J Radiat Biol 2010; 86(5): 376-83.

612 Mohammed HS, Fahmy HM, Radwan NM and Elsayed AA. *Non-thermal continuous and modulated electromagnetic radiation fields effects on sleep EEG of rats*. J Adv Res 2013; 4(2): 181-7.

613 Hidisoglu E, Kantar Gok D, Er H, Akpinar D, Uysal F, Akkoyunlu G, et al. *2100-MHz electromagnetic fields have different effects on visual evoked potentials and oxidant/antioxidant status depending on exposure duration*. Brain Res 2016; 1635: 1-11.

614 Zentai N, Csatho A, Trunk A, Fiocchi S, Parazzini M, Ravazzani P, et al. *No effects of acute exposure to Wi-Fi electromagnetic fields on spontaneous EEG activity and psychomotor vigilance in healthy human volunteers*. Radiat Res 2015; 184(6): 568-77.

615 Thuróczy G, Kubinyi G, Bodo M, Bakos J and Szabo LD. *Simultaneous response of brain electrical activity (EEG) and cerebral circulation (REG) to microwave exposure in rats*. Rev Environ Health 1994; 10(2): 135-48.

616 Lv B, Shao Q, Chen Z, Ma L and Wu T. *Effects of acute electromagnetic fields exposure on the interhemispheric homotopic functional connectivity during resting state*. Conf Proc IEEE Eng Med Biol Soc 2015; 2015: 1813-6.

617 Roggeveen S, van Os J and Lousberg R. *Does the brain detect 3G mobile phone radiation peaks? An explorative in-depth analysis of an experimental study*. PLoS One 2015; 10(5): e0125390.

618 Roggeveen S, van Os J, Viechtbauer W and Lousberg R. *EEG changes due to experimentally induced 3G mobile phone radiation*. PLoS One 2015; 10(6): e0129496.

619 Vorobyov VV, Galchenko AA, Kukushkin NI and Akoev IG. *Effects of weak microwave fields amplitude modulated at ELF on EEG of symmetric brain areas in rats*. Bioelectromagnetics 1997; 18(4): 293-8.

620 Sidorenko AV. *The analysis of animal bioelectric brain activity influenced by microwaves or by the introduction of strychnine*. Bioelectrochem Bioenerg 1999; 48(1): 223-6.

621 Marino AA, Nilsen E and Frilot C. *Nonlinear changes in brain electrical activity due to cell phone radiation*. Bioelectromagnetics 2003; 24(5): 339-46.

622 Chizhenkova RA. *Pulse activity of populations of cortical neurons under microwave exposures of different intensity*. Bioelectrochemistry 2004; 63(1-2): 343-6.

623 Barcal J, Cendelin J, Vozeh F and Zalud V. *Effect of whole-body exposure to high-frequency electromagnetic field on the brain electrogeny in neurodefective and healthy mice*. Prague Med Rep 2005; 106(1): 91-100.

624 Petrova EV, Gulyaeva NV, Titarov SI, Rozhnov YV and Koval'zon VM. *Actions of pulsed ultra-broadband electromagnetic irradiation on the*

EEG and sleep in laboratory animals. Neurosci Behav Physiol 2005; 35(2): 165-70.

625 Sallam SM. *Cortical spreading depression elicited in rat brain after exposure to microwave from GSM mobile phone*. Int J Biomed Sci 2006; 2(2): 172-7.

626 Sallam SM, Mohamed EI and Dawood AF. *Changes in mice brain spontaneous electrical activity during cortical spreading depression due to mobile phone radiation*. Int J Biomed Sci 2008; 4(2): 130-4.

627 Sistani S, Fatemi I, Shafeie SA, Kaeidi A, Azin M and Shamsizadeh A. *The effect of Wi-Fi electromagnetic waves on neuronal response properties in rat barrel cortex*. Somatosens Mot Res 2019; 36(4): 292-7.

628 Söderqvist F, Carlberg M and Hardell L. *Use of wireless telephones and serum S100B levels: a descriptive cross-sectional study among healthy Swedish adults aged 18-65 years*. Sci Total Environ 2009; 407(2): 798-805.

629 Söderqvist F, Carlberg M and Hardell L. *Mobile and cordless telephones, serum transthyretin and the blood-cerebrospinal fluid barrier: a cross-sectional study*. Environ Health 2009; 8: 19.

630 Söderqvist F, Carlberg M, Zetterberg H and Hardell L. *Use of wireless phones and serum beta-trace protein in randomly recruited persons aged 18-65 years: a cross-sectional study*. Electromagn Biol Med 2012; 31(4): 416-24.

631 Finnie JW, Blumbergs PC, Manavis J, Utteridge TD, Gebski V, Swift JG, et al. *Effect of global system for mobile communication (gsm)-like radiofrequency fields on vascular permeability in mouse brain*. Pathology 2001; 33(3): 338-40.

632 Finnie JW, Blumbergs PC, Manavis J, Utteridge TD, Gebski V, Davies RA, et al. *Effect of long-term mobile communication microwave exposure on vascular permeability in mouse brain*. Pathology 2002; 34(4): 344-7.

633 Finnie JW and Blumbergs PC. *Mobile telephones and brain vascular leakage*. Pathology 2004; 36(1): 96-7.

634 Kuribayashi M, Wang J, Fujiwara O, Doi Y, Nabae K, Tamano S, et al. *Lack of effects of 1439 MHz electromagnetic near field exposure on the blood-brain barrier in immature and young rats*. Bioelectromagnetics 2005; 26(7): 578-88.

635 Finnie JW, Blumbergs PC, Cai Z, Manavis J and Kuchel TR. *Effect of mobile telephony on blood-brain barrier permeability in the fetal mouse brain*. Pathology 2006; 38(1): 63-5.

636 Finnie JW, Blumbergs PC, Cai Z, Manavis J and Kuchel TR. *Neonatal mouse brain exposure to mobile telephony and effect on blood-brain barrier permeability*. Pathology 2006; 38(3): 262-3.

637 Masuda H, Ushiyama A, Hirota S, Wake K, Watanabe S, Yamanaka Y, et al. *Effects of acute exposure to a 1439 MHz electromagnetic field on the microcirculatory parameters in rat brain*. In Vivo 2007; 21(4): 555-62.

638 Masuda H, Ushiyama A, Hirota S, Wake K, Watanabe S, Yamanaka Y, et al. *Effects of subchronic exposure to a 1439 MHz electromagnetic*

field on the microcirculatory parameters in rat brain. In Vivo 2007; 21(4): 563-70.

