

The EMF Research Book (draft edition)

**A collection of theories and hypotheses for the study of biological and health
effects of electromagnetic fields**

Mads Rohde

2024-11-09

Table of contents

Preface	5
1 Introduction (draft)	6
1.1 Historical heritance	6
1.1.1 “Dosimetry”, 1931-1941	6
1.1.2 Safetety limits, Schwan, 1953	6
1.2 Exposure values, limits, levels, thresholds,	7
1.2.1 ICNIRP: “Basic restrictions” and “reference levels”	7
I Characteristics (draft)	9
2 Characteristics of electromagnetic fields and radiation	11
2.1 Clean waves versus waves used for communication	11
2.1.1 Clean waves	11
2.1.2 Pulses	11
2.1.3 Polarization	12
2.2 Natural electromagnetism	12
2.2.1 Space and the sun	12
3 Nomenclature (draft)	13
II Effects (draft)	14
4 Thermal theories (draft)	15
5 Non-thermal theories (draft)	16
5.1 The interaction with specific biological components	16
5.1.1 Melanin	16
5.2 The Zeeman effect (Chiabrera et al. 2000)	16
5.3 The Rouleaux Effect	16
5.4 Microbiome	16
6 Ionizing radiation theories (draft)	17

7	Specific diseases (draft)	18
7.1	Cardiovascular disease	18
7.1.1	Blood pressure	18
7.2	Cancer	18
8	Psychological theories (draft)	19
III	Exposure assessment	20
9	Real world measurements (draft)	22
9.1	5G exposure	22
10	Exposure in general (draft)	23
10.1	Fifth generation mobile phone technology (5G)	23
IV	Resources (draft)	24
	Identifying research gaps	25
11	Literature data (draft)	26
11.1	Soviet research	26
11.2	General articles about EMF research history	26
11.3	Short notes about general databases for scientific literature	28
11.3.1	Biomedical and health literature databases	28
11.3.2	Multidisciplinary databases	31
11.3.3	Technical disciplines literature databases	32
11.3.4	Psychology or social sciences literature databases	32
11.3.5	Databases that possibly capture literature in languages other than English	33
11.3.6	Grey literature	34
11.3.7	Books and online libraries	35
11.4	Finding a journal to publish in	36
11.4.1	Impact factor	36
11.4.2	h-index	37
11.4.3	Scimago Journal & Country Rank	38
12	Open data (draft)	39
13	EMF research around the world (draft edition)	40
14	Hypotheses(draft)	41
14.1	List of novel hypotheses or research questions	41
14.2	Long leaps and speculations	41

15 Terms to use (draft)	42
References	43

Preface

Tip

The best book for scientific ideas, including generating new ideas and bringing ideas to life – within the field of biological and health effects of electromagnetic fields (EMF).

This is a collection of theories and hypotheses related to the study of biological and health effects of non-ionizing radiation.

Copyright © 2025 Mads K. Rohde. All Rights Reserved.

The aim of the book is to be a comprehensive list of the theories and hypotheses related to non-ionizing radiation that can be used for researchers and others who want to familiar themselves with the topic; look up potential frameworks to interpret findings; or explore research gaps and possible new research questions and methods.

The aim is not to discuss specific research findings, but rather to provide a scope of theories. However, relevant scientific references for each theory should be included. But to support the progress of the development of this book, such lists may most often not be exhaustive, meaning that a theory may be included with one reference initially that is not necessarily the most updated and correct reference.

It is also not the aim that theories or hypotheses included should have been proven to be correct (or scientifically speaking, not haven been falsified). Theories that are speculative, or even wrong, may also be included, and the reader should be aware this. The reason for this is that ideas that have not yet been researched may have extra value in that they may point to research gaps, and theories that have proven wrong may prohibit other researchers to waste their effort following that same path.

1 Introduction (draft)

Electromagnetic fields are ...

1.1 Historical heritage

1.1.1 “Dosimetry”, 1931-1941

“Domistry” is a term with historical roots in the the treatment of disease. Guy writes the following (2015) (my emphasis):

Between 1931 and 1941, there were many basic problems in the use of radiofrequency energy for effective therapeutic heating of tissues. Most of these problems arose because investigators were not able to quantify the **actual rate of energy absorption** by tissues during treatment. The results of uncontrolled experiments resulted in contradictory statements in the medical literature. The various short-wave generators produced by different manufacturers had variable outputs. It was implied through advertisements that the heating of deeper tissues would be enhanced with greater output power of the generating equipment.

1.1.2 Safety limits, Schwan, 1953

After a proposal by Schwan in 1953, ANSI adopted a recommendation in 1966, on a limit of 10 mW/cm² (Arthur W. Guy 2015) (which is the same as 100.000 mW/m², 100.000.000 μ W/m², or 100 W/m²):

In 1953, Schwan recommended that microwave radiation of 10 mW/cm² be accepted as a tolerance dose. Five years later, however, the Soviet Union promulgated an occupational standard limiting microwave exposure to only 10 uWIsqcm. Subsequently, after a review of all the experimental data on animal exposure at that time, it was the conclusion of various American investigators that it required exposure levels in excess of 100 mWIncrr to produce any effect of biological significance. On this basis, with a safety factor of ten, a maximum safe exposure level of 10 mWIncrr was recommended by the United States of America Standards Institute (USASI) in 1966. The standard specifying only power density was defined to cover

the frequency range 10 MHz-100 GHz. Later, the name of USASI was changed to the American National Standards Institute (ANSI), and the ANSI-C95 Committee responsible for the 1966 recommended guidelines continued its work [...]

1.2 Exposure values, limits, levels, thresholds, ...

When addressing what safe levels of exposures are, many different names are used.

1.2.1 ICNIRP: “Basic restrictions” and “reference levels”

For instance the *International Commission on Non-Ionizing Radiation Protection* (ICNIRP) (International Commission on Non-Ionizing Radiation Protection 2020) has set *exposure guidelines* for radio-frequency (RF) radiation (100 kHz to 300 GHz), using the terms “*basic restrictions*” and “*reference levels*”. Basic restrictions are measured in W/kg and are related to *absorbed* radiation. Because absorbed radiation is not easily measured, reference levels that are measured in W/m² (or V/m and A/m for the electric and magnetic field components), is used instead for practical purposes. Reference levels reflects the intensity of the radiation over a surface area, you can say outside the body if you will.

