NextGEM

Next Generation Integrated Sensing and Analytical System for Monitoring and Assessing Radiofrequency Electromagnetic Field Exposure and Health

D2.3: Health risks, citizen's concerns and international guidelines

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Table of Contents

List of Figures

List of Tables

Glossary of terms and abbreviations used

Abbreviation / Term	Description
CCARS	Comité Científico Asesor en Radiofrecuencias y Salud
CDC	Centers for Disease Control and Prevention
CNS	Central Nervous System
CENELEC	European Committee for Electrotechnical Standardization
COSTER	Recommendations for the conduct of systematic reviews in toxicology and environmental health research
EBPH	Evidence Based Public Health
ECDC	European Centers for Disease Control
FCC	Federal Commission Communications
ICNIRP	International Commission on Non-Ionizing Radiation Protection
HE	Electromagnetic Hypersensitivity
IEEE	Institute of Electrical and Electronics Engineers
KP-EMV	Knowledge Platform on EMF and Health (in the Netherlands)
MHW	Modern Health Worries
MR	Mendelian Randomization
MPBS	Mobile Phone Base Station
PECO	Population, Exposure, Comparator, and Outcomes
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Control Trial
RF-EMF	Radiofrequency electromagnetic fields
RP	Risk Perception
SCHEER	Scientific Committee on Health, Environmental and Emerging Risks
WHO	World Health Organization

Executive Summary

Deliverable D2.3 "Health risks, citizen´s concerns and international guidelines" provides an overview of the evidence on risk perception of RF-EMFs; the needs, issues, and concerns of European citizens. In order to obtain the most up-to-date scientific evidence and to meet the objectives of this deliverable, 4 sources of information have been used. The first one is a specific questionnaire that was designed and sent to the participants in this D2.3 about national surveys, experiences, good practices, etc., on needs, problems, and concerns regarding the risk perception of RF-EMF. An analysis of surveys was conducted on risk perception at national and European levels. One scope revision of evidence of the qualitative and quantitative studies carried out to identify needs, problems, and concerns of the population on RF-EMF. In addition, an overview was conducted (papers published during the period 2015-2022) to improve the quality of the information collected from the three sources of information mentioned above. The scientific basis of guidelines on safe exposure limits established by competent organizations and agencies are reviewed. A review and analysis have been conducted on scientific foundations of the exposure limits and security factor for health protection in Europe in order to identify the scientific basis for these international guidelines and to comply with NextGEM, WP2 goals. In this direction, we identify and propose new strategies to improve risk communication. D2.3 provides solid evidence and knowledge on requirements, needs, problems, concerns of the population and the main factors that determine the perception of the risk of RF-EMF. Finally, this document intends to provide public health authorities with the mentioned knowledge to help them in decision making.

1 Introduction

Deliverable D2.3: "Health risks, citizen´s concerns and international guidelines" is part of NextGEM's Work Package (WP) 2. The goal of this task is to identify needs, problems, and concerns of the population on the real effects of the real exposure to EMF, as documented in exposure monitoring campaigns, in an environment where sometimes contradictory and confusing information is delivered and thus causing uncertainty".

We assume that evidence in general refers to "data, information, and knowledge from multiple sources, including quantitative data such as statistics and measurements, qualitative data such as opinions, stakeholder input, conclusions of evaluations, as well as scientific and expert advice"[1]. One of the main objectives of this deliverable is to provide the competent authorities in public health with the best evidence about the main factors that determine the perception of the risk of RF-EMF.

What is the magnitude and seriousness of the problem about risk perception of RF-EMF? What the needs, problems and concerns of citizens are? The answers are not very simple but there is still a percentage of the European population, approximately 20-30%[2], who express concerns about health effects of RF-EMF. For that reason, it is very important to identify and better understand the evidence regarding the main factors that determine the publics risk perception about RF-EMF. Knowledge about these factors needs to be improved in order to promote public health policies on RF-EMF based on the best evidence and citizens' rights.

The citizens' needs and concerns about RF-EMF are being undercut by misinformation (e.g. 5G and coronavirus, anti-vaccine, etc.), conspiracy theories, hoaxes, and falsehoods that diffused significantly faster, deeper, and more broadly than the truth in all categories of information. This undermines public regulations and communication actions and consequently the efforts to establish safe limits of exposure to RF-EMF based on the best available evidence.

Due to introduction of new telecommunication technologies, especially the introduction of 5G, citizens have expressed their concerns about the possible health effects due to radiation from base station antennas. International organizations such as the World Health Organization (WHO) made statements that EMF from 5G network base stations would not cause substantial adverse health effects, as their levels were well within the regulated exposure limits; however, the public high-risk perception remains. Dread and unknown risk considerations are natural candidates to be regarded as drivers of inter-individual differences in risk perception of 5G:

But how do people make decision on risks? What are the main risk perception factors influencing the refusal to install telecommunication technologies? One of the most widely accepted explanations is that people often make decisions on the basis of simple heuristics to form their perceptions when they make decisions on RF-EMF risk perception, so risks can be misjudged, sometimes overestimated, or underestimated.

We have to take into account that the conflicts and controversies surrounding risk perception are not due to public ignorance or irrationality, but instead are seen as a side effect of our remarkable form of participatory democracy, amplified by powerful technological and social changes that systematically break trust. One of the main objectives of this D2.3 aims to provide some answers to these questions raised and identify the main factors influencing risk perception.

The competent authorities who promote and regulate public health and safety, need to understand how people think about, take decisions and respond to risk. Without such understanding well-intended policies may be ineffective.

In order to meet the goals of this deliverable the available evidence on the needs, problems, concerns and main factors influencing citizens' risk perception of RF-EMF we have applied the following methodology. We have collected and analyzed mainly from 4 sources.

[1] https://op.europa.eu/webpub/eca/special-reports/agri-big-data-16-2022/en/

[2] This percentage is approximate. It is an average of the studies reviewed which cannot be easily compared because of the various sampling differences. No serious historical comparisons are available. The percentages obtained in national and international studies are quoted in the text.

1) By means of a **specific questionnaire** sent to the participants in this D2.3 about national surveys, experiences, good practices, etc., on needs, problems, and concerns regarding the risk perception of RF-EMF.

2) From the **analysis of surveys** conducted on risk perception at national and European levels.

3) One **scope revision** of evidence of the qualitative and quantitative studies carried out to identify needs, problems, and concerns of the population on RF-EMF.

4) In order to obtain more refined and reliable results on the most important determinants of the risk perception of RF-EMFs, an overview was conducted (papers published during the period 2015-2022) to improve the quality of the information collected from the three sources of information mentioned above.

We have carried out an integrated analysis of all scientific information cited above in order to make an adequate assessment of the needs, factor of risk perception and requirements for competent authorities to be able to provide an adequate response to citizens' problems and concerns about RF-EMF.

One of the main conclusions of the analysis of the published studies is that there is enormous diversity and variability in the results of the studies published on the factors that influence the risk perceptions of RF-EMF. That was the main reason to carry out the overview.

The majority of studies reviewed are observational studies based on household surveys; questionnaires, including face-to-face interactions; telephone or electronic interviews. This kind of studies are retrospective and therefore carry the risk for recall bias. However, risk perceptions surveys, despite their methodological limitations, are an accepted method of identifying subjective needs in terms of what is needed to identify risk perceptions.

Another important objective of D2.3 and the WP2 is the assessment of scientific foundations of the exposure limits and security factor for health protection in Europe (international guidelines). To better understand the situation of exposure limits, the current limits in force in Europe are described.

In this deliverable, it is assumed that the exposure limits proposed by International Commission on Non-Ionizing Radiation Protection (ICNIRP), WHO, Institute of Electrical and Electronics Engineers (IEEE), Council Recommendation 1999/519/EC and Directive 2013/35/EU and SCHEER, are safe to ensure health protection because they are based on the best available scientific evidence. We have summarized the latest systematic reviews conducted by agencies, international committees and competent authorities on health effects of RF-EMF and the evidence of the international limits of exposure.