[639] Ushiyama A, Masuda H, Hirota S, Wake K, Kawai H, Watanabe S, et al. *Biological effect on blood cerebrospinal fluid barrier due to radio frequency electromagnetic fields exposure of the rat brain in vivo*. The Environmentalist 2007; 27(4): 489-92.

[640] Grafström G, Nittby H, Brun A, Malmgren L, Persson BR, Salford LG, et al. *Histopathological examinations of rat brains after long-term exposure to GSM-900 mobile phone radiation*. Brain Res Bull 2008; 77(5): 257-63.

[641] McQuade JM, Merritt JH, Miller SA, Scholin T, Cook MC, Salazar A, et al. *Radiofrequency-radiation exposure does not induce detectable leakage of albumin across the blood-brain barrier*. Radiat Res 2009; 171(5): 615-21.

[642] Masuda H, Ushiyama A, Takahashi M, Wang J, Fujiwara O, Hikage T, et al. *Effects of 915 MHz electromagnetic-field radiation in TEM cell on the blood-brain barrier and neurons in the rat brain*. Radiat Res 2009; 172(1): 66-73.

[643] Poulletier de Gannes F, Billaudel B, Taxile M, Haro E, Ruffie G, Leveque P, et al. *Effects of head-only exposure of rats to GSM-900 on blood-brain barrier permeability and neuronal degeneration*. Radiat Res 2009; 172(3): 359-67.

[644] Finnie JW, Blumbergs PC, Cai Z and Manavis J. *Expression of the water channel protein, aquaporin-4, in mouse brains exposed to mobile telephone radiofrequency fields*. Pathology 2009; 41(5): 473-5.

[645] Nittby H, Brun A, Strömblad S, Moghadam MK, Sun W, Malmgren L, et al. *Nonthermal GSM RF and ELF EMF effects upon rat BBB permeability*. The Environmentalist 2011; 31(2): 140-8.

[646] Masuda H, Hirota S, Ushiyama A, Hirata A, Arima T, Kawai H, et al. *No dynamic changes in blood-brain barrier permeability occur in developing rats during local cortex exposure to microwaves*. In Vivo 2015; 29(3): 351-7.

[647] Masuda H, Hirota S, Ushiyama A, Hirata A, Arima T, Watanabe H, et al. *No changes in cerebral microcirculatory parameters in rat during local cortex exposure to microwaves*. In Vivo 2015; 29(2): 207-15.

[648] Poulletier de Gannes F, Masuda H, Billaudel B, Poque-Haro E, Hurtier A, Leveque P, et al. *Effects of GSM and UMTS mobile telephony signals on neuron degeneration and blood-brain barrier permeation in the rat brain*. Sci Rep 2017; 7(1): 15496.

[649] Fritze K, Sommer C, Schmitz B, Mies G, Hossmann KA, Kiessling M, et al. *Effect of global system for mobile communication (GSM) microwave exposure on blood-brain barrier permeability in rat*. Acta Neuropathol 1997; 94(5): 465-70.

[650] Eberhardt JL, Persson BR, Brun AE, Salford LG and Malmgren LO. *Blood-brain barrier permeability and nerve cell damage in rat brain 14*

and 28 days after exposure to microwaves from GSM mobile phones. Electromagn Biol Med 2008; 27(3): 215-29.

651 Sirav B and Seyhan N. *Blood-brain barrier disruption by continuous-wave radio frequency radiation*. Electromagn Biol Med 2009; 28(2): 215-22.

652 Sirav B and Seyhan N. *Effects of radiofrequency radiation exposure on blood-brain barrier permeability in male and female rats*. Electromagn Biol Med 2011; 30(4): 253-60.

653 Sirav B and Seyhan N. *Effects of GSM modulated radio-frequency electromagnetic radiation on permeability of blood-brain barrier in male & female rats*. J Chem Neuroanat 2016; 75(Pt B): 123-7.

654 Nittby H, Widegren B, Krogh M, Grafström G, Berlin H, Rehn G, et al. *Exposure to radiation from global system for mobile communications at 1,800 MHz significantly changes gene expression in rat hippocampus and cortex*. The Environmentalist 2008; 28(4): 458-65.

655 Moriyama E, Salcman M and Broadwell RD. *Blood-brain barrier alteration after microwave-induced hyperthermia is purely a thermal effect: I. Temperature and power measurements*. Surg Neurol 1991; 35(3): 177-82.

656 Lin JC, Yuan PMK and Jung DT. *Enhancement of anticancer drug delivery to the brain by microwave induced hyperthermia*. Bioelectrochem Bioenerg 1998; 47(2): 259-64.

657 Neubauer C, Phelan AM, Kues H and Lange DG. *Microwave irradiation of rats at 2.45 GHz activates pinocytotic-like uptake of tracer by capillary endothelial cells of cerebral cortex*. Bioelectromagnetics 1990; 11(4): 261-8.

658 Lange DG and Sedmak J. *Japanese encephalitis virus (JEV): potentiation of lethality in mice by microwave radiation*. Bioelectromagnetics 1991; 12(6): 335-48.

659 Persson BR, Salford LG, Brun A, Eberhardt JL and Malmgren L. *Increased permeability of the blood-brain barrier induced by magnetic and electromagnetic fields*. Ann N Y Acad Sci 1992; 649: 356-8.

660 Salford LG, Eberhardt JL and Persson BR. *Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous wave and modulated at 8, 16, 50 and 200 Hz*. Bioelectrochem Bioenerg 1993; 30: 293-301.

661 Salford LG, Brun A, Sturesson K, Eberhardt JL and Persson BR. *Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous wave and modulated at 8, 16, 50, and 200 Hz*. Microsc Res Tech 1994; 27(6): 535-42.

662 Persson BR, Salford LG and Brun A. *Blood-brain barrier permeability in rats exposed to electromagnetic fields used in wireless communication*. Wireless Netw 1997; 3: 455-61.

663 Tsurita G, Nagawa H, Ueno S, Watanabe S and Taki M. *Biological and morphological effects on the brain after exposure of rats to a 1439 MHz TDMA field*. Bioelectromagnetics 2000; 21(5): 364-71.

664 Salford LG, Brun AE, Eberhard JL, Malmgren L and Persson BRR. *Nerve cell damage in mammalian brain after exposure to microwaves*

from GSM mobile phones. Environ Health Perspect 2003; 111(7): 881-3.