ICNIRPs reference levels are made to reflect the basic restrictions. That is, if a human being is exposed to radiation at a *reference level* (measured in W/m²), the heating effect of the body would be the corresponding values of the *basic restrictions* (measured in W/kg).

So ICNIRPs division of limits into such *basic restrictions* and *reference values* follows from practical considerations, but at the root it follows from ICNIRPs dosimetric tradition, that is based on the premise that the *absorbed amount of radiation* is the relevant parameter as this creates heat effects of radiation that is absorbed by the human body (see description of dosimetry elsewhere).

However, it should be noted that the ICNIRP guidelines are even more complicated than this. In total they use *five* different values for *basic restrictions* in their guidelines (SAR, Sab, SA, Uab, and Eind) and eight different values for levels:

SAR, Sab, SA, Uab, and Eind are the quantities used in these guidelines to specify the basic restrictions. As the quantities used to specify basic restrictions can be difficult to measure, quantities that are more easily evaluated are also specified, as reference levels. The reference level quantities relevant to these guidelines are incident electric field strength (E_{inc}) and incident magnetic field strength (H_{inc}), incident power density (S_{inc}), plane-wave equivalent incident power density (S_{eq}), incident energy density (U_{inc}), and plane-wave equivalent incident energy density (U_{eq}), all measured outside the body, and electric current inside the body, I , described in units of ampere (A). Basic restriction and reference level units are

shown in Table 1, and definitions of all relevant terms provided in Appendix A, in the “Quantities and Units” section

The reason for the many different ways to quantize the radiation, is for instance that for higher frequencies that are not absorbed deeply into tissue, ICNIRP (International Commission on Non-Ionizing Radiation Protection 2020) (p.486) take the position that the *absorption* over surface area is more relevant:

From a health risk perspective, we are generally interested in how much EMF power is absorbed by biological tissues, as this is largely responsible for the heating effects described above. This is typically described as a function of a relevant dosimetric quantity. For example, below about 6 GHz, where EMFs penetrate deep into tissue (and thus require depth to be considered), it is useful to describe this in terms of “specific energy absorption rate” (SAR), which is the power absorbed per unit mass (W kg^{-1}). Conversely, above 6 GHz, where EMFs are absorbed more superficially (making depth less relevant), it is useful to describe exposure in terms of the density of absorbed power over area (W m^{-2}), which we refer to as “absorbed power density” (S_{ab}).

Anyhow, the general and most relevant values from the ICNIRP guidelines are that the *basic restrictions* are set at 0.08 W/kg for the general population and 0.4 W/kg in occupational settings, for whole body exposure, as specified in table 2 in the ICNIRP guidelines (International Commission on Non-Ionizing Radiation Protection 2020). These *basic restrictions* can be transformed to *reference values*, depending on the frequencies of the radiation, using various formulas, such as from table 3 in the ICNIRP guidelines.

Part I

Characteristics (draft)

This chapter ...

2 Characteristics of electromagnetic fields and radiation

2.1 Clean waves versus waves used for communication

2.1.1 Clean waves

2.1.2 Pulses

When talking about *pulsed* waves, how can we try to understand what is meant, as concretely as possible?

Presman (Presman 1970, 120–21) provides a description, from which we can infer what *pulses* really are (my emphasis):

[...] [a] series of experiments in which different regions of the body were exposed to more intense radiation – **pulses of continuous waves** (700-1200 mW/cm² per pulse) **or a series of short pulses** (1 μ sec long, 700 pulses/sec, mean power in series 350-380 mW/cm²), **the duration of the pulses and series being 0.1 sec and the repetition rate two per second.**

So pulses has several components, and can consist of either a continuous wave (being turn on/off) or a series of smaller pulses within each pulse.

The first component is the amount of time the pulse is on, here 0.1 seconds.

Think of the continuous wave pulse as a burst of radiation, that turns on for that specific amount of time.

The second component is the repetition rate, here two times per second. One can infer from that the time the wave is off, here it must be 0.4 seconds, since there are only two 0.1 second pulses per second, i.e. the pulse is off for a total of 0.8 seconds, per second.

In addition, if the radiation is not a continuous wave, it can instead be seen as *pulses within pulses*, or *outer* and *inner* pulses, in such a way that for each two 0.1 second burst, per second there are actually 700 smaller 1 μ sec long pulses where the radiation is turned on/off. *Inner* pulses. Since there are 700 pulses per second, but the pulse is only 0.1 second each time, then there are 70 pulses each time the *outer* pulse is on, so 140 pulses in total per second.

2.1.3 Polarization

2.2 Natural electromagnetism

2.2.1 Space and the sun

Coronal mass ejection (CME): Ejection of plasma mass from the sun. One often talks about flares, and flares of different strength, e.g. X1 to X100. The Carrington event (1859) is said to have been between X45 or X80 flare (ADD REFERENCE). One also talk about the KP-index – the geomagnetic storm index, with values like typically Kp5-Kp9.

Cosmic microwave background radiation (CMB(R)): (LOOK UP AND IMPROVE TERMINOLOGY AND ABBREVIATION, NOT SURE IF THIS IS USED OR COMMONLY USED)

3 Nomenclature (draft)

Part II

Effects (draft)

4 Thermal theories (draft)

5 Non-thermal theories (draft)

5.1 The interaction with specific biological components

5.1.1 Melanin

5.2 The Zeeman effect (Chiabrera et al. 2000)

5.3 The Rouleaux Effect

5.4 Microbiome

A hypothesis about how the microbiome can be affected by exposure to anthropogenic electromagnetic fields and create health effects, may first have been presented in a conference abstract in 2022, for a conference in Sogn og Fjordane in Norway (Manzetti 2022)

6 Ionizing radiation theories (draft)

7 Specific diseases (draft)

7.1 Cardiovascular disease

7.1.1 Blood pressure

Cell phone calls, and thus radiofrequency radiation, may be related to the development of high *blood-pressure* (hypertension) , according to a large study using data from the UK Biobank (Ye et al. 2023). Radiation exposure can be assumed to be strongly affected by cell phone usage. Confounding factors and other explanatory models can always exist. Mecanistic models for how a blood pressure increase can happen due to radiofrequency radiation, is a topic for future studies, – and such studies will increase the confidence in the findings from epidemiological studies on cell phone usage or similar exposure, and blood pressure.