In light of the results of this deliverable it seems clear that setting arbitrary exposure limits lower than those of ICNIRP or IEEE and endorsed by the EU and WHO does not decrease the public's perception of risk, and neither does this lead to lower exposure levels but rather increases the public's perception of risk. One of the contributions of this Task T2.3 is to facilitate the development of practical guidelines for RF–EMF exposure and participatory engagement, in coordination with Task 8.2.

The results of our work provide relevant information to improve the management and communication of the alleged risks of RF-EMF and to establish the best specifications on security foundation of international guidelines and safety limits.

We identify and propose new strategies to improve risk communication. It is essential to communicate the difference between risk and hazard to avoid confusion and misinterpretations. This confusion explains much of the mistakes that are made in risk communication about RF-EMF. Based on the evidence reviewed and the good practices proposed by the WHO we formulate some recommendations to improve communication on RF-EMF. We observed that there is a general need for improvement in providing accurate, accessible and should be appropriate for the specific type of recipients of the message.

Finally, one of the main objectives of communication should be empowering risk literacy of the general public. Risk perception varies according to many social, demographic, psychological, educational, and political variables. The role of good communication on RF-EMs is to increase people's knowledge so that they can make more informed and balanced judgements about the different risks they face in everyday life.

Our findings and conclusions contribute to understanding the scientific basis for the decisions of competent authorities in risk assessment, risk management and risk communication and facilitate to accomplish the objectives of WP2.

1.1 Mapping NextGEM Outputs

The purpose of this section is to map NextGEM's Grant Agreement (GA) commitments, both within the formal Task description and deliverable, against the project's respective outputs and work performed.

Table 1: Adherence to NextGEM's GA Tasks and Deliverables Descriptions

TASKS	
Task Number & Title	**Respective extract from formal Task Description**
Task 2.3 - Health requirements, citizen concerns and participatory engagement perspectives	The goal of this task is to identify needs, problems, and concerns of the population on the real effects of the real exposure to EMF as documented in exposure monitoring campaigns in an environment where sometimes contradictory and confusing information is delivered and thus causing uncertainty. NextGEM will develop proposals for participatory engagement of key stakeholders, including competent authorities, civil organizations, scientific agencies, and academia. In the formulation of recommendations on how to explain the EMF exposure limits that are adopted to ascertain safety. NextGEM will use new and appropriate tools to improve management and communication of risks with the interested public, considering a gender sensitive approach and with messages adapted according to the literacy levels of the target population.
DELIVERABLE	
Deliverable: D2.3: Health risks, citizen´s concerns and international guidelines This deliverable will provide the specification of health requirements and citizen´s concerns regarding EMF exposures and safe limits.	

1.2 Deliverable overview and report structure

Based on the objectives and work carried out under Task 2.3, the document starts with the Executive Summary followed by the introduction of the document in Section 1.

Section 2 provides an extensive identification of public needs, problems, and concerns about the actual effects of EMF exposure. This section analyses the results of a specifics questionnaire sent to all members of the WP2 (D2.3) and the results of qualitative and quantitative studies carried out to identify needs, problems and concern of citizens and stakeholders. The limitations of observational studies and analysis of risk perception studies are included. This section contains an overview and analysis of evidence on the main factors and value drivers that influence the population's confidence and risk perception on the effects of RF-EMF.

Section 3 is devoted to the description of the basis for support public authorities and regulators with good scientific evidence. Summarises the main conclusions of reviews of the evidence on the effects of RF-MFE published by national and international agencies and committees. Provides a review of national and international surveys on the perception of risks and hazards of RF-EMF.

Section 4 focuses on proposals for participatory engagement of key stakeholders: practical guidelines, participatory engagement, and public resistance.

Section 5 identifies and proposes new strategies to improve risk communication.

Section 6 concludes the deliverable.

2 Public needs and concerns about the effects of RF-EMF exposure

Within the current technological evolution, especially with the revolution of Industry 4.0, rapid changes in technology, industries, and societal patterns and processes are being imposed through the increasing interconnectivity and smart automation. In this direction, the Radio-Frequency Electromagnetic Field (RF-EMF) exposure, as created by sources such as mobile phones, home appliances, telecommunications and broadcasting installations, is constantly increasing due to high demand for connectivity and automated services (Figure 1). More specifically, these sources can be categorized into three basic types such as personal, occupational, and environmental exposures [1].

- **Personal exposure**, which is of immediate public concern, refers to the incident electromagnetic fields on the exact location of a person's body, and occurs due to the daily exposure to Wi-Fi, mobile phones, electronic devices, ovens, etc.
- **Occupational exposure**, which is probably the most important and difficult to resolve, may be derived from the very nature of a profession, or as a result of EMF industrial use and by-products.
- **Environmental exposure** is derived from large broadcasting sources, such as Macro-Antennae (Macro-cell Base Stations), radio stations, radars, marine and aviation equipment, satellites, etc.

Although the measuring of personal exposure and its implications for policy making and regulations, the three types of exposure overlap to some degree.

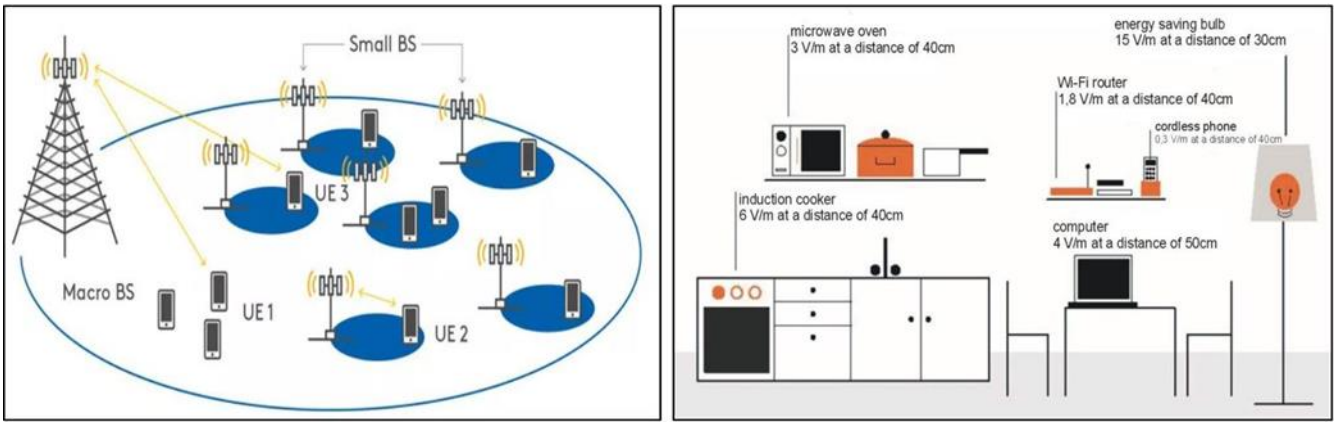

Figure 1: Telecommunications radiation sources and at home EMF exposure levels3

However, many people are concerned that long-term exposure to EMFs, produced by the new technologies of telecommunications such as 5G, may increase the risk of cancer, neurological disorders, and other health problems. Serious concerns of the public about the exposure of humans to EMFs are also reported regarding their potential cognitive effects, especially on children[4]. In addition, public worries about new technologies are not always justified and often stem from misinformation and the inherent sense of danger from forces that cannot be consciously perceived. A reflection of that fact is the inconsistency of information on the issue circulating among even well-educated people or groups of the general population. Similar issues have historically been encountered concerning other break-through technological innovations in the previous century and were inherently resolved by the inevitable economic growth and improved quality of life that followed the implementation of new technology. But in the long term, this rather indefinite social resolution has obstructed humanity's ability to prevent the drawbacks of massive use of new technologies, and the big scale consequences on the physical environment and public health.