665 Persson BRR, Eberhardt J, Malmgren L, Persson MB, Brun A and Salford LG. *Effects of microwaves from GSM mobile phones on t he blood-brain barrier and neurons in rat brain*. PIERS Online 2005; 1(6): 638-41.

666 Vojtisek M, Knotkova J, Kasparova L, Hornychova M, Frantik M and Svandova E. *Potential impact of simulated mobile phone radiation on blood-brain barrier*. Electromagn Biol Med 2005; 24(3): 355-8.

667 Nittby H, Brun A, Eberhardt J, Malmgren L, Persson BR and Salford LG. *Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone*. Pathophysiology 2009; 16(2-3): 103-12.

668 de Pomerai DI, Iqbal N, Lafayette I, Nagarajan A, Kaviani Moghadam M, Fineberg A, et al. *Microwave fields have little effect on alpha-synuclein aggregation in a Caenorhabditis elegans model of Parkinson's disease*. Bioelectromagnetics 2016; 37(2): 116-29.

669 Gökçek-Saraç Ç, Er H, Kencebay Manas C, Kantar Gok D, Özen S and Derin N. *Effects of acute and chronic exposure to both 900 MHz and 2100 MHz electromagnetic radiation on glutamate receptor signaling pathway*. Int J Radiat Biol 2017; 93(9): 980-9.

670 Kim JH, Yu DH, Kim HJ, Huh YH, Cho SW, Lee JK, et al. *Exposure to 835 MHz radiofrequency electromagnetic field induces autophagy in hippocampus but not in brain stem of mice*. Toxicol Ind Health 2018; 34(1): 23-35.

671 Keles AI, Nyengaard JR and Odaci E. *Changes in pyramidal and granular neuron numbers in the rat hippocampus 7 days after exposure to a continuous 900-MHz electromagnetic field during early and mid-adolescence*. J Chem Neuroanat 2019; 101: 101681.

672 Seaman RL and Phelix CF. *Acute effects of pulsed microwaves and 3-nitropropionic acid on neuronal ultrastructure in the rat caudate-putamen*. Bioelectromagnetics 2005; 26(2): 82-101.

673 Daşdağ S, Akdağ MZ, Kizil G, Kizil M, Cakir DU and Yokus B. *Effect of 900 MHz radio frequency radiation on beta amyloid protein, protein carbonyl, and malondialdehyde in the brain*. Electromagn Biol Med 2012; 31(1): 67-74.

674 Celikozlu SD, Ozyurt MS, Cimbiz A, Yardimoglu MY, Cayci MK and Ozay Y. *The effects of long-term exposure of magnetic field via 900-MHz GSM radiation on some biochemical parameters and brain histology in rats*. Electromagn Biol Med 2012; 31(4): 344-55.

675 Kopani M, Filova B, Sevcik P, Kosnac D, Misek J, Polak S, et al. *Iron deposition in rabbit cerebellum after exposure to generated and mobile GSM electromagnetic fields*. Bratisl Lek Listy 2017; 118(10): 575-9.

676 Fragopoulou AF, Polyzos A, Papadopoulou MD, Sansone A, Manta AK, Balafas E, et al. *Hippocampal lipidome and transcriptome profile alterations triggered by acute exposure of mice to GSM 1800 MHz*

mobile phone radiation: An exploratory study. Brain Behav 2018; 8(6): e01001.

[677] Seymen CM, Ilgaz C, Erdogan D, Elmas C, Saglam A, Elmazoglu Z, et al. *Melatonin modulates NMDA-receptor 2B/Calpain-1/ Caspase-12 pathways in rat brain after long time exposure to GSM radiation*. Turk Neurosurg 2019; 29(6): 887-900.

[678] Fritze K, Wiessner C, Kuster N, Sommer C, Gass P, Hermann DM, et al. *Effect of global system for mobile communication microwave exposure on the genomic response of the rat brain*. Neuroscience 1997; 81(3): 627-39.

[679] Stagg RB, Hawel LH, Pastorian K, Cain C, Adey WR and Byus CV. *Effect of immobilization and concurrent exposure to a pulse-modulated microwave field on core body temperature, plasma ACTH and corticosteroid, and brain ornithine decarboxylase, Fos and Jun mRNA*. Radiat Res 2001; 155(4): 584-92.

[680] Finnie JW. *Expression of the immediate early gene, c-fos, in mouse brain after acute global system for mobile communication microwave exposure*. Pathology 2005; 37(3): 231-3.

[681] Finnie JW, Cai Z, Blumbergs PC, Manavis J and Kuchel TR. *Expression of the immediate early gene, c-fos, in fetal brain after whole of gestation exposure of pregnant mice to global system for mobile communication microwaves*. Pathology 2006; 38(4): 333-5.

[682] Finnie JW, Cai Z, Blumbergs PC, Manavis J and Kuchel TR. *Stress response in mouse brain after long-term (2 year) exposure to mobile telephone radiofrequency fields using the immediate early gene, c-fos*. Pathology 2007; 39(2): 271-3.

[683] Paparini A, Rossi P, Gianfranceschi G, Brugaletta V, Falsaperla R, De Luca P, et al. *No evidence of major transcriptional changes in the brain of mice exposed to 1800 MHz GSM signal*. Bioelectromagnetics 2008; 29(4): 312-23.

[684] Finnie JW, Chidlow G, Blumbergs PC, Manavis J and Cai Z. *Heat shock protein induction in fetal mouse brain as a measure of stress after whole of gestation exposure to mobile telephony radiofrequency fields*. Pathology 2009; 41(3): 276-9.

[685] Finnie JW, Cai Z, Manavis J, Helps S and Blumbergs PC. *Microglial activation as a measure of stress in mouse brains exposed acutely (60 minutes) and long-term (2 years) to mobile telephone radiofrequency fields*. Pathology 2010; 42(2): 151-4.

[686] Watilliaux A, Edeline JM, Lévêque P, Jay TM and Mallat M. *Effect of exposure to 1,800 MHz electromagnetic fields on heat shock proteins and glial cells in the brain of developing rats*. Neurotox Res 2011; 20(2): 109-19.

[687] Court-Kowalski S, Finnie JW, Manavis J, Blumbergs PC, Helps SC and Vink R. *Effect of long-term (2 years) exposure of mouse brains to global system for mobile communication (GSM) radiofrequency fields on astrocytic immunoreactivity*. Bioelectromagnetics 2015; 36(3): 245-50.

688 McNamee JP, Bellier PV, Konkle AT, Thomas R, Wasoontarajaroen S, Lemay E, et al. *Analysis of gene expression in mouse brain regions after exposure to 1.9 GHz radiofrequency fields*. Int J Radiat Biol 2016; 92(6): 338-50.