7.2 Cancer

One of the earliest finding of cancer (malignant tumors) fom RF exposure was found in rats in 1984 (Microwave News 1984) The finding came after exposure to low level pulsed 2450 MHz radiation, in the first long-term study on microwave exposure in the United States, funded by the U.S. Air Force in a \$5 million (1984 value) dollar study. Notably, it took eight years from the findings were first presented at a conference until they were published in a scientific journal (Microwave News 1993; Chou et al. 1992).

8 Psychological theories (draft)

Part III

Exposure assessment

...

9 Real world measurements (draft)

9.1 5G exposure

2022:

- Columbia, SC, USA (Koppel and Hardell 2022)

2024:

- Stockholm, Sweden, 2024 (Hardell and Koppel 2024)

1998-2023:

A 2024 review (Ramirez-Vazquez et al. 2024) looked at a *“total of 86 papers published between 1 January 1998 and 31 December 2023 are included: 61 studies with spot measurements and 25 studies with mixed methodologies (spot measurements, personal measurements with volunteers or with a trained researcher and prediction models) are highlighted.”* They found the following:

The minimum mean value was measured in Palestine at $0.0600 \mu\text{W}/\text{m}^2$, and the maximum mean value was measured in Norway at $200,000 \mu\text{W}/\text{m}^2$.

As a reference, although disputed for providing safety, we can keep in mind the Schwan limit from 1953 written about elsewhere in this book, at $100,000.000 \mu\text{W}/\text{m}^2$, or $100 \text{ W}/\text{m}^2$ (Arthur W. Guy 2015). The high level measured in Norway, at $200,000 \mu\text{W}/\text{m}^2$ or $0.2 \text{ W}/\text{m}^2$, is not reaching the Schwan limit, but is 1/500th of that limit.

10 Exposure in general (draft)

10.1 Fifth generation mobile phone technology (5G)

Non-user exposure:

A 2023 study performed measurements “near two 5G New Radio (NR) base stations, one with an Advanced Antenna System (AAS) capable of **beamforming** and the other a traditional microcell.” (emphasizement/bold part added)(Aerts et al. 2023).

They found that exposure was in general lower for non-users than for users, but that “for the non-user, the difference lies in whether they are in a beam or not” and that when there are many users around the base station exposure can generally increase for the non-user.

Part IV

Resources (draft)

In this part of the book, various resources that can aid in research on electromagnetic fields. The various chapters holds resources such as information on literature databases, open data and scientific communities around the world.

Identifying research gaps

If you are interested in conducting new research on EMFs, the table below with *the seven research gaps* from Miles (2017) may aid you. What research gap *type* do you find to be the most important within EMF science?

Research Gap Type	Definition
Evidence Gap (Contradictory Evidence Gap)	Results from studies allow for conclusions in their own right, but are contradictory when examined from a more abstract point of view [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Knowledge Gap (Knowledge Void Gap)	Desired research findings do not exist [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Practical-Knowledge Gap (Action-Knowledge Conflict Gap)	Professional behavior or practices deviate from research findings or are not covered by research [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Methodological Gap (Method and Research Design Gap)	A variation of research methods is necessary to generate new insights or to avoid distorted findings [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Empirical Gap (Evaluation Void Gap)	Research findings or propositions need to be evaluated or empirically verified [Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Theoretical Gap (Theory Application Void Gap)	Theory should be applied to certain research issues to generate new insights. There is lack of theory thus a gap exists [Müller-Bloch & Kranz, 2014; Jacobs, 2011; Müller-Bloch & Kranz, 2014; Miles, 2017].
Population Gap	Research regarding the population that is not adequately represented or under-researched in the evidence base of prior research (e.g., gender, race/ethnicity, age, etc.) [Robinson, et al, 2011].
Sources	Robinson, Saldanha, & McKoy (2011); Müller-Bloch & Kranz, (2015); Miles, (2017).

11 Literature data (draft)

11.1 Soviet research

In the earliest time of EMF science, much research was done in the Soviet Union.

Big portions of this body of research may not be available in literature databases. As a starting point of an exploration of the Soviet research, below is a list of some sources discussing this literature.

- Glaser and Dodge (1976)
- D. I. McRee (1979)
- Donald I. McRee (1980)
- Kositsky, Nizhelska, and Ponezha (2001)
- Kostoff (2019)
- Kostoff (2020)

11.2 General articles about EMF research history

- Michaelson, Grandolfo, and Rindi (1985a)
- Arthur William Guy (2003)
- Arthur W. Guy (2015)
- Michaelson, Grandolfo, and Rindi (1985b)

Consideration of the historical development of the study of biological effects of extremely low frequency (ELF) fields should go back more than 2500 years, when Thales of Miletus (600 B.C.) observed that a piece of amber could be made to acquire the property of attracting small particles by rubbing it with a piece of cloth.

- Herman Schwan summarizes his experience with working as a researcher in the field from 1937 to the early 1970s as follows (Schwan 1992).

The early history of bioelectromagnetics is reviewed as I experienced it. The period of time chosen extends from my joining the Institute for Physical Foundations of Medicine in Frankfurt in 1937 to the early 1970s, when I retired from the chair of my department at the University of Pennsylvania. Several themes emerge from these recollections. First, clinical and biological work led almost immediately to a heated controversy about the role of athermal vs. thermal effects; this issue has never been settled to the satisfaction of most. Second, good quantitative work on electrical properties and dosimetry began early, well before World War II; its impact on future developments was significant.