Consequently, any similar form or type of random social resolution may not be allowed due to the growing gaps in people's access to and understanding of high technology. Therefore, explicit precautionary measures on all levels must be taken in the present against any form of misinformation and misuse of technology. In this direction, the constantly updated, and articulate regulations and persistent informative communication with the public are the key actions taken

[3] https://www.itu.int/en/ITU-T/studygroups/2017-2020/20/sg20rgafr/20190827/Documents/S2-P1-Lewicki-EMF.pdf

[4] https://apps.who.int/iris/rest/bitstreams/50422/retrieve

in the aforementioned direction. However, the national regulations and exposure limits vary depending on national health policies [2], and there are still many necessary policies that are not fully established or adopted, especially those concerning the occupational exposure limits and protection measures[5], in both developing and developed countries.

Most arguably, a prudent way to inform the general population responsibly and effectively, is the establishment of consistent pathways of communication of the issue to the public, through permanent relative campaigns by governments and industries, so as to engage citizens in all levels of social life. Citizens must be extensively informed, in groups, or solely, in ways that complement their different social activities and interests as individuals. All aspects of our daily lives are involved in the matter differently. Consequently, people need to be cumulatively informed, throughout every aspect of their social identity, as workers, students, consumers, professionals, parents, etc. Important considerations are the public's problem of equal and seamless access to technological resources, as well as the public's concerns about the most proper and safest ways to incorporate and use these resources in an ever-changing environment. In any case, addressing responsibly the public's actual needs for energy, automation and interconnectivity is of greatest importance, with regards to the global effort for a highly automated and clean future.

Exploiting these drives is a promising starting point of actively engaging citizens in the matter. However, there are still several basic points to be explicitly cleared out in the public's minds, such as the difference between biological and overall health effects, hazards and risk, the importance of risk assessment, etc. Therefore, the scientific communities need to grasp the essence of citizens' concerns and encourage the relevant stakeholders to guide the public to understanding the natural principles of new technologies, as well as the significance of the implications from their different implementations. Lastly, and most importantly, the encouragement of citizens' active participation in the procedures of risk assessment and protection practices needs to be in the forefront of all stakeholders' efforts.

2.1 Analysis of specific questionnaire sent to all NextGEM members

In order to gather reliable information on the needs, problems and concerns of the population, a specific questionnaire was designed (Questionnaire on Needs, problems, and concern of citizens about the effects of RF-EMF and proposed measures for their prevention and control) and sent to members of Task 2.3, NextGEM. Analysis of specific questionnaire sent to the members of WP2 about relevant national studies, experiences, surveys or reports on the needs, problems, and concerns of citizens about the effects of RF-EMF and proposed measures for their prevention and control has been performed considering:

- The main factors influencing the population's perception of risk.
- Processes of citizen participation of stakeholders in the risk assessment of RF-EMF and proposed measures for their prevention and control.

The concept of need is an assessment that reveals a gap between an analyzed situation, and another considered ideal or reference situation. Four concepts, derived from the matrix idea of need, have been developed, two of them refer to the assessment of the situation made by the person (felt and expressed need) and two refer to the assessment coming from a technician or professional (normative and comparative) [3]. The procedures for obtaining information on population health needs and problems in health planning are applicable for same purposes on the RF-EMF. The instruments for measuring these needs and problems are as follows:

- Identification of results, experiences and best practices on risk assessment, management, and communication on RF-EMF.
- Identification of health indicators: morbidity, mortality, prevalence, and incidence of diseases associated with exposure to RF-EMF based on official information sources. E.g. Cancer Registers – Tumors of Central Nervous System (CNS).
- The review of scientific evidence, experimental studies (controlled clinical trials) and systematic reviews and meta-analyses. Critical and systematic reading of the bibliography: quality, validity, and reliability. Information based on faithful, objective, and verifiable data.
- Studies and surveys about needs, concerns, problems, and risk perception of the population on the effects of RF-EMF,

[5] https://www.hse.gov.uk/radiation/nonionising/emf-regulations.htm

- Impact on social networks, internet, social impacts, media news, etc.
- Qualitative studies of consensus search and face-to-face interviews, key informants' method, Delphi technique, Nominal Group, etc.

The combination and integration of all this information, provided that it is available and accessible, will be used in this deliverable to allow us to make a better assessment of needs and problems about RF-EMF. It is all this evidence that allows us to establish the specifications of health requirements citizen´s concerns and security foundation exposures and safe limits.

A summary of the information provided is described below.

2.1.1 Sweden

There are two competent governmental authorities that have a responsibility to govern questions related to possible health effects of electromagnetic fields in Sweden. The Swedish Radiation Safety Authority[6] reports to the Ministry of Climate and Enterprise and has mandates from the Swedish Government within the areas of nuclear safety, radiation protection and nuclear non-proliferation. Issues related to EMF sort under radiation protection and comprises a minor part of the authority. This authority is responsible for issues related to the general public, while EMF-related labor issues are handled by the Swedish Work Environment Authority[7]. This authority is tasked by the government and parliament with ensuring that laws on the work environment and working hours are complied with by companies and organisations. In addition, The Public Health Agency of Sweden[8] has a national responsibility for public health issues and works to ensure good public health. This authority is the regulatory guidance authority for health protection issues under the Environmental Code. This includes questions about risks from electromagnetic fields. The Swedish Public Health Agency provides supervisory guidance to the municipal environmental and health protection boards, which are the supervisory authorities for health protection. The Swedish Public Health Agency's guidance is based, among other things, on the opinions of the WHO and the Swedish Radiation Safety Authority's (SSM) scientific council.

Regarding SSM, this authority carries out measurements, evaluates research in the areas of magnetic fields and wireless technology, provides advice and recommendations, and develops regulations. The authority's reference values for exposure are based on EU guidelines, which in turn are based on assessments by ICNIRP. Regarding possible health risks, SSM's interpretation of the state of knowledge is that there are no confirmed health risks associated with weak electromagnetic fields. However, their stance is that it is not healthy to be exposed to EM fields. The authority's reference values are set to provide a good margin of protection against all established health risks and essentially follow the ICNIRP guidelines. The authority´s website is furthermore equipped with a FAQ section that deals with not only issues related to mobile telecommunication but to other EMF areas as well[9]. In collaboration with other stakeholders, SSM is engaged in information events of different kinds, addressing the public's concern regarding the various generations of mobile telecommunication.

SSM has appointed an international Scientific Council of experts in different EMF areas that are tasked with regularly monitoring current research on potential health risks in relation to exposure to electromagnetic fields and provides the authority with advice on assessing possible health risks. The Council gives guidance when the authority must give an opinion on policy matters when scientific testing is necessary. The council is required to submit a written report each year on the current research and knowledge situation. The report is a consensus document which means that all members of the Scientific Council agree with the complete report. This increases the strength of the given conclusions. The report has the primary objective of covering the previous year's research in the area of RF-EMF and health but also to place this in the context of present knowledge. The report gives the authority an overview and provides an important basis for risk assessment.

The published report [4] covers studies on all areas of EMF (from static fields to high frequency fields up to 300 GHz) and includes studies published from January 2020 up to and including December 2020. The report is the sixteenth in

[6] formerly Strålskyddsinstitutet, SSI. https://www.stralsakerhetsmyndigheten.se/

[7] https://www.av.se/

[8] https://www.folkhalsomyndigheten.se

[9] https://www.stralsakerhetsmyndigheten.se/omraden/magnetfalt-och-tradlos-teknik/fragor-och-svar-om-elektromagnetiska-falt-emf

a series of annual scientific reviews which consecutively discusses and assesses relevant new studies and put these in the context of available information.

Another major area of activity deals with exposure assessments, including exposures to RF-EMF from mobile phone base stations. Here monitoring is currently performed, either due to own initiatives or because other stakeholders have asked for specific measurements in each geographical location. A blueprint measuring activity was performed in 2004 [5] where measurement data regarding 3G mobile telephony was collected from two suburban communities in the larger Stockholm area. The approach and specific measurement were validated in this study that subsequently has been providing guidance for other measurements in Sweden.