689 Lameth J, Gervais A, Colin C, Lévêque P, Jay TM, Edeline JM, et al. *Acute Neuroinflammation Promotes Cell Responses to 1800 MHz GSM Electromagnetic Fields in the Rat Cerebral Cortex*. Neurotox Res 2017; 32(3): 444-59.

690 Morrissey JJ, Raney S, Heasley E, Rathinavelu P, Dauphinee M and Fallon JH. *IRIDIUM exposure increases c-fos expression in the mouse brain only at levels which likely result in tissue heating*. Neuroscience 1999; 92(4): 1539-46.

691 Brillaud E, Piotrowski A and de Sèze R. *Effect of an acute 900MHz GSM exposure on glia in the rat brain: a time-dependent study*. Toxicology 2007; 238(1): 23-33.

692 Ammari M, Brillaud E, Gamez C, Lecomte A, Sakly M, Abdelmelek H, et al. *Effect of a chronic GSM 900 MHz exposure on glia in the rat brain*. Biomed Pharmacother 2008; 62(4): 273-81.

693 Ammari M, Gamez C, Lecomte A, Sakly M, Abdelmelek H and De Sèze R. *GFAP expression in the rat brain following sub-chronic exposure to a 900 MHz electromagnetic field signal*. Int J Radiat Biol 2010; 86(5): 367-75.

694 Daşdağ S, Akdağ MZ, Erdal ME, Erdal N, Ay OI, Ay ME, et al. *Long term and excessive use of 900 MHz radiofrequency radiation alter microRNA expression in brain*. Int J Radiat Biol 2015: 1-6.

695 Xu F, Bai Q, Zhou K, Ma L, Duan J, Zhuang F, et al. *Age-dependent acute interference with stem and progenitor cell proliferation in the hippocampus after exposure to 1800 MHz electromagnetic radiation*. Electromagn Biol Med 2017; 36(2): 158-66.

696 Kumar R, Deshmukh PS, Sharma S and Banerjee B. *Activation of endoplasmic reticulum stress in rat brain following low-intensity microwave exposure*. Environ Sci Pollut Res Int 2019; 26(9): 9314-21.

697 Zhao YL, Li YX, Ma HB, Li D, Li HL, Jiang R, et al. *The Screening of Genes Sensitive to Long-Term, Low-Level Microwave Exposure and Bioinformatic Analysis of Potential Correlations to Learning and Memory*. Biomed Environ Sci 2015; 28(8): 558-70.

698 Fragopoulou AF, Samara A, Antonelou MH, Xanthopoulou A, Papadopoulou A, Vougas K, et al. *Brain proteome response following whole body exposure of mice to mobile phone or wireless DECT base radiation*. Electromagn Biol Med 2012; 31(4): 250-74.

699 Xiong L, Sun CF, Zhang J, Gao YB, Wang LF, Zuo HY, et al. *Microwave exposure impairs synaptic plasticity in the rat hippocampus and PC12 cells through over-activation of the NMDA receptor signaling pathway*. Biomed Environ Sci 2015; 28(1): 13-24.

[700] Paulraj R and Behari J. *Protein kinase C activity in developing rat brain cells exposed to 2.45 GHz radiation*. Electromagn Biol Med 2006; 25(1): 61-70.

[701] Jorge-Mora T, Misa-Agustiño MJ, Rodríguez-González JA, Jorge-Barreiro FJ, Ares-Pena FJ and López-Martín E. *The effects of single and repeated exposure to 2.45 GHz radiofrequency fields on c-Fos protein expression in the paraventricular nucleus of rat hypothalamus*. Neurochem Res 2011; 36(12): 2322-32.

[702] Ohtani S, Ushiyama A, Maeda M, Hattori K, Kunugita N, Wang J, et al. *Exposure time-dependent thermal effects of radiofrequency electromagnetic field exposure on the whole body of rats*. J Toxicol Sci 2016; 41(5): 655-66.

[703] Yang XS, He GL, Hao YT, Xiao Y, Chen CH, Zhang GB, et al. *Exposure to 2.45 GHz electromagnetic fields elicits an HSP-related stress response in rat hippocampus*. Brain Res Bull 2012; 88(4): 371-8.

[704] Singh N, Rudra N, Bansal P, Mathur R, Behari J and Nayar U. *Poly ADP ribosylation as a possible mechanism of microwave--biointeraction*. Indian J Physiol Pharmacol 1994; 38(3): 181-4.

[705] Daşdağ S, Akdağ MZ and Aksen F. *Does 900 MHz GSM mobile phone exposure affect rat brain?* Electromagn Biol Med 2004; 23(3): 201-14.

[706] El-Swefy S, Soliman H and Huessein M. *Calcium channel blockade alleviates brain injury induced by long term exposure to an electromagnetic field*. J Appl Biomed 2008; 6: 153-63.

[707] Kim TH, Huang TQ, Jang JJ, Kim MH, Kim HJ, Lee JS, et al. *Local exposure of 849 MHz and 1763 MHz radiofrequency radiation to mouse heads does not induce cell death or cell proliferation in brain*. Exp Mol Med 2008; 40(3): 294-303.

[708] Lee KS, Choi JS, Hong SY, Son TH and Yu K. *Mobile phone electromagnetic radiation activates MAPK signaling and regulates viability in Drosophila*. Bioelectromagnetics 2008; 29(5): 371-9.

[709] Yilmaz F, Daşdağ S, Akdağ MZ and Kilinc N. *Whole-body exposure of radiation emitted from 900 MHz mobile phones does not seem to affect the levels of anti-apoptotic bcl-2 protein*. Electromagn Biol Med 2008; 27(1): 65-72.

[710] Guler G, Tomruk A, Ozgur E and Seyhan N. *The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns*. Gen Physiol Biophys 2010; 29(1): 59-66.

[711] Maskey D, Kim M, Aryal B, Pradhan J, Choi IY, Park KS, et al. *Effect of 835 MHz radiofrequency radiation exposure on calcium binding proteins in the hippocampus of the mouse brain*. Brain Res 2010; 1313: 232-41.

[712] Aryal B, Maskey D, Kim MJ, Yang JW and Kim HG. *Effect of Ginseng on Calretinin Expression in Mouse Hippocampus Following Exposure to 835 MHz Radiofrequency*. J Ginseng Res 2011; 35(2): 138-48.