- A short historical summary of EMF research by EMF:data (n.d.), states:

General research overview

As early as in the 1930s, first studies on radio-frequency radiation were published that observed effects relevant to human health. Shortly after World War II, studies began to focus on the radiation from radar equipment. The striking frequency of cataracts in radar technicians initiated the research efforts. Already at the beginning of the 1980s, on average about five studies on biological effects of radio-frequency radiation were published per month. Some of those studies, however, used field strengths that frequently resulted in the heating of tissues and thus documented a so-called thermal effect. The thermal dogma — which only recognizes thermal effects as promoted by the military-industrial complex, but not nonthermal effects — led to the circumstance that one area of research findings has been ignored in Western countries. This is also the cause of the very different exposure limits and safety guidelines in contrast to those in former Eastern Bloc countries in which nonthermal effects had been researched.

The health effects of radio-frequency radiation are anything but “not researched.” When considering the studies carried out by researchers independent of industry ties, a clear picture emerges: Radio-frequency radiation from wireless communication applications can cause considerable damage in biological systems, and studies demonstrate more and more often that such effects already occur at levels far below current exposure limits.

-

11.3 Short notes about general databases for scientific literature

11.3.1 Biomedical and health literature databases

11.3.1.1 Pubmed/MEDLINE

- “PubMed is a more user-friendly search engine for MEDLINE” (my translation of [snl.no article](#)).
- “MEDLINE is the largest and oldest biomedical database in the world” (“MEDLINE Data” n.d.).
- PubMed makes content searchable from three databases MEDLINE, PubMed Central and Bookshelf, and MEDLINE is the main component of PubMed:

To be added to a database, a publication must apply and be selected by NLM for inclusion in MEDLINE, PMC, or Bookshelf. PubMed indexes and makes searchable the contents of these databases; MEDLINE is the primary component of PubMed.

— [About PMC](#)

- Kostoff and Lau (2017) highlights the that PubMed (MEDLINE) has **MeSH terms**, which are unique keywords:

The two premier biomedical research article databases are the Web of Science (WOS-Science Citation Index/Social Science Citation Index/Arts and Humanities Citation Index-SCI/SSCI/A&HCI) and Medline. Each has its unique strengths. WOS has the capability for citation linkages (references, citing papers, papers that share at least one reference), while Medline has a unique taxonomy/keyword structure called MeSH. Both databases were used in this chapter for query development.

11.3.1.2 Embase (by Elsevier)(paid-access)

Embase has a similar scope to PubMed/MEDLINE - a database for biomedical research literature.

Embase claims to contain 99% of journals in MEDLINE, plus 3000 more journals that are not indexed by PubMed. It is stronger on drug literature than MEDLINE. It is also supposed to be better at capturing conference abstracts.

See also the [about page at Embase](#).

11.3.1.3 Cochrane Reviews database

What is a Cochrane review?

A Cochrane Review is a systematic review of research in health care and health policy that is published in the Cochrane Database of Systematic Reviews.”

— [About Cochrane Reviews](#)

A total of 9211 Cochrane Reviews had been published as of March 2024.

11.3.1.4 SveMed+

SveMed has better coverage for Scandinavian literature ([from](#)) (AI translation):

SveMed+ is a bibliographic database that contains references to articles from Scandinavian journals in the fields of medicine, dentistry, healthcare, occupational therapy, nursing, and physiotherapy.

11.3.1.5 Epistemonikos

About Epistemonikos from the Norwegian site [Helsebiblioteket](#) (AI translation):

Epistemonikos is a free international (multilingual) database that contains systematic reviews on clinical questions. Epistemonikos systematically searches PubMed and other databases for relevant systematic reviews and overviews of reviews on treatment, diagnosis, prognosis, harm, and etiology.

From the quote, it seems to focus on clinical questions, i.e. *treatment of disease*. Although etiology is also mentioned, so the database may provide useful in some instances for health related questions outside treatment of disease.

11.3.1.6 CINAHL (by EBSCO) (paid-access)

The [CINAHL](#) database focuses on nursing, allied health, and healthcare literature:

CINAHL indexes the top nursing and allied health literature available including nursing journals and publications from the National League for Nursing and the American Nurses Association.

It includes:

3,630 active indexed and abstracted journals 3,320 active peer-reviewed indexed and abstracted journals

11.3.1.7 Global Health (by EBSCO) (paid-access)

The *Global Health* database focuses on global health issues:

Global Health is the only specialized bibliographic, abstracting and indexing database dedicated to public health, completing the picture of international medical and health research by capturing key literature that is not covered by other databases, providing users with a truly global perspective.

It includes (as of March, 2025):

- 4,500,000 scientific records from 1973 to the present day
- 185,000 records added each year
- 7,000 indexed serials, books, book chapters, reports, conference proceedings, patents, theses, electronic publications and other hard-to-find resources
- 4,480 journals, of which more than 3,600 are unique to Global Health

11.3.1.8 AMED (paid-access)

AMED stands for (Allied and Complementary Medicine).

About AMED from the Norwegian page *Helsebiblioteket* (AI translated):

AMED (Allied and Complementary Medicine) registers journal articles in alternative medicine, physiotherapy, occupational therapy, palliative care, speech therapy, and rehabilitation. It covers nearly 600 journals, many of which are not found in other databases.

11.3.1.9 OVID (paid-access): Search several databases

OVID allows you to search through multiple databases

- MEDLINE, EMBASE, PsychInfo, HaPI, AMED, Maternity and Infant Care, Global Health and ERIC (an education-related research database)
- Clinical reference sources: BMJ Best Practices, UpToDate

11.3.1.10 AI tools for literature reviews

A lot of journals (but not all) submit publications to Semantic Scholar.

The following two tools use Semantic scholar as their primary data source:

- Elicit.com (148 million scientific papers): Good for systematic reviews and meta-analyses.
- Consensus.app (>220 million scientific papers): Summaries of “scientific consensus” on any question or research question.

Semantic Scholar is great for for instance finding academic papers and citation analysis. At semanticscholar.org, they say that Semantic Scholar is a “free, AI-powered research tool for scientific literature”.

11.3.2 Multidisciplinary databases

11.3.2.1 Web of Science (by Clarivate) (paid-access)

Some main features are listed below. For more information see [Web of Science website](https://www.clarivate.com/web-of-science).