The Swedish Work Environment Authority is the authority responsible for occupational health in Sweden. This can also include schools, because pupils and students are considered workers in this context. The authority has regulations also on electromagnetic fields for occupational exposure. The relevant regulation is implementing the Directive 2013/35/EU on occupational exposure to EMF and has subsequently published the corresponding Swedish law[10].

2.1.2 Netherlands

In the Netherland (2020) the Antenna Bureau, the information agency of the Dutch government concerning antennas and part of the Dutch Radiocommunications Agency[11] carried out a study on the information needs of its target groups. The target groups as defined in the study were the general public (citizens) and Officials from local government (including city councillors).

The main conclusions of this study were:

- Largest group of Dutch citizens are not concerned about EMF (13% is worried too very worried). However, the group of concerned citizens has grown since the previous study commissioned by the Antenna Bureau in 2017. According to another study in the Netherlands 21% of citizens continue to express concerns about the health risks of cell sites [6].
- The general attitude towards 5G is neutral to positive.
- The general public experiences a limited need for information regarding 5G, despite the fact that many people know little about the subject.
- Interest in antennas for mobile communication in general and 5G is incident driven: people want information when there are specific building plans for an antenna-installation in their neighbourhood.
- When it comes to informing the public, Dutch citizens expect information from governmental organizations (for example: local and national government, National Institute for Public Health and the Environment[12] and the Municipal Public Health Service[13].

The study also included some recommendations on communication:

- Provide the general public with objective and neutral information about 5G and antennas.
- Provide information from different sources.
- Support municipalities regarding 5G.
- Encourage the use of small and/or less visible antennas to minimize psychological impact from visual stimuli.

The study also compared the general public's worries regarding EMF with other current themes (for example the COVID19-pandemic, climate change and privacy). Compared to these other themes, the Dutch are less concerned about antennas, EMF and 5G.

[10] https://www.av.se/globalassets/filer/publikationer/foreskrifter/elektromagnetiska-falt-foreskrifter-afs2016-3.pdf?hl=elektromagnetiska %20f%C3%A4lt

[11] https://www.antennebureau.nl

[12] https://www.rivm.nl/en

[13] https://ggdleefomgeving.nl/informatie-over/zendmasten-en-5g/

One interesting study [7] has applied a multi-level longitudinal mixed method to map changes in citizens' experiences of technological risks and asks if these are influenced by risk governance. The concerns about cell site deployment (bases stations) can be summarized in 5 framing concerns that are common to other countries:

- Happy Technology (need for better coverage, capacity, and quality of the wireless network).
- Health Hazard (related disease, cancer, sleep problems, etc.).
- Visual Pollutant (environmental and deterioration landscapes).
- Property Value (reduction in the price of houses near antennas).
- Democratic Control (right to take decision).

In the European Union the construction of a cell site is a subject of political and ideological importance and an issue of due process and trust in decision makers in the majority of countries. The authors of the study carried out a quantitative survey on a national level panel of citizens in the Netherlands and made use of mixed-method panels of citizens who are being confronted with siting practices in the Netherlands and Southern California. They found that often and quite unsurprisingly, cell site deployment is of limited importance in the everyday lives of citizens. The authors consider three ways in which risk governance affects citizens' experiences. First, the framing of cell site deployment among citizens closely resembles the frames in policy. Second, following the depoliticization of cell phone health risks, the absence of alarming health effects and the withering of public debate, a stable three quarter of citizens seems unconcerned for a couple of years, while an equally stable quarter reports health worries. Third, on an individual and local level, they find some changes in citizens' risk perception, framings, feelings and – albeit extremely limited, actions.

2.1.3 Germany

In Germany, a report published by the German Federal Office for Radiation Protection [8] can be translated as: "What does Germany think about radiation" and about the perception of the risk (potential risk) of radiation in the general population, including radiofrequency magnetic fields. Prior to the main field phase, the questionnaire, and Computer-Assisted Telephone Interviewing (CATI) instruments were pretested. The survey method was a telephone survey and the selection method used was a systematic random selection on the basis of an ADM dual-frame sample (Arbeitsgemeinschaft ADM-Telefonstichproben). The target population were the German population aged 15 or older and the sample size was N=2,000, men and women representative in terms of age, gender, household size and regional distribution for the German residents. The average interview length was 24 minutes, and the surveys were conducted between July and September 2019. The following topics were targeted in the survey:

1. **What do citizens know about radiation?**
2. **What is the general perception of the topic?**
3. **How great is the perceived threat?**
4. **What preventive measures do citizens know and use?**
5. **Is there a lack of information?**

Key aspects on radiofrequency EMF exposure will be mentioned as per work undertaken on NextGEM.

2.1.3.1 What do citizens know about radiation

Four types of radiation are of particular relevance in citizens' everyday lives. High-frequency and low-frequency fields (also referred to here as radiation), optical radiation and ionizing radiation. The most familiar type named by the participants is high-frequency radiation: 54% of the respondents know it by name and 20% demonstrate good knowledge of its properties. Whenever the respondents demonstrated good knowledge of a particular form of radiation, this most frequently concerned optical and high-frequency radiation (21% and 20%). The respondents are particularly unable to make a clear distinction between low-frequency and high-frequency radiation.

In order to gauge citizens' knowledge of different forms of radiation, various "quiz questions" were asked during the survey. Regarding high-frequency radiation, it was asked whether the greatest radiation exposure is caused by mobile phone masts or one's own mobile phone/smartphone. 57% of the participants correctly chose the latter. The average respondent scored 11 points out of a possible 17. It may be concluded that the respondents' knowledge is good but expandable.

Regarding the question "What comes to mind spontaneously when you hear the term radiation" 23% replied mobile phones/ base stations/ smart phones/ 5G. That was the most frequently given answer to this question.

2.1.3.2 What is the general perception of the topic

When asked to identify sources of radiation, practically all citizens knew that the sun emits UV rays and that smartphones / mobiles have electromagnetic fields (both 95%). Related products, such as wireless telephones and WLAN routers, were identified as radiation sources by 84% of the participants.

2.1.3.3 How great is the perceived threat

31% of the respondents think people in Germany are exposed to an excessive amount of radiation, 34% think the opposite. Their opinion is similarly balanced with regard to ubiquitous radiation: 35% are worried that we are surrounded by radiation everywhere, while 40% are not concerned about the issue. Twenty-two percent of the respondents often – or quite often – think about the potentially harmful effects of this form of radiation. This is not the case for 52% (i.e., the narrow absolute majority).

The form of radiation that worries most respondents is radioactivity from nuclear power plants: 53% of the respondents are very worried, while 21% are quite worried. This puts it in fourth place amongst all the so-called "modern health concerns" in the survey. The participants only identified greater concerns about multi-resistant bacteria in hospitals (84% very or quite worried), nanoparticles and plastic in food, and pesticides in food (both 81%). Half of the respondents are worried about UV radiation from sunlight. This is followed by radiation from mobile phone masts and mobile phones, smartphones, and tablets (51% very or quite worried about each). The majority of the participants are not really worried – or not at all worried – about any other form of radiation. The least worrying forms are the radiation emitted during air travel (26%), by radon (23%) and by microwaves (26%).

2.1.3.4 What preventive measures do citizens know and use

Only **37%** of the respondents believe the state institutions for radiation protection are actually protecting the population against the harmful effects of radiation. 21% completely disagree with this notion, and 19% somewhat disagree. Just over half of the respondents are also satisfied with their level of protection against the electromagnetic fields generated by power lines. Once again, they are most critical when it comes to mobile phone masts: Only 40% consider themselves to be well protected or very well protected, while 49% do not.

While the majority of citizens do not believe the measures taken by state institutions provide adequate protection against the threat of radiation, a look towards Europe reveals a comparatively satisfactory situation in Germany. In comparison to other European countries, 45% of the people surveyed in Germany feel much better or slightly better protected, while 38% see their level of protection as equally good. Only 8% perceive a slightly worse or much worse situation compared to the rest of Europe.