[713] Maskey D, Kim HJ, Kim HG and Kim MJ. *Calcium-binding proteins and GFAP immunoreactivity alterations in murine hippocampus after 1*

month of exposure to 835 MHz radiofrequency at SAR values of 1.6 and 4.0 W/kg. Neurosci Lett 2012; 506(2): 292-6.

[714] Tsybulin O, Sidorik E, Kyrylenko S, Henshel D and Yakymenko I. *GSM 900 MHz microwave radiation affects embryo development of Japanese quails*. Electromagn Biol Med 2012; 31(1): 75-86.

[715] Eser O, Songur A, Aktas C, Karavelioglu E, Caglar V, Aylak F, et al. *The effect of electromagnetic radiation on the rat brain: an experimental study*. Turk Neurosurg 2013; 23(6): 707-15.

[716] Kesari KK, Meena R, Nirala J, Kumar J and Verma HN. *Effect of 3G cell phone exposure with computer controlled 2-D stepper motor on non-thermal activation of the hsp27/p38MAPK stress pathway in rat brain*. Cell Biochem Biophys 2014; 68(2): 347-58.

[717] Motawi TK, Darwish HA, Moustafa YM and Labib MM. *Biochemical modifications and neuronal damage in brain of young and adult rats after long-term exposure to mobile phone radiations*. Cell Biochem Biophys 2014; 70(2): 845-55.

[718] Yilmaz A, Yilmaz N, Serarslan Y, Aras M, Altas M, Ozgur T, et al. *The effects of mobile phones on apoptosis in cerebral tissue: an experimental study on rats*. Eur Rev Med Pharmacol Sci 2014; 18(7): 992-1000.

[719] Saili L, Hanini A, Smirani C, Azzouz I, Azzouz A, Sakly M, et al. *Effects of acute exposure to WIFI signals (2.45 GHz) on heart variability and blood pressure in Albinos rabbit*. Environ Toxicol Pharmacol 2015; 40(2): 600-5.

[720] Tohidi FZ, Bahreyni-Toosi MH, ZAzimian H, Khademi S, Fardid R and Anani Sarab G. *The gene expression level of p53 and p21 in mouse brain exposed to radiofrequency field*. Int J Radiat Res 2015; 13(4): 337-43.

[721] Guler G, Ozgur E, Keles H, Tomruk A, Vural SA and Seyhan N. *Neurodegenerative changes and apoptosis induced by intrauterine and extrauterine exposure of radiofrequency radiation*. J Chem Neuroanat 2016; 75(Pt B): 128-33.

[722] Hussein S, El-Saba AA and Galal MK. *Biochemical and histological studies on adverse effects of mobile phone radiation on rat's brain*. J Chem Neuroanat 2016; 78: 10-9.

[723] Kerimoğlu G, Aslan A, Baş O, Çolakoğlu S and Odaci E. *Adverse effects in lumbar spinal cord morphology and tissue biochemistry in Sprague Dawley male rats following exposure to a continuous 1-h a day 900-MHz electromagnetic field throughout adolescence*. J Chem Neuroanat 2016; 78: 125-30.

[724] Kim JH, Huh YH and Kim HR. *Induction of Autophagy in the Striatum and Hypothalamus of Mice after 835 MHz Radiofrequency Exposure*. PLoS One 2016; 11(4): e0153308.

[725] Kim JH, Yu DH and Kim HR. *Activation of autophagy at cerebral cortex and apoptosis at brainstem are differential responses to 835 MHz RF-EMF exposure*. Korean J Physiol Pharmacol 2017; 21(2): 179-88.

[726] Ghatei N, Nabavi AS, Toosi MHB, Azimian H, Homayoun M, Targhi RG, et al. *Evaluation of bax, bcl-2, p21 and p53 genes expression variations*

on cerebellum of BALB/c mice before and after birth under mobile phone radiation exposure. Iran J Basic Med Sci 2017; 20(9): 1037-43.

[727] Gohari FA, Saranjam B, Asgari M, Omidi L, Ekrami H and Moussavi-Najarkola SA. *An experimental study of the effects of combined exposure to microwave and heat on gene expression and sperm parameters in mice*. J Hum Reprod Sci 2017; 10(2): 128-34.

[728] Ibitayo AO, Afolabi OB, Akinyemi AJ, Ojiezeh TI, Adekoya KO and Ojewunmi OO. *RAPD profiling, DNA fragmentation, and histomorphometric examination in brains of Wistar rats exposed to indoor 2.5 GHz Wi-Fi devices radiation*. Biomed Res Int 2017; 2017: 8653286.

[729] Radon K, Parera D, Rose DM, Jung D and Vollrath L. *No effects of pulsed radio frequency electromagnetic fields on melatonin, cortisol, and selected markers of the immune system in man*. Bioelectromagnetics 2001; 22(4): 280-7.

[730] Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J, et al. *Effects of exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and immunoglobulin A*. Biomed Environ Sci 2010; 23(3): 199-207.

[731] Chagnaud JL and Veyret B. *In vivo exposure of rats to GSM-modulated microwaves: flow cytometry analysis of lymphocyte subpopulations and of mitogen stimulation*. Int J Radiat Biol 1999; 75(1): 111-3.

[732] Gatta L, Pinto R, Ubaldi V, Pace L, Galloni P, Lovisolo GA, et al. *Effects of in vivo exposure to GSM-modulated 900 MHz radiation on mouse peripheral lymphocytes*. Radiat Res 2003; 160(5): 600-5.

[733] Nasta F, Prisco MG, Pinto R, Lovisolo GA, Marino C and Pioli C. *Effects of GSM-modulated radiofrequency electromagnetic fields on B-cell peripheral differentiation and antibody production*. Radiat Res 2006; 165(6): 664-70.

[734] Prisco MG, Nasta F, Rosado MM, Lovisolo GA, Marino C and Pioli C. *Effects of GSM-modulated radiofrequency electromagnetic fields on mouse bone marrow cells*. Radiat Res 2008; 170(6): 803-10.

[735] Jin YB, Pyun BJ, Jin H, Choi HD, Pack JK, Kim N, et al. *Effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic field on immune functions in rats*. Int J Radiat Biol 2012; 88(11): 814-21.

[736] Rosado MM, Nasta F, Prisco MG, Lovisolo GA, Marino C and Pioli C. *Effects of GSM-modulated 900 MHz radiofrequency electromagnetic fields on the hematopoietic potential of mouse bone marrow cells*. Bioelectromagnetics 2014; 35(8): 559-67.