Also, note that Kostoff and Lau (2017) highlights the that Web of Science has “*has the capability for citation linkages (references, citing papers, papers that share at least one reference)*”:

The two premier biomedical research article databases are the Web of Science (WOS-Science Citation Index/Social Science Citation Index/Arts and Humanities Citation Index-SCI/SSCI/A&HCI) and Medline. Each has its unique strengths. WOS has the capability for citation linkages (references, citing papers, papers that share at least one reference), while Medline has a unique taxonomy/keyword structure called MeSH. Both databases were used in this chapter for query development.

Web of Science Core Collection:

- Number of journals: “> 22,171 journals + books and conference proceedings”
- Coverage: Over 91 million records; More than 143,000 books; Over 304,000 conferences.
- Content: “Life sciences, biomedical sciences, engineering, social sciences, arts & humanities. Strongest coverage of natural sciences, health sciences, engineering, computer science, materials sciences.”

Web of Science platform

- Number of journals: “> 34,651 journals + books, proceedings, patents, and data sets”
- Coverage: Over 217 million records (journals, books, and proceedings); 59 million patent families (> 115 million patents); More than 13 million data sets

– Content: “Biomedical sciences, natural sciences, engineering, social sciences, arts & humanities. Strongest coverage of natural sciences & engineering, computer science, materials sciences, patents, data sets. Regional Citation indexes provide deep coverage in sciences, social sciences, and humanities for Korea, Russia (suspended as of March 2022), Latin America, and China.”

11.3.2.2 Scopus (by Elsevier)

What is Scopus (from [Wikipedia](#)):

Scopus is Elsevier’s abstract and citation database launched in 2004.[1] Scopus covers 36,377 titles (22,794 active titles and 13,583 inactive titles) from 11,678 publishers, of which 34,346 are peer-reviewed journals in top-level subject fields: life sciences, social sciences, physical sciences and health sciences. It covers three types of sources: book series, journals, and trade journals. Scopus also allows patent searches in a dedicated patent database Lexis-Nexis, albeit with a limited functionality.[2]

11.3.3 Technical disciplines literature databases

11.3.3.1 IEEE Xplore:

[IEEE Xplore](#) lists 6,266,140 items as of April 1 2024.

This can be an important additional source for literature related to electromagnetic fields, as it relates to health, even if articles will be more on the technical side, than about health per se.

If you for instance [search “James Benford”](#) you will see a few example for articles that are not found in PubMed.

A quick search for [“Microwave health”](#) returned 2114 items on April 1 2024, and may give some indication on the number of studies to expect to find of more direct relevance for health in IEEE Xplore.

11.3.4 Psychology or social sciences literature databases

11.3.4.1 PsychINFO (by APA)

PsychINFO by APA is a database for literature within the discipline of psychology:

The premier abstracting and indexing database covering the behavioral and social sciences from the authority in psychology.

APA PsycInfo at a glance • Over 5,000,000 peer-reviewed records • 144 million cited references • Spanning 600 years of content • Updated twice-weekly • Research in 30 languages from 50 countries • Records from 2,400 journals • Content from journal articles, book chapters, and dissertations • AI and machine learning-powered research assistance

11.3.5 Databases that possibly capture literature in languages other than English

11.3.5.1 LIVIVO by ZB MED (German)

About LIVIVO:

LIVIVO is Europe's largest search engine for literature and information (research data) in the field of life sciences. It is run by ZB MED – Information Centre for Life Sciences. Drawing on nearly 80 million data records, it brings together under one roof the specialist subjects of medicine and health and nutritional, environmental and agricultural sciences. With comprehensive coverage of its core subjects, it supports interdisciplinarity and transdisciplinarity in academic and scientific works.

About ZB MED:

ZB MED – Information Centre for Life Sciences is Germany's national infrastructure and research hub for data and information in the life sciences. Our digital services support research projects that benefit people and the environment: from medicine and biodiversity to environmental protection.

Go to [ZBMED](#) to search LIVIVO.

11.3.5.2 LILACS

The most important index of the technical-scientific literature in Latin America and the Caribbean, LILACS, was created in 1985 to record scientific and technical production in health. It has been maintained and updated by a network of more than 600 institutions of education, government, and health research and coordinated by Latin America and Caribbean Center on Health Sciences Information (BIREME), Pan American Health Organization (PAHO), and World Health Organization (WHO).

LILACS contains scientific and technical literature from over 908 journals from 26 countries in Latin America and the Caribbean, with free access. About 900,000 records from articles with peer review, theses and dissertations, government documents, conference proceedings, and books; more than 480,000 of them are available with the full-text link in open access.

The LILACS Methodology is a set of standards, manuals, guides, and applications in continuous development, intended for the collection, selection, description, indexing of documents, and generation of databases. This centralised methodology enables the cooperation between Latin American and Caribbean countries to create local and national databases, all feeding into the LILACS database. Currently, the databases LILACS, BBO, BDENF, MEDCARIB, and national databases of the countries of Latin America are part of the LILACS System.

Health Sciences Descriptors (DeCS) is the multilingual and structured vocabulary created by BIREME to serve as a unique language in indexing articles from scientific journals, books, congress proceedings, technical reports, and other types of materials, and also for searching and retrieving subjects from scientific literature from information sources available on the Virtual Health Library (VHL) such as LILACS, MEDLINE, and others. It was developed from the MeSH with the purpose of permitting the use of common terminology for searching in multiple languages, and providing a consistent and unique environment for the retrieval of information. DeCS vocabulary is dynamic and totals 34,118 descriptors and qualifiers, of which 29,716 come from MeSH, and 4,402 are exclusive.

The quote is from this [link](#).

11.3.5.3 WHO Global Index Medicus (GIM)

[WHO Global Index Medicus](#)

The Global Index Medicus (GIM) provides worldwide access to biomedical and public health literature produced by and within low-middle income countries. The main objective is to increase the visibility and usability of this important set of resources. The material is collated and aggregated by WHO Regional Office Libraries on a central search platform allowing retrieval of bibliographical and full text information.

The quote is from this [link](#).