According to the respondents, they most commonly protect themselves against microwave radiation (21%). Very few citizens have ever done anything to protect themselves against other sources of radiation. 10% protect themselves against radiation during air travel, 6% against the radiation emitted by high-voltage power lines, 4% against mobile phone mast radiation, and 3% against the natural radiation from radon.

As regards the use of mobile phones, the Federal Office for Radiation Protection recommends a series of preventive measures to minimize exposure to high-frequency electromagnetic fields. The most observed recommendation is to not carry mobile phones on one's body. This is observed by 47% of the respondents. 29% state that they try to avoid making phone calls if the reception is poor. One quarter of the respondents claim to use mobile phones that emit as little radiation as possible, and 18% use a headset when making calls.

2.1.3.5 Is there a lack of information

Almost half of the respondents say they feel badly informed by the state institutions for radiation protection and a quarter feel very badly informed. 21% consider the amount of available information to be good and only 2% think it is very good. So, the citizens have identified a general need for improvement in this regard. This is not unusual for a topic that is somewhat on the margins of everyday life. The exchange of information is also dependent on the provision and reception of facts. This means there must be an adequate supply of information, but it also has to be used by the recipients. If this is not the case, their dissatisfaction may be caused by an insufficient demand for information, the supply of irrelevant or unwanted information, or the inadequate preparation of the information. Both possibilities should be checked with regard to the information on radiation protection provided by state institutions but the participants in this study were not asked to indicate the specific reasons for their dissatisfaction with the information provided.

In order to adapt future information to citizens' needs, they were asked to express their interest in various topics. The respondents displayed practically the same level of interest in all the topics. The most popular topics, which received 70% of the votes, concerned individual radiation protection measures and the concrete levels of radiation exposure in Germany and local regions. This was followed, in descending order but with insignificant differences in popularity, by the other topics: the specific sources of hazardous radiation, the specific risks associated with certain forms of radiation, and the radiation protection measures taken by state authorities. Around two thirds of all respondents were interested in all five topics.

2.1.4 Spain

In Spain, in November 2021, the first Health and Environment Strategic Plan [9] (PESMA) was adopted by Ministries of Health and Ecological Transition in which it is includes a chapter on EMF**.** This plan was open to public consultation and participation. This made it possible to identify the main concerns and problems expressed, without any limits, by entities, organizations of affected people and activists who, since the beginning of the deployment of telephone base stations, have opposed their installation, warning about the alleged dangers of exposure to RF-EMF**.** The PESMA announces that the government intends to update the legislation with limits for radiofrequency EMF by adopting the 2020 ICNIRP guidelines. The PESMA also contains plan and monitor the incidence of brain tumours and Leukemia and mortality rate in Spanish population. The practical details and responsible bodies will be specified in biennial action programs. Two interesting reports have been published in compliance with the intervention guidelines of this plan on EMFs.

The first report [10] concludes that the results of the study show an upward trend in the incidence of brain tumours in the 1980s possibly caused by the diagnostic improvements implemented in these years, and subsequently a stabilization, and do not support the hypothesis of a correlation between the use of cell phones and malignant brain tumours. The results of this report are similar to other recent studies on trends in CNS tumour incidence rates [11].

The second report [12] "Mortality due to Leukemias, non-Hodgkin's lymphomas and Lymphomas and Central Nervous System tumours in Spain 2001-2020" concluded that in the last 20 years, during which exposure to radiofrequency waves has been increasing in the general population, there has been no increase in mortality from these diseases in Spain.

No active information and communication policy on EMFs has been implemented. There is currently no significant movement to oppose the installation of base antennas or 5G.

2.1.5 Belgium

In Belgium, to our knowledge, no survey that could provide a representative picture of the perception of risks related to electromagnetic fields has been conducted in a recent past. In this overview, to shed light on the situation in Belgium, a country with particularly low regulatory exposure limits for the population, among the lowest in Europe, we will in a first step give a brief history of the origin of the establishment of these limits and the differences that have emerged between the three regions of the country: Brussels, Flanders and Wallonia. It is interesting to note that despite the low limits, there is a significant opposition in Belgium against the installation of new antennas and the deployment of 5G technology as we will see hereafter.

Then, regarding the evaluation of risk perception, we will report on initiatives that are more localized, either to a type of population or geographically, with the aim of providing some insight. In a third step, we will provide a summary of initiatives taken by the different levels of governance, initiatives that can serve as an illustration of how the public authorities manage risk perceptions associated with the introduction of these new technologies.

2.1.5.1 Exposure limits in Belgium

In its recommendation 1999/519/EC, the Council of the European Union recommends to the Member States a limit of 41.2 volts/meter at 900 MHz. This recommendation is based on the ICNIRP guidelines published in 1998 and revised in 2020. Most European countries have adopted this recommendation. Belgium has even incorporated an additional safety margin compared to the European recommendation. The Belgian standards are therefore stricter than the European exposure limits. (Information from the website Parlons5G.be, an initiative of the Federal Government, the Flemish, Walloon and Brussels governments, the FPS Public Health, BIPT and with the cooperation of Sciensano.)

2.1.5.1.1 The standards in Belgium are set at regional level

- In the Flemish Region a cumulative standard is set in all publicly accessible locations for radiation from all fixed transmitting antennas combined. A standard is also set per operator at the places of stay for antennas for GSM and wireless internet (e.g. GSM, UMTS) to further limit exposure. Limits are set per frequency of applications, see https://omgeving.vlaanderen.be/nl/normen-zendantennes. In 900 MHz, the cumulative standard is set at 21.6 V/m and per operater at 9.2 V/m;
- In the Brussels-Capital Region, the cumulative field strength is limited per antenna site. Limits are set per frequency band. Currently this intensity is limited to 6 V/m at 900 MHz. On July 23, 2021, the decision in principle was taken to raise the standard to 14.5 V/m. This standard applies to all public places. Even after the standard has been raised, the standard in the Brussels-Capital Region will remain significantly stricter - about eight times - than the ICNIRP standards.
- In the Walloon Region, the standard sets two limits: a cumulative limit and a limit per operator. Limits are set per frequency of applications. The limit per operator is aligned with the Flemish standard (9.2 V/m at 900 MHz). The cumulative limit is set at 18.4 V/m at 900 MHz. The standard applies to living areas.

2.1.5.1.2 Origin of these standards

In 2001, the Belgian Superior Council of Hygiene released an opinion advocating the limit the public exposure values to 3 V/m. This is the standard that was used in Brussels until the advent of 4G, for which operators have been pushing to raise the limits. The solution accepted by the Brussels Parliament and Government was to raise the threshold to 6 V/m, simplify the administrative procedure to install and antenna and change the definition of what constitutes a zone accessible to the public. It also creates a group of experts whose task is to follow the evolution of the scientific literature on electromagnetic waves. In 2015-2016, this ordinance was challenged in court (Constitutional Court) by a group of environmental associations on the grounds that it would violate the principle of "standstill", which prohibits going back when a certain level of protection is reached, unless there is a compelling reason of general interest.

An attractive way to understand the limits adopted in Belgium is identified by Joris in his PhD thesis in 2011[14] and Deblander at al., 2012 [13]. He takes the choice to analyze the definition of guidelines and limits at the European, Belgian, regional and local levels, based on the significance given to the different actors who participate, directly or indirectly, to the "regulation process", bringing together heterogeneous actors (public actors, economic actors, environmental associations, citizens or scientists...).

At the European level, the actors involved in the debates surrounding their adoption of the guidelines include the public and economic actors, and the scientists, the environmental associatins being absent. The reached compromise was built on the basis of scientific expertise.

In view of Belgium's European anchorage, the actors at the Belgian federal level were initially in line with the European approach. Moreover, since Belgian scientific actors are also active at the European level, it was to be expected that Belgium would follow the European guidelines. However, despite these overlaps, the standards finally adopted in Belgium turn out to be more restrictive.