[737] Megha K, Deshmukh PS, Banerjee BD, Tripathi AK and Abegaonkar MP. *Microwave radiation induced oxidative stress, cognitive impairment and inflammation in brain of Fischer rats*. Indian J Exp Biol 2012; 50(12): 889-96.

[738] Elekes E, Thuróczy G and Szabo LD. *Effect on the immune system of mice exposed chronically to 50 Hz amplitude-modulated 2.45 GHz microwaves*. Bioelectromagnetics 1996; 17(3): 246-8.

[739] Poulletier de Gannes F, Taxile M, Duleu S, Hurtier A, Haro E, Geffard M, et al. *A confirmation study of Russian and Ukrainian data on effects of 2450 MHz microwave exposure on immunological processes and teratology in rats*. Radiat Res 2009; 172(5): 617-24.

[740] Sambucci M, Laudisi F, Nasta F, Pinto R, Lodato R, Altavista P, et al. *Prenatal exposure to non-ionizing radiation: effects of WiFi signals on pregnancy outcome, peripheral B-cell compartment and antibody production*. Radiat Res 2010; 174(6): 732-40.

[741] Laudisi F, Sambucci M, Nasta F, Pinto R, Lodato R, Altavista P, et al. *Prenatal exposure to radiofrequencies: effects of WiFi signals on thymocyte development and peripheral T cell compartment in an animal model*. Bioelectromagnetics 2012; 33(8): 652-61.

[742] Nakamura H, Seto T, Nagase H, Yoshida M, Dan S and Ogino K. *Effects of exposure to microwaves on cellular immunity and placental steroids in pregnant rats*. Occup Environ Med 1997; 54(9): 676-80.

[743] Nakamura H, Seto T, Hatta K, Matsuzaki I, Nagase H, Yoshida M, et al. *Natural killer cell activity reduced by microwave exposure during pregnancy is mediated by opioid systems*. Environ Res 1998; 79(2): 106-13.

[744] Grigoriev YG, Grigoriev OA, Ivanov AA, Lyaginskaya AM, Merkulov AV, Shagina NB, et al. *Confirmation studies of Soviet research on immunological effects of microwaves: Russian immunology results*. Bioelectromagnetics 2010; 31(8): 589-602.

[745] Sambucci M, Laudisi F, Nasta F, Pinto R, Lodato R, Lopresto V, et al. *Early life exposure to 2.45GHz WiFi-like signals: effects on development and maturation of the immune system*. Prog Biophys Mol Biol 2011; 107(3): 393-8.

[746] Fesenko EE, Makar VR, Novoselova EG and Sadovnikov VB. *Microwaves and cellular immunity. I. Effect of whole body microwave irradiation on tumor necrosis factor production in mouse cells*. Bioelectrochem Bioenerg 1999; 49(1): 29-35.

[747] Novoselova EG, Fesenko EE, Makar VR and Sadovnikov VB. *Microwaves and cellular immunity. II. Immunostimulating effects of microwaves and naturally occurring antioxidant nutrients*. Bioelectrochem Bioenerg 1999; 49(1): 37-41.

[748] Moustafa YM, Moustafa RM, Belacy A, Abou-El-Ela SH and Ali FM. *Effects of acute exposure to the radiofrequency fields of cellular phones on plasma lipid peroxide and antioxidase activities in human erythrocytes*. J Pharm Biomed Anal 2001; 26(4): 605-8.

[749] Kimata H. *Microwave radiation from cellular phones increases allergen-specific IgE production*. Allergy 2005; 60(6): 838-9.

[750] Jin YB, Lee HJ, Seon Lee J, Pack JK, Kim N and Lee YS. *One-year, simultaneous combined exposure of CDMA and WCDMA radiofrequency electromagnetic fields to rats*. Int J Radiat Biol 2011; 87(4): 416-23.

[751] Kismali G, Ozgur E, Guler G, Akcay A, Sel T and Seyhan N. *The influence of 1800 MHz GSM-like signals on blood chemistry and oxidative stress in non-pregnant and pregnant rabbits*. Int J Radiat Biol 2012; 88(5): 414-9.

[752] Cao Y, Xu Q, Jin ZD, Zhou Z, Nie JH and Tong J. *Induction of adaptive response: pre-exposure of mice to 900 MHz radiofrequency fields reduces hematopoietic damage caused by subsequent exposure to ionising radiation*. Int J Radiat Biol 2011; 87(7): 720-8.

[753] Braithwaite LA, Morrison WD, Bate L, Otten L, Hunter B and Pei DC. *Effect of exposure to operant-controlled microwaves on certain blood and immunological parameters in the young chick*. Poult Sci 1991; 70(3): 509-14.

[754] Trošić I, Busljeta I and Pavičić I. *Blood-forming system in rats after whole-body microwave exposure; reference to the lymphocytes*. Toxicol Lett 2004; 154(1-2): 125-32.

[755] Trošić I and Busljeta I. *Erythropoietic dynamic equilibrium in rats maintained after microwave irradiation*. Exp Toxicol Pathol 2006; 57(3): 247-51.

[756] Goldoni J, Durek M and Koren Z. *Health status of personnel occupationally exposed to radiowaves*. Arh Hig Rada Toksikol 1993; 44(3): 223-8.

[757] Busljeta I, Trošić I and Milkovic-Kraus S. *Erythropoietic changes in rats after 2.45 GHz nonthermal irradiation*. Int J Hyg Environ Health 2004; 207(6): 549-54.

[758] Adang D, Remacle C and Vander Vorst A. *Results of a long-term low-level microwave exposure of rats*. IEEE Trans Microw Theory Tech 2009; 57(10): 2488-97.

[759] van Rongen E, van Rhoon GC, Aleman A, Kelfkens G, Kromhout H, van Leeuwen FE, et al. *Comments on "Results of a long-term low-level microwave exposure of rats"*. IEEE Trans Microw Theory Tech 2011; 7(59): 1893-4.

[760] Achudume A, Onibere B, Aina F and Tchokossa P. *Induction of oxidative stress in male rats subchronically exposed to electromagnetic fields at non-thermal intensities*. J Electromagn Anal Appl 2010; 2(8): 482-7.

[761] Mortavazi S, Motamedifar M, Mehdizadeh AR, Namdari G and Taheri M. *The effect of pre-exposure to radiofrequency radiations emitted from a GSM mobile phone on the susceptibility of BALB/c mice to Escherichia coli*. J Biomed Phys Eng 2012; 2(4): 139-46.