11.3.6 Grey literature

11.3.6.1 Open Grey System for Information on Grey Literature in Europe

[Opengrey.eu](#)

No longer maintained:

The System for Information on Grey Literature in Europe used to give open access to 700.000 bibliographical references of grey literature (paper) produced in Europe and allowed to export records and locate the documents.

The quote is from this [link](#).

Kilder til kliniske oppslagsverk, pågående studier og grå litteratur.

11.3.6.2 OAIster (oclc.org)

[OAIster](#)

OAIster is a union catalog of millions of records that represent open access resources. This catalog was built through harvesting from open access collections worldwide using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Today, OAIster includes more than 50 million records that represent digital resources from more than 2,000 contributors.

11.3.7 Books and online libraries

Some (40) sites to find books are (from [ScholarshipPhd X/Twitter post](#)):

1. Planet eBook
2. Free-eBooks. net
3. ManyBooks
4. LibriVox
5. Internet Archive
6. BookBub
7. Open Library
8. BookBoon
9. Feedbooks
10. Smashwords
11. Project Gutenberg
12. Google Books
13. PDFBooksWorld
14. FreeTechBooks
15. Bookyards
16. GetFreeBooks
17. eBookLobby
18. FreeComputerBooks
19. OpenCulture
20. Library Genesis (LibGen)
21. Goodreads

22. Obooko
23. O'Reilly
24. PDF Drive
25. Anna's Archive
26. PDF Room
27. PDF Coffee
28. Dokumen Pub
29. Z Library
30. Ocean of PDF
31. Dirzon
32. Booksfree
33. EngbooksPDF
34. Elejandria
35. Espaebook
36. Wonderful Books
37. Lectuland
38. LeerLibrosOnline
39. ePubLibre
40. Standard Ebooks

11.3.7.1 Libraries

The national library in Great Britain: British Library [explore.bl.uk](https://www.britishlibrary.org/explore)

The world's biggest library - the library of the congress in the United States: [Library of congress](https://www.loc.gov/)

[WorldCat](https://www.worldcat.org/): > WorldCat is the world's largest library catalog, helping you find library materials online

11.4 Finding a journal to publish in

11.4.1 Impact factor

When choosing an journal, the *impact factor* may be useful to factor in to your decision.

Some lists of impact factors for potential journals may exit. For instance a researcher listed "*the best journals in electromagnetic fields and waves in 2019*", at [ResearchGate](https://www.researchgate.net/publication/351111111) in June, 2021:



Mahmoud Fallah

Iran University of Science and Technology



What are the best journals in electromagnetic fields and waves in 2019 (This list will be complete)?

Question Asked June 19, 2021

Science-IF=41.8

[\(https://www.sciencemag.org/\)](https://www.sciencemag.org/)

Science Advances-IF=13.1

[\(https://www.sciencemag.org/\)](https://www.sciencemag.org/)

Nature-IF=42.7

[\(https://www.nature.com/\)](https://www.nature.com/)

Nature materials-IF= 38.663

[\(https://www.nature.com/\)](https://www.nature.com/)

Advanced materials- IF=27.3

[\(https://onlinelibrary.wiley.com/\)](https://onlinelibrary.wiley.com/)

Nature Communications-IF= 12.121

[\(https://www.nature.com/\)](https://www.nature.com/)

Nanophotonics-IF=8.449

<https://www.degruyter.com/journal/key/NANOPH/html>

IEEE Transactions on Antennas and Propagation -IF=4.3

[\(https://ieeexplore.ieee.org/\)](https://ieeexplore.ieee.org/)

IEEE Antennas and Wireless Propagation Letters-IF=3.7

[\(https://ieeexplore.ieee.org/\)](https://ieeexplore.ieee.org/)

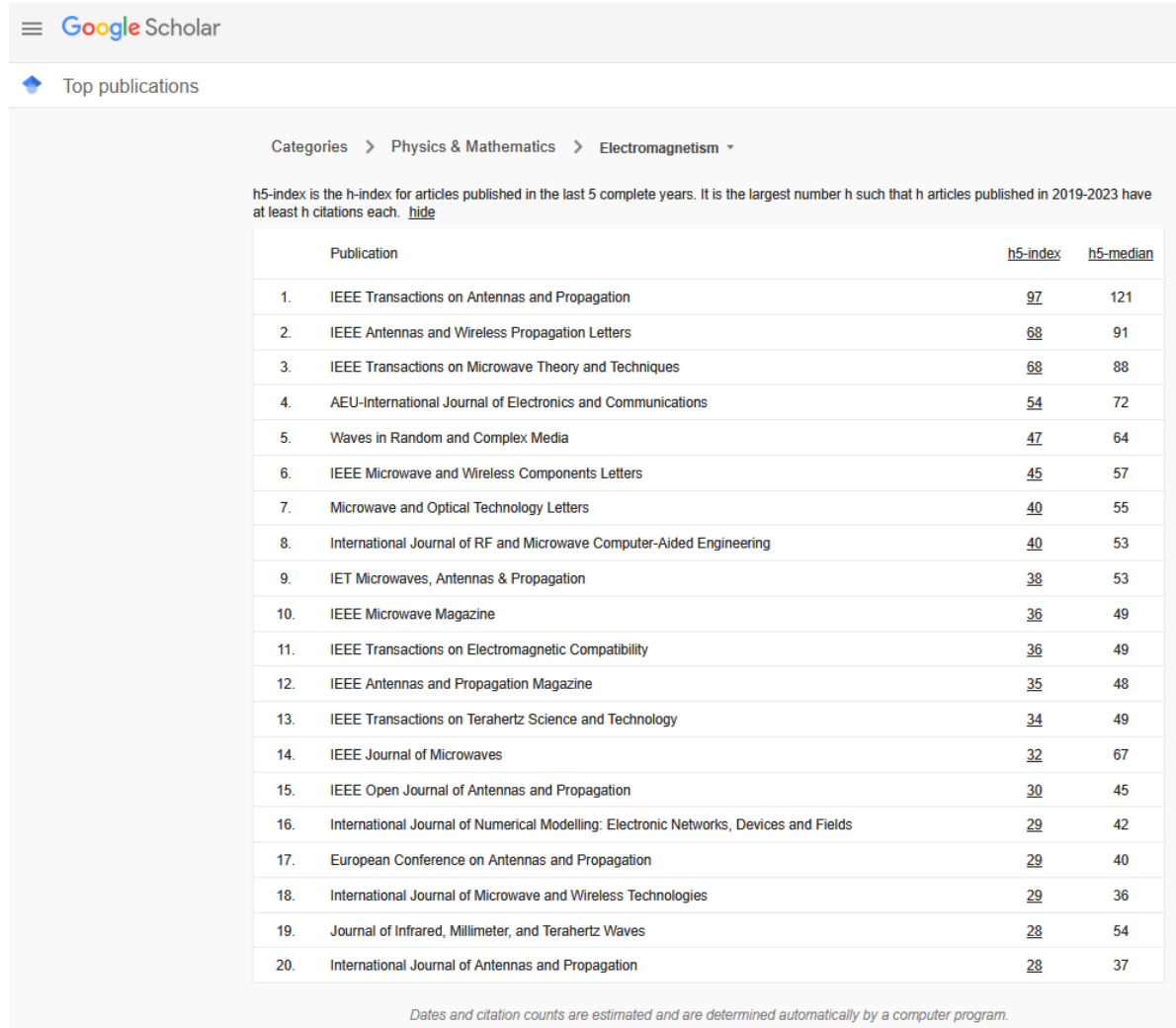
Note that impact factors may vary overtime. For instance the for the journal *Frontiers in Public Health*, which has an own section for the speciality of *Radiation and Health*, [the impact factor was 3.709, then 6.461 in 2022](#). The journals usually list their impact factor at their [website](#) (the impact factor was 3.0 for *Frontiers in Public Health* in March 2025).