According to Joris, 2011, two reasons could explain these differences: first of all, the participation of actors from environmental associations, rather absent from the discussions at the European level, but who were active in the discussions at the Belgian federal level. These actors formed an alliance with whistleblowing scientists, called marginalized scientific actors by Joris (2011), in order to interest public actors in health issues related to electromagnetic fields. Gathered in associations, citizens gained more weight in the debates and Belgian political actors can hardly ignore these claims. It is ultimately their electorate. This readjustment plays a priori in favor of the actors of the environmental associations by mobilizing their alliance with the marginalized scientific actors. Also, according to Joris 2011, a second difference could be attributed to the relative weight of marginalized scientific actors, which tends to be reinforced at the Belgian federal level. Indeed, if they are not proportionally more numerous than at the European level, the reduced size of the communities tends to guarantee them a better visibility, which translates into a highlighting of the scientific controversies dividing the scientific community as such. Finally, aware of the divergences within their

[14] https://orbi.uliege.be/bitstream/2268/98103/1/JORIS%20G_th%C3%A8se_2011.pdf

panel and more widely within the scientific community, the Belgian scientific experts invited the political actors to take a precautionary approach, leading to the definition of more restrictive standards.

Following the decision of the Constitutional Court, recognizing the right to a broad interpretation of environmental competences, the Federal State is emptied of this competence linked to the electromagnetic fields. It is then the Regions that are competent to adopt standards of exposure related to electromagnetic fields. It is not the purpose of this report to give an account of the different stages that led to this transfer of competences. However, as noted by Joris (2011), in this dynamic, the central question is who decides what, and especially who imposes what on whom. In other words, the management of electromagnetic fields requires that the effects of Belgium's federalization be considered. In this sense, the precautionary dynamic seems inseparable from the Belgian institutional dynamic.

In addition to regulatory instruments, public actors have also implemented so-called participatory approaches. The case of the implantation of cell phone antennas is a good example of these new trends. Initially, the competences of the Regions in the implementation of antennas were limited to urban planning aspects. With the transfer of competences to the Regions, the controversies related to the implementation of mobile phone antennas are not limited to the urbanistic dimensions of these projects. On the contrary, the implementation raises many questions in terms of public health.

Until recently, 5G deployment was only possible in Flanders, where standards for RF emission had already been adopted[15]. On the Walloon side, the decree having been passed at the end of 2022, the Walloon government and mobile operators have recently agreed on a charter of common commitments for a regulated deployment of 5G. In Brussels, as written above, the revision of emission standards is underway. It remains, that Belgium is behind in the deployment of 5G in Europe. However, many antennas have already been installed but have not yet been activated. To accelerate the adoption of this new technology, "5G Labs", indoor or outdoor, have been installed locally in some of the country's major cities in the different regions.

2.1.5.2 Surveys on risk perceptions

Regarding risk perception, a master thesis entitled Risk perception of 5G in the Brussels-Capital Region[16] was conducted in 2020-2021 [14]. Given the media coverage of the issue, the protests organized by environmental associations against the deployment of 5G, and a survey of Lee et al. (2020)[17] of 1909 Belgian respondents, which showed that more than 30% of respondents thought there were risks to their health risks associated with 5G, which placed Belgium in 2nd position out of 15 countries with a high level of risk perception, the primary hypothesis of the work was that the inhabitants of the Brussels-Capital Region had a high risk perception of EMF emitted by 5G relay antennas in relation to their health. The secondary hypothesis was based on the influence of socio-demographic parameters, psychological parameters, objective knowledge on the subject and parameters related to perceived health, perceived exposure, and information source.

The target population is people over 18 years old, who understand French and live in one of the 19 municipalities of the Brussels Capital Region. The questionnaire is divided into five sections: socio-demographic data, exposure to EMF, psychological factors, and risk perception of fields from 5G antennas and other diverse sources. Responses were obtained from 403 individuals. Analysis of the results revealed that, on average, respondents perceived the risks associated with EMF-5G as moderate to high risk. Furthermore, high perceived exposure was significantly associated with higher perceived risk. Risk perceptions were also higher among those whose primary source of information was press websites. Severity of consequences" and "fear" are variables that are also significantly associated with higher risk perception. Conversely, "scientific knowledge" and "immediacy of the effect of the risk" are parameters associated with a lower perception.

[15]https://www.proximus.be/support/fr/id_sfaqr_map_network_5g/particuliers/support/internet/internet-en-deplacement/surfer-en-5g-4g-ou-3g/carte-de-la-couverture-reseau-5g.html (accedido 21 de julio de 2023).

[16] translated from French

[17]https://www2.deloitte.com/xe/en/insights/industry/technology/technologymedia-and-telecom-predictions/2021/5g-radiation-dangers-health-concerns.html

2.1.6 Europe

There is a study sponsored by the European Commission, on 5G shows that 39% of participants believe that 5G is safe for health, while 21% believe that 5G is harmful and 40% have doubts[18].

Another study was conducted by IPSOS in 23 European countries in 2020[19] in a sample n=7350 adults, 18-65 years old. In terms of attitudes, 54% Europeans are "positive" about 5G, while 36% declare themselves "neutral". In general, the Europeans think 5G will be useful and important for innovation, business, and development.

2.2 Analysis of results qualitative and quantitative studies carried out to identify needs, problems and concerns of citizens and stakeholders

The volume of studies published in scientific journals on the hypothetical effects of RF exposure and on the factors influencing risk perception is enormous, but the scientific quality of the research articles is quite varied and heterogeneous.

2.2.1 Limitations of observational studies, over-reporting, and regulatory measures on RF-EMF

There is a huge amount of information, whose quality is very difficult to review and analyse (Figure 2). Quality of evidence or quality of scientific studies is understood as the confidence that potential biases in the conduct of the study have been adequately addressed and that the results and recommendations are valid both internally and externally. Within the review process, the critical reading of evidence allows us to analyze the quality or validity of scientific evidence to support decision-making by competent authorities. In our society the regulation of exposure limits to (environmental) factors should be based on objective scientific evidence, supported by studies of high methodological quality and a sensible application of the common good and the precautionary principle [15].

Figure 2: There is a huge amount of information

Problems for citizens and stakeholders arise when news about alleged associations observed in some studies between a mobile phone antenna and an undefined number of diseases are published. However, a large proportion of these studies are often of very low methodological quality and do not allow valid conclusions to be drawn. Their dissemination in the media leads to a high-risk perception, confusion, concern, and alarm that may induce a *"felt need"* for health measures that are not justified by solid evidence. The biased results of some studies published in scientific journals can be used to call for public health interventions, such as a drastic reduction of RF-EMF exposure levels that are not supported by good scientific evidence. This has been the case in some countries that have set RF-EMF exposure limits lower than those of ICNIRP- WHO- IEEE- FCC or the EU.

[18]https://www2.deloitte.com/xe/en/insights/industry/technology/technologymedia-and-telecom-predictions/2021/5g-radiation-dangers-health-concerns.html

[19] https://www.ipsos.com/sites/default/files/ct/news/documents/2020-10/5g-awareness-needs-2020.pdf

For the above reasons, we should be very cautious when interpreting the results of survey-based studies that use psychometric techniques and that often use non-validated questionnaires.

Two very common issues in those studies are bias and confounding. They may result in an over- or underestimation of the true association. A common type of bias is the selection bias of study participants, which is more frequent in retrospective studies and, in particular, in cross-sectional or survey studies. It is also common the failure to control for potential confounding variables, for example, in studies about the effect of exposure to electromagnetic radiation from mobile phone masts on perceived and self-reported symptoms [16].

In addition to the above problems, some researchers persist in relying too heavily on statistical significance, ignoring arguments that statistical tests alone do not sufficiently justify scientific knowledge [17].

Acknowledging the limitations and biases cited can improve the quality of studies but we need to be critical and discerning about the quality of research papers. These mistakes have been pointed out by some that suggest that false-positive results are a common problem in cancer and other types of epidemiological studies [18]. What can be done, these authors wonder, within the practice of epidemiology, and in in science in general, to reduce the problem? One of the simplest yet potentially most effective remedies involve increasing emphasis on scepticism when assessing study results, particularly when they are new. Epidemiologists should practice some epistemological modesty when interpreting and presenting their findings.