[762] Shojaeifard MB, Jarideh S, Owjfard M, Nematollahii S, Talaei-Khozani T and Malekzadeh M. *Electromagnetic Fields of Mobile Phone Jammer Exposure on Blood Factors in Rats*. J Biomed Phys Eng 2018; 8(4): 403-8.

[763] El-Maleky NF and Ebrahim RH. *Effects of exposure to electromagnetic field from mobile phone on serum hepcidin and iron status in male albino rats*. Electromagn Biol Med 2019; 38(1): 66-73.

[764] Mann K, Wagner P, Brunn G, Hassan F, Hiemke C and Röschke J. *Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system*. Neuroendocrinology 1998; 67(2): 139-44.

[765] Wood AW, Loughran SP and Stough C. *Does evening exposure to mobile phone radiation affect subsequent melatonin production?* Int J Radiat Biol 2006; 82(2): 69-76.

[766] Singh S and Kapoor N. *Occupational EMF exposure from radar at X and Ku frequency band and plasma catecholamine levels*. Bioelectromagnetics 2015; 36(6): 444-50.

[767] de Sèze R, Ayoub J, Peray P, Miro L and Touitou Y. *Evaluation in humans of the effects of radiocellular telephones on the circadian patterns of melatonin secretion, a chronobiological rhythm marker*. J Pineal Res 1999; 27(4): 237-42.

[768] de Sèze R, Fabbro-Peray P and Miro L. *GSM radiocellular telephones do not disturb the secretion of antepituitary hormones in humans*. Bioelectromagnetics 1998; 19(5): 271-8.

[769] Djeridane Y, Touitou Y and de Sèze R. *Influence of electromagnetic fields emitted by GSM-900 cellular telephones on the circadian patterns of gonadal, adrenal and pituitary hormones in men*. Radiat Res 2008; 169(3): 337-43.

[770] Geronikolou SA, Chamakou A, Mantzou A, Chrousos G and Kanaka-Gantenbein C. *Frequent cellular phone use modifies hypothalamic-pituitary-adrenal axis response to a cellular phone call after mental stress in healthy children and adolescents: A pilot study*. Sci Total Environ 2015; 536: 182-8.

[771] Jarupat S, Kawabata A, Tokura H and Borkiewicz A. *Effects of the 1900 MHz electromagnetic field emitted from cellular phone on nocturnal melatonin secretion*. J Physiol Anthropol Appl Human Sci 2003; 22(1): 61-3.

[772] Møllerløkken OJ, Moen BE, Baste V, Mageroy N, Oftedal G, Neto E, et al. *No effects of MRI scan on male reproduction hormones*. Reprod Toxicol 2012; 34(1): 133-9.

[773] Ferreira AR, Bonatto F, de Bittencourt Pasquali MA, Polydoro M, Dal-Pizzol F, Fernandez C, et al. *Oxidative stress effects on the central nervous system of rats after acute exposure to ultra high frequency electromagnetic fields*. Bioelectromagnetics 2006; 27(6): 487-93.

[774] Khalil AM, Alshamali AM and Gagaa MH. *Detection of oxidative stress induced by mobile phone radiation in tissues of mice using 8-oxo-7, 8-dihydro-20-deoxyguanosine as a biomarker*. World Acad Sci Eng Technol 2011; 76: 657-62.

[775] Kerimoğlu G, Hanci H, Baş O, Aslan A, Erol HS, Turgut A, et al. *Pernicious effects of long-term, continuous 900-MHz electromagnetic field throughout adolescence on hippocampus morphology, biochemistry and pyramidal neuron numbers in 60-day-old Sprague Dawley male rats*. J Chem Neuroanat 2016; 77: 169-75.

[776] Köylü H, Mollaoglu H, Ozguner F, Naziroglu M and Delibas N. *Melatonin modulates 900 Mhz microwave-induced lipid peroxidation changes in rat brain*. Toxicol Ind Health 2006; 22(5): 211-6.

[777] Ozguner F, Bardak Y and Comlekci S. *Protective effects of melatonin and caffeic acid phenethyl ester against retinal oxidative stress in long-term use of mobile phone: a comparative study*. Mol Cell Biochem 2006; 282(1-2): 83-8.

[778] Sokolovic D, Djindjic B, Nikolic J, Bjelakovic G, Pavlovic D, Kocic G, et al. *Melatonin reduces oxidative stress induced by chronic exposure of microwave radiation from mobile phones in rat brain*. J Radiat Res 2008; 49(6): 579-86.

[779] Daşdağ S, Akdağ MZ, Ulukaya E, Uzunlar AK and Ocak AR. *Effect of mobile phone exposure on apoptotic glial cells and status of oxidative stress in rat brain*. Electromagn Biol Med 2009; 28(4): 342-54.

[780] Aydin B and Akar A. *Effects of a 900-MHz electromagnetic field on oxidative stress parameters in rat lymphoid organs, polymorphonuclear leukocytes and plasma*. Arch Med Res 2011; 42(4): 261-7.

[781] Kerman M and Senol N. *Oxidative stress in hippocampus induced by 900 MHz electromagnetic field emitting mobile phone: protection by melatonin*. Biomed Res (Aligarh) 2012; 23(1): 147-51.

[782] Jelodar G, Akbari A and Nazifi S. *The prophylactic effect of vitamin C on oxidative stress indexes in rat eyes following exposure to radiofrequency wave generated by a BTS antenna model*. Int J Radiat Biol 2013; 89(2): 128-31.

[783] Akbari A, Jelodar G and Nazifi S. *Vitamin C protects rat cerebellum and encephalon from oxidative stress following exposure to radiofrequency wave generated by a BTS antenna model*. Toxicol Mech Methods 2014; 24(5): 347-52.

[784] Megha K, Deshmukh PS, Banerjee BD, Tripathi AK, Ahmed R and Abegaonkar MP. *Low intensity microwave radiation induced oxidative stress, inflammatory response and DNA damage in rat brain*. Neurotoxicology 2015; 51: 158-65.

[785] Furtado-Filho OV, Borba JB, Maraschin T, Souza LM, Henriques JA, Moreira JC, et al. *Effects of chronic exposure to 950 MHz ultra-high-frequency electromagnetic radiation on reactive oxygen species metabolism in the right and left cerebral cortex of young rats of different ages*. Int J Radiat Biol 2015; 91(11): 891-7.

[786] Bodera P, Stankiewicz W, Antkowiak B, Paluch M, Kieliszek J, Sobiech J, et al. *Influence of electromagnetic field (1800 MHz) on lipid peroxidation in brain, blood, liver and kidney in rats*. Int J Occup Med Environ Health 2015; 28(4): 751-9.