11.4.2 h-index

Another indicator to look at is the h-index, which is *the largest number h such that h articles published [for a given period] have at least h citations each*.

A list at Google Scholar lists the h5-index for the top publications within the category *Physics & Medicine/Electromagnetism*. A screenshot of the [list](#) from 30 March 2025 is shown below.

None of the lists mentioned above may however not be the most relevant for publications specifically related to *health* and EMFs.



The screenshot shows the Google Scholar interface for the 'Top publications' section under the category 'Physics & Mathematics > Electromagnetism'. It includes a table of 20 top publications with their h5-index and h5-median values. A note explains that the h5-index is the largest number h such that h articles published in 2019-2023 have at least h citations each. A disclaimer at the bottom states that dates and citation counts are estimated and determined automatically by a computer program.

Publication	h5-index	h5-median
1. IEEE Transactions on Antennas and Propagation	97	121
2. IEEE Antennas and Wireless Propagation Letters	68	91
3. IEEE Transactions on Microwave Theory and Techniques	68	88
4. AEU-International Journal of Electronics and Communications	54	72
5. Waves in Random and Complex Media	47	64
6. IEEE Microwave and Wireless Components Letters	45	57
7. Microwave and Optical Technology Letters	40	55
8. International Journal of RF and Microwave Computer-Aided Engineering	40	53
9. IET Microwaves, Antennas & Propagation	38	53
10. IEEE Microwave Magazine	36	49
11. IEEE Transactions on Electromagnetic Compatibility	36	49
12. IEEE Antennas and Propagation Magazine	35	48
13. IEEE Transactions on Terahertz Science and Technology	34	49
14. IEEE Journal of Microwaves	32	67
15. IEEE Open Journal of Antennas and Propagation	30	45
16. International Journal of Numerical Modelling: Electronic Networks, Devices and Fields	29	42
17. European Conference on Antennas and Propagation	29	40
18. International Journal of Microwave and Wireless Technologies	29	36
19. Journal of Infrared, Millimeter, and Terahertz Waves	28	54
20. International Journal of Antennas and Propagation	28	37

Dates and citation counts are estimated and are determined automatically by a computer program.

11.4.3 Scimago Journal & Country Rank

At [Scimago Journal & Country Rank](#) you can inspect different metrics of journal indicating the quality of the research in it.

12 Open data (draft)

13 EMF research around the world (draft edition)

14 Hypotheses(draft)

14.1 List of novel hypotheses or research questions

- Can RF radiation increase strength of risk from UV light exposure?

14.2 Long leaps and speculations

Here are some speculative theories or ideas. The ideas are only scientific in so far that they are possible to test and disprove (falsify). They might be stimulating, engaging or just fun or provocative to read.

- 1) Today, all have their own phones. Particularly with the introduction of the fifth generation of mobile technology (5G) and beamforming, being close to others can increase exposure.

If it is so that RF-EMF is a stressor, a question becomes, can there be *subliminal conditioning* (*pavlovian*), where the body experience stress when close to others, and thus starts to associate being close to others as stressful.

How can such a theory be tested? Rats can be mounted with their own mini “mobile phone” with beamforming technology in a rat city with transmission antennas around the “city”. Control groups do not have their own phone. Will the rats become less social?

15 Terms to use (draft)

Many phenomena within this research field have a diverse nomenclature.

In this chapter we list various terms with examples on usage.

- *electromagnetic radiation*

electromagnetic radiation emitted by wireless communication devices

From (Leszczynski 2025)