Boffetta, et al., proposes strict adherence to the highest epidemiological standards in the design, analysis, reporting, and interpretation of studies would help reduce the likelihood and impact of false-positive results. These standards include provisions to reduce the opportunity for bias and confounding in study design, adequate statistical power, avoidance (or at least cautious interpretation) of data-driven subgroup analyses, and accounting for multiple comparisons, and a lack of relevant confounder. It is evident that similar problems affect other areas of scientific research like risk perception or psychometric studies. Unfortunately, we do not have randomised controlled clinical studies or more large-scale research that show the true variables that explain the causes of risk perception.

This is doubling (very slow, extremely time consuming), in order to safely detect enough cases for the results to be significant and most importantly they raise ethical problems.

The observational epidemiological studies have been criticized for their methodological limitations when establishing anything more than a simple association between an exposure factor studied and the disease of interest. The associations proposed by some of these observational studies are frequently not confirmed by the results of Randomized Controlled Trials (RCT). This is generally due to the inability to rule out the presence of confounding factors or variables that were unexpected or not measured and the existence of an inverse causal relationship between the exposure and the outcome. Mendelian Randomization (MR) [19], [20], studies are considered a special case within a more extensive type of applied statistics, known as instrumental variables used in the statistical analysis to adjust for possible confounding factors in the research study. This type of analysis was developed for the social sciences (particularly econometrics), where they are usually used to estimate the impact of certain policies or social measures when it is not possible to implement an experimental design.

Furthermore, the continuous development and advances of technologies associated with "omics," together with the perfection of current statistical methods, will doubtlessly overcome current experimental limitations and confirm MR studies as fundamental and will become essential elements to support RCTs during the drafting of clinical practice guidelines and the implementation of public health policies and measures.

We need to use other novel methodological approaches like MR and Umbrella revisions (to see WP5 D5) and large scales prospective studies to improve the causal relationships between an environmental factor (RF-EMF) and disease.

In the absence of these types of studies, we should strive to act with prudence, respect, humility, honesty and applying the findings of scientific studies of high methodological quality is the best way to deal with the complexity and uncertainty of reality. These skills can be developed by applying the scientific method and adopting critical and sceptical thinking [21].

2.2.2 Analysis of qualitative and quantitative risk perception studies

Understanding the mental frameworks of people who reject or oppose the use of new telecommunications technologies is essential to enforce RF-EMF exposure limits**.** The presence of any new technology has always aroused

rejection from some sectors of society (Figure 3) as was the case with the train, telegraph and automobile, vaccines, etc.).

Figure 3: The presence of any new technology has always aroused rejection from sectors of society

Observational studies (cross-sectional and without appropriate dosimetry) increase a distorted risk perception, unsupported by research of high internal and external validity and lead to the elaboration of alleged relationships where only speculation exists. Another consequence of very low-quality studies is that they undermine the evidence-based international guidelines of competent agencies and bodies (WHO, ECDC, CDC, EU) and encourage denialist groups to spread hoaxes or fake news on exposure to RF-EMF. It should not be forgotten that no causal relationship has been established between RF-EMF exposure and any disease or adverse health effects (see section 3).

There is enormous heterogeneity and variability in the results of the studies published on the factors that influence the risk perception of RF-EMF. However, these types of studies allow us to "get closer" to a rough estimate of the needs, problems, and concerns of the public. The analysis of the results of these studies measuring psychological factors or variables together with the review of the best scientific evidence does allow us to assess perception on the safety of international exposure limits and their acceptability or rejection.

Some of the studies analysed in this subsection are observational studies based on household surveys, questionnaires, some experimental, in sensitised populations or in the normal population by means of face-to-face, telephone or electronic interviews. On the other hand, the symptoms and variables included in the questionnaires have a large retrospective and subjective component which are susceptible to recall bias and makes them difficult to quantify and objectify.

In order to reduce these methodological errors as much as possible, the WHO has promoted the publication of several protocols, to improve the methodological quality of the studies.

1) Quality and strength of the evidence provided by human observational studies for a causal association between exposure to RF-EMF and risk of cancer [22].

2) Systematic review on the effects of exposure to RF fields on symptoms evaluated in human experimental studies [23].

3) Systematic review of the effects of the RF-EMF on symptoms evaluated in human observational studies [24]. The application of these protocols by research groups is the best guarantee to ensure the quality and validity of this type of studies on RF-EMF and their effects on health and symptom perception

What are the main factors influencing the perception of risk of RF-EMF?

Dread and unknown risk are natural candidates to be considered as drivers of inter-individual differences in risk perception of 5G. Some people may perceive high levels of unknown risk because 5G is a novel technology with potentially uncertain consequences. A Swiss study [25] has investigated psychological drivers of individual differences in risk perception focusing in 5G using a representative population sample in Switzerland (N = 2,919 individuals between 15 and 94 years old). The author concluded that inter individual differences in risk perceptions were strongly

associated with hazard-related drivers (e.g., trust in the institutions regulating 5G, dread) and person-specific drivers (e.g., electromagnetic hypersensitivity)—and strongly predictive of people's policy-related attitudes (e.g., voting intentions).

However, it is not known if individuals' perception towards the health risks of RF-EMF is dependent on their knowledge of the objectively measured personal RF-EMF exposure levels. One experimental study [26] was conducted on 383 adults, recruited in Melbourne, Australia. This pilot study aimed to demonstrate the feasibility of objectively measuring personal RF-EMF exposure from mobile phone base stations (MPBS) and to determine if the risk perception of people to the potential health risk of exposure to RF-EMF from MPBS is dependent on their knowledge of personal RF-EMF exposure levels.

It is no clear if the provision of precaution messages increases or reduce the risk perception on RF-EMF. The authors concluded that providing people with personal RF-EMF exposure measurements may not affect their perceived risk from MPBS but increase their confidence in protecting themselves [26].

However, people are more concerned about the mobile phone base stations (MPBS) than their personal phone use [27]. A critical review of the literature about trust and risk perception [28] analyses various trust models and the relationship between trust and affect heuristics. This author consider that most studies are observational and provide very little reliable information on causal relationships. Many studies in the field of risk perception and acceptance of hazards include trust as an explanatory variable. Future research should focus more on experiments that test whether trust is a consequence of people's attitudes or influences their attitudes toward a technology. Trust is useful because help people to reduce complexity and uncertainty of the novel risks. This author states that we do not yet know whether trust is a causal factor in the perception of risk or hazards; well-designed experimental studies are needed to assess how the decision-making process for accepting or rejecting a new technology occurs. The author concluded that the importance of trust varies by hazard and respondent group.

A qualitative sociological study (thesis) on the controversies surrounding the installation of mobile phone masts proposes to change the usual policy approach of the competent authorities who must deal with citizen opposition [29]. This work points out the negative consequences of dealing with a multifaceted societal issue only in terms of a risk-issue. It made siting controversies into a problem of science and communication, and a challenge that needed to be overcome, according to the authorities. The author proposes to use the notion of *engagement* in this thesis: as a constant reminder that citizens are not passive laypersons who suffer from deficits but are active social beings.

A qualitative survey [30] among the Dutch population ($n = 1009$), applied a questionnaire which contained questions about risk responses to EMF, perceived risk and benefits of several EMF sources, trust in government policy and perceived control over EMF exposure. The authors concluded that, especially in people with low perceived control, a lack of trust in government policy may enhance perceptions of health risks, thereby increasing their inclination for risk responses.