[787] Sahin D, Ozgur E, Guler G, Tomruk A, Unlu I, Sepici-Dincel A, et al. *The 2100 MHz radiofrequency radiation of a 3G-mobile phone and the DNA oxidative damage in brain*. J Chem Neuroanat 2016; 75(Pt B): 94-8.

[788] Bodera P, Makarova K, Zawada K, Antkowiak B, Paluch M, Sobiczewska E, et al. *The effect of 1800MHz radio-frequency radiation on NMDA receptor subunit NR1 expression and peroxidation in the rat*

brain in healthy and inflammatory states. Biomed Pharmacother 2017; 92: 802-9.

[789] Ertilav K, Uslusoy F, Ataizi S and Naziroglu M. *Long term exposure to cell phone frequencies (900 and 1800 MHz) induces apoptosis, mitochondrial oxidative stress and TRPV1 channel activation in the hippocampus and dorsal root ganglion of rats*. Metab Brain Dis 2018; 33(3): 753-63.

[790] Alkis ME, Bilgin HM, Akpolat V, Dasdag S, Yegin K, Yavas MC, et al. *Effect of 900-, 1800-, and 2100-MHz radiofrequency radiation on DNA and oxidative stress in brain*. Electromagn Biol Med 2019; 38(1): 32-47.

[791] Ahmed NA, Radwan NM, Aboul Ezz HS and Salama NA. *The antioxidant effect of Green Tea Mega EGCG against electromagnetic radiation-induced oxidative stress in the hippocampus and striatum of rats*. Electromagn Biol Med 2017; 36(1): 63-73.

[792] Naziroğlu M and Gümral N. *Modulator effects of L-carnitine and selenium on wireless devices (2.45 GHz)-induced oxidative stress and electroencephalography records in brain of rat*. Int J Radiat Biol 2009; 85(8): 680-9.

[793] Aït-Aïssa S, Pouletier de Gannes F, Taxile M, Billaudel B, Hurtier A, Haro E, et al. *In situ expression of heat-shock proteins and 3-nitrotyrosine in brains of young rats exposed to a WiFi signal in utero and in early life*. Radiat Res 2013; 179(6): 707-16.

[794] Chauhan P, Verma HN, Sisodia R and Kesari KK. *Microwave radiation (2.45 GHz)-induced oxidative stress: Whole-body exposure effect on histopathology of Wistar rats*. Electromagn Biol Med 2017; 36(1): 20-30.

[795] Irmak MK, Fadillioğlu E, Güleç M, Erdoğan H, Yağmurca M and Akyol O. *Effects of electromagnetic radiation from a cellular telephone on the oxidant and antioxidant levels in rabbits*. Cell Biochem Funct 2002; 20(4): 279-83.

[796] Ilhan A, Gurel A, Armutcu F, Kamisli S, Iraz M, Akyol O, et al. *Ginkgo biloba prevents mobile phone-induced oxidative stress in rat brain*. Clin Chim Acta 2004; 340(1-2): 153-62.

[797] Meral I, Mert H, Mert N, Deger Y, Yoruk I, Yetkin A, et al. *Effects of 900-MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels of guinea pigs*. Brain Res 2007; 1169: 120-4.

[798] Imge EB, Kilicoglu B, Devrim E, Cetin R and Durak I. *Effects of mobile phone use on brain tissue from the rat and a possible protective role of vitamin C - a preliminary study*. Int J Radiat Biol 2010; 86(12): 1044-9.

[799] Kesari KK, Kumar S and Behari J. *900-MHz microwave radiation promotes oxidation in rat brain*. Electromagn Biol Med 2011; 30(4): 219-34.

[800] Avci B, Akar A, Bilgici B and Tunçel OK. *Oxidative stress induced by 1.8 GHz radio frequency electromagnetic radiation and effects of garlic extract in rats*. Int J Radiat Biol 2012; 88(11): 799-805.

[801] Naziroğlu M, Celik O, Ozgul C, Cig B, Dogan S, Bal R, et al. *Melatonin modulates wireless (2.45 GHz)-induced oxidative injury through*

TRPM2 and voltage gated Ca(2+) channels in brain and dorsal root ganglion in rat. Physiol Behav 2012; 105(3): 683-92.

802 Ben Salah M, Abdelmelek H and Abderraba M. *Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals*. Environ Toxicol Pharmacol 2013; 36(3): 826-34.

803 Bilgici B, Akar A, Avci B and Tuncel OK. *Effect of 900 MHz radiofrequency radiation on oxidative stress in rat brain and serum*. Electromagn Biol Med 2013; 32(1): 20-9.

804 Çetin H, Naziroğlu M, Çelik O, Yüksel M, Pastaci N and Özkaya MO. *Liver antioxidant stores protect the brain from electromagnetic radiation (900 and 1800 MHz)-induced oxidative stress in rats during pregnancy and the development of offspring*. J Matern Fetal Neonatal Med 2014; 27(18): 1915-21.

805 Gürler HŞ, Bilgici B, Akar AK, Tomak L and Bedir A. *Increased DNA oxidation (8-OHdG) and protein oxidation (AOPP) by low level electromagnetic field (2.45 GHz) in rat brain and protective effect of garlic*. Int J Radiat Biol 2014; 90(10): 892-6.

806 Hu S, Peng R, Wang C, Wang S, Gao Y, Dong J, et al. *Neuroprotective effects of dietary supplement Kang-fu-ling against high-power microwave through antioxidant action*. Food Funct 2014; 5(9): 2243-51.

807 Narayanan SN, Kumar RS, Kedage V, Nalini K, Nayak S and Bhat PG. *Evaluation of oxidant stress and antioxidant defense in discrete brain regions of rats exposed to 900 MHz radiation*. Bratisl Lek Listy 2014; 115(5): 260-6.

808 Ragy MM. *Effect of exposure and withdrawal of 900-MHz-electromagnetic waves on brain, kidney and liver oxidative stress and some biochemical parameters in male rats*. Electromagn Biol Med 2014.

809 An K, Wang Q, Zhang Y, Guo D and Cui X. *The preventative effects of zinc and vitamin E supplementation on cellular phone radiation-induced oxidative stress in brain tissues of rats and their fetuses*. Trace Elem Electrol 2015; 32(3): 119-25.

810 Kamali K, Taravati A, Sayyadi S, Gharib FZ and Maftoon H. *Evidence of oxidative stress after continuous exposure to Wi-Fi radiation in rat model*. Environ Sci Pollut Res Int 2018; 25(35): 35396-403.

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