References

- “About EMF:data - Emfdata.org.” n.d. <https://www.emfdata.org/en/about-emf-data>. Accessed December 6, 2020.
- Aerts, Sam, Kenneth Deprez, Leen Verloock, Robert G. Olsen, Luc Martens, Phung Tran, and Wout Joseph. 2023. “RF-EMF Exposure Near 5G NR Small Cells.” *Sensors (Basel, Switzerland)* 23 (6): 3145. <https://doi.org/10.3390/s23063145>.
- Chiabrera, A., B. Bianco, E. Moggia, and J. J. Kaufman. 2000. “Zeeman-Stark Modeling of the RF EMF Interaction with Ligand Binding.” *Bioelectromagnetics* 21 (4): 312–24. [https://doi.org/10.1002/\(sici\)1521-186x\(200005\)21:4%3C312::aid-bem7%3E3.0.co;2-#](https://doi.org/10.1002/(sici)1521-186x(200005)21:4%3C312::aid-bem7%3E3.0.co;2-#).
- Chou, C. K., A. W. Guy, L. L. Kunz, R. B. Johnson, J. J. Crowley, and J. H. Krupp. 1992. “Long-Term, Low-Level Microwave Irradiation of Rats.” *Bioelectromagnetics* 13 (6): 469–96. <https://doi.org/10.1002/bem.2250130605>.
- Glaser, Zorach R., and Christopher H. Dodge. 1976. “Biomedical Aspects of Radiofrequency and Microwave Radiation: A Review of Selected Soviet, East European, and Western References.” In *Biologic Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting (Boulder, Colorado, Oct. 20-23, 1975)*, 2–34. HEW Publications (FDA) 77-8010 and 77-8011.
- Guy, Arthur W. 2015. “Biological Effects of Electromagnetic Radiation.” *ETHW*. https://ethw.org/Biological_Effects_of_Electromagnetic_Radiation.
- Guy, Arthur William. 2003. “History of Biological Effects and Medical Applications of Microwave Energy.” *IEEE Transactions on Microwave Theory and Techniques* 32 (9): 1182–1200.
- Hardell, Lennart, and Tarmo Koppel. 2024. “Spots with Extremely High Radi-ofrequency Radiation After Deployment of 5G Base Sta-tions in Stockholm, Sweden.” *Ann Clin Med Case Rep* 14 (4): 1–8.
- International Commission on Non-Ionizing Radiation Protection. 2020. “Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz).” *Health Physics* 118 (5): 483–524.
- Koppel, Tarmo, and Lennart Hardell. 2022. “Measurements of Radiofrequency Electromagnetic Fields, Including 5G, in the City of Columbia, SC, USA.” *World Academy of Sciences Journal* 4 (3): 22. <https://doi.org/10.3892/wasj.2022.157>.
- Kositsky, Nikolai Nikolaevich, Aljona Igorevna Nizhelska, and Grigory Vasil’evich Ponezha. 2001. “Influence of High-Frequency Electromagnetic Radiation at Non-Thermal Intensities on the Human Body.” *No Place To Hide-Newsletter of the Cellular Phone Taskforce Inc* 3 (1): 1–33.
- Kostoff, Ronald N. 2019. “Adverse Effects of Wireless Radiation.”

- . 2020. “The Largest Unethical Medical Experiment in Human History.” *PDF*. <http://hdl.handle.net/1853/62452>.
- Kostoff, Ronald N., and Clifford G. Y. Lau. 2017. “Modified Health Effects of Non-ionizing Electromagnetic Radiation Combined with Other Agents Reported in the Biomedical Literature.” In *Microwave Effects on DNA and Proteins*, edited by Chris D. Geddes, 97–157. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-50289-2_4.
- Leszczynski, Dariusz. 2025. “Wireless Radiation and Health: Making the Case for Proteomics Research of Individual Sensitivity.” *Frontiers in Public Health* 12 (January). <https://doi.org/10.3389/fpubh.2024.1543818>.
- Manzetti, Sergio. 2022. “On the Potential Underlying Cause of Electromagnetic Field Hypersensitivity: A Connection to the Gut Microbiome.”
- McRee, D. I. 1979. “Review of Soviet/Eastern European Research on Health Aspects of Microwave Radiation.” *Bulletin of the New York Academy of Medicine* 55 (11): 1133–51.
- McRee, Donald I. 1980. “Soviet and Eastern European Research on Biological Effects of Microwave Radiation.” *Proceedings of the IEEE* 68 (1): 84–91.
- “MEDLINE Data.” n.d. <https://www.ncbi.nlm.nih.gov/IEB/ToolBox/SDKDOCS/MEDLINE.HTML>. Accessed March 3, 2024.
- Michaelson, Sol M., Martino Grandolfo, and Alessandro Rindi. 1985a. “Historical Development of the Study of the Effects of ELF Fields.” In *Biological Effects and Dosimetry of Static and ELF Electromagnetic Fields*, edited by M. Grandolfo, S. M. Michaelson, and A. Rindi, 1–13. Boston, MA: Springer US. https://doi.org/10.1007/978-1-4613-2099-9_1.
- . 1985b. “Historical Development of the Study of the Effects of ELF Fields.” In *Biological Effects and Dosimetry of Static and ELF Electromagnetic Fields*, edited by M. Grandolfo, S. M. Michaelson, and A. Rindi, 1–13. Boston, MA: Springer US. https://doi.org/10.1007/978-1-4613-2099-9_1.
- Microwave News. 1984. “Microwaves Promote Cancer” 4 (6): 1–5.
- . 1993. “Updates - Guy Study” 8 (1): 13.
- Miles, D. Anthony. 2017. “A Taxonomy of Research Gaps: Identifying and Defining the Seven Research Gaps.” In *Doctoral Student Workshop: Finding Research Gaps-Research Methods and Strategies, Dallas, Texas*, 1–15.
- Presman, A. S. 1970. *Electromagnetic Fields and Life*. Edited by Frank A. Brown. Boston, MA: Springer US. <https://doi.org/10.1007/978-1-4757-0635-2>.
- Ramirez-Vazquez, Raquel, Isabel Escobar, Enrique Arribas, and Guy AE Vandenbosch. 2024. “Systematic Review of Exposure Studies to Radiofrequency Electromagnetic Fields: Spot Measurements and Mixed Methodologies.” *Applied Sciences* 14 (23): 11161.
- Schwan, Herman P. 1992. “Early History of Bioelectromagnetics.” *Bioelectromagnetics* 13 (6): 453–67. <https://doi.org/10.1002/bem.2250130604>.
- Ye, Ziliang, Yanjun Zhang, Yuanyuan Zhang, Sisi Yang, Mengyi Liu, Qimeng Wu, Chun Zhou, Panpan He, Xiaoqin Gan, and Xianhui Qin. 2023. “Mobile Phone Calls, Genetic Susceptibility, and New-Onset Hypertension: Results from 212 046 UK Biobank Participants.” *European Heart Journal - Digital Health* 4 (3): 165–74. <https://doi.org/10.1093/ehjdh/ztad024>.