An online survey [31] was conducted in six European countries with 2,454 respondents, referring to RF-EMF risk potentials from base stations, and access points, such as Wi-Fi routers and cell phones. According to the authors high levels of concerns expressed in questionnaires do not automatically imply that these concerns are thematically relevant in everyday life. Compared to other participants, enduringly concerned subjects consider radio frequency electromagnetic field exposure to a greater extent as a moral and affective issue. They also see themselves as highly exposed to radio frequency electromagnetic fields. However, despite these differences, subjects with high levels of thematic relevance are nevertheless sensitive to exposure reduction as a means for improving the acceptance of base stations in their neighbourhoods. This underlines the value of exposure reduction for the acceptance of radio frequency electromagnetic field communication technologies. This characteristic should be considered in risk communication.

A study on social networking [32] performed a series of sentiment polarity analyses on data retrieved from Twitter to the fifth generation of cellular networks (5G). The authors collected relevant tweets in the English language and proposed a framework for mobile networks (such as 5G) based on different feature combinations. The performance of the proposed framework was evaluated using different feature combination in terms of different evaluation metrics such as accuracy, precision, recall, and f-measure. More than 10,000 tweets were retrieved. It is worth mentioning that there were lot of tweets related to conspiracy theories, for example some of tweets believed that 5G could cause COVID-19 in people. Most of the Twitter users believed that 5G could cause damage to their health.

A novel experimental study [33] aimed to investigate whether risk perception is amplified by framing hazards as as-if risks. The starting hypothesis was if a hazard is framed as if there is a risk, then it can be assumed that this framing amplifies the risk perception of the addressees of this communication. Psychology refers to framing as *an explicit* intention to use a particular scheme of interpretation. Through the choice of words, emphasized contexts, and highlighting in descriptions, recipients are led to see an issue in a special light. For example, it makes a difference for the health assessment whether a food is labelled as 5% fat-containing or 95% fat-free the study is based on an online sample from the Access Panel of the commercial provider Consumer fieldwork. A total of 404 subjects participated in the study. The response rate was 37%. Data collection took place in 2021.Overall the authors conclude that they found support for the hypothesis that risk perception is a multidimensional construct.

They recognize that although did not assess exposure and vulnerability explicitly in the study, perhaps the most accurate equation for measuring risk perception would characterize probability as a function of exposure and vulnerability, while consequences is a function of severity and emotion:

$$\text{Risk} = \text{Probability (Exposure + Vulnerability)} \times \text{Consequences (Severity + Affect)}.$$

This study, according to the authors, represents a first step toward identifying a multidimensional measure of risk perception for use across different types of hazards, this implies that multiple disciplines are needed to work toward a solution.

Future measures of risk perception should incorporate the experiential components of risk, namely, affect and the severity of consequences. Measures of probability should be included for understanding behavioural intensions, but further work is needed to better differentiate exposure and vulnerability when thinking about how individuals perceive the likelihood of experiencing negative consequences. Moving toward standardization in how risk perception is measured will be necessary to unify the many disciplines with interests in this topic, and to allow for comparisons in perceived risk across space and time.

One of the world's top experts (his career began in 1959) [34] has published an interesting article on Risk perception and Risk Analysis. The author points out that risk experts and lay persons sometimes agreed in their judgements but also strongly disagreed particularly in their evaluations of the controversial hazards. He describes that in some circumstances, feelings reflect an important value that deserve to be considered alone with traditional analyses of physical and economic risk.

Slovic, considers that the strongest predictor of perceived and acceptable risk for a particular hazard was the degree to which it evoked feelings of dread in people. The perceived risk and perceived benefit were inversely (odd) correlated across hazards. He gives as an example the different perception of the risk of nuclear energy and medical X-rays. The people judge the benefits of nuclear plant to be low and its risk to be high. One explanation for this inverse relationship between perceived risk and benefit is due to the affect heuristic.

The risk analysts used data, theory, and mathematical models to measure the core elements of risk, adverse consequences such as injuries, diseases, deaths, and monetary costs coupled with their respective probabilities. Social scientists examined risk perceptions and found them determined by subjectivity, values, and feelings in ways that had implications for technical analysis. Slovic, draws attention to the fact that a new element has become part of the mix, *risk as politics,* contributing to conflicting and controversy and even irrationality, and resulting in greater, rather than reduced level of danger.

A study [35] assessed whether risk perception of MPBS was associated with concerns about other environmental and health risks, psychological strain and was stable on the individual level over time. Self-administered questionnaires filled in by 3,253 persons aged 15–69 years in 2004 and 2006 in Germany. Risk perception of MPBS was strongly associated with concerns about various other risks like side effects of medications, air pollution or electric power lines. Persons showing more anxiety, depression, or stress were more often concerned about MPBS and more often attributed health complaints to MPBS. 46.7% of those concerned about MPBS in 2004 expressed these concerns again 2 years later, the corresponding figure for attribution of health complaints to MPBS was 31.3%. The authors concluded that Risk perception of MPBS is strongly associated with general concern, anxiety, depression, stress and rather instable over time.

Although there is no clear evidence for an association between RF-EMF from either mobile phones or MPBS and health outcomes, people often express concerns and perceive the risk from MPBS exposure to be higher than that

from their personal phone use, precautionary messages about RF-EMFs appear to affect different people in different ways.

In a study [36] using an online consumer panel (n=245), the authors tested the effects of providing people with information about EMF on lay understanding of exposure, and on perceptions and responses to risks, using an experimental design. They concluded that providing people with specific information explaining the distance–exposure relationship, clarifying EMF policy, or specifying personal exposure management options actions resulted in a better understanding of exposure. The authors concluded that information provision as such had no effects on concerns about EMF nor on perceived risk of personal sources, i.e., mobile phones, but lowered perception of risk of public sources, i.e., mobile phone base stations and high-voltage power lines. Moreover, participants who understood more about exposure in relation to the distance to the source showed lower perceptions of risk, were less likely to restrict their own exposure, and more likely to accept new installations of public sources of EMF in their neighbourhood.

Trust in government policy affects the way people perceive and handle risks. One Dutch study [30] investigated the relationships between trust in government policy regarding EM, perceived risk and perceived benefits of public and personal EMF sources, perceived control over exposure to EMF and responses to the possible EMF health risk (e.g. protest against placement of mobile phone base stations or power lines, or taking own measures against EMF exposure). They performed a survey among the Dutch population (n = 1009). The authors concluded that, especially in people with low perceived control, a lack of trust in government policy may enhance perceptions of health risks, thereby increasing their inclination for risk responses.

One study [37] about exposure knowledge and risk perception of RF EMF in the framework of the project EU-Project Low EMF Exposure Future Networks (LEXNET) which deals among other things with the issue of whether a reduction of the radiofrequency RF-EMF exposure will result in more acceptance of wireless communication networks in the public sphere. The research aims were oriented in how specific EMF sources are perceived regarding their health risk potentials. The survey was conducted in 2013 as an online study. Data were gathered in eight European countries, and after quality control, 3097 interviews remained for analysis with most respondents being citizens of the country in which the survey was carried out (Germany n= 652, France n= 200, Spain n = 298, Portugal n= 838, Romania n= 83, Serbia n= 800, Montenegro n = 199, and Belgium n= 27). The authors assumed that the effects of any reduction of EMF exposure will depend on the subjective link between exposure perception and risk perception (RP). The results show that participants are more concerned about base stations than about all other RF EMF sources. The results show a tendency that better exposure knowledge leads to higher RP, especially for mobile phones. The study provides empirical support for models of the relationships between exposure perception and RP. It is not the aim to extrapolate these findings to the whole population because the samples are not exactly representative for the general public in the participating countries.

In Korea, the nation where the world's cell phone usage is the highest, a study [38] researched differences between the level of objective knowledge regarding radio-frequency electromagnetic fields (RF-EMF) and risk perception of cell phones. A total of 3393 study subjects completed a survey measuring the degree of risk perception of EMF. The authors investigated the relationship between objective knowledge and the risk perception of cell phones using knowledge-related EMF questions drawn from the literature. The subjective factor, perceived level of exposure to EMF, was more strongly related to risk perception of cell phones than level of knowledge regarding EMF, an objective factor in this study.

As a result of the study, although psychological factors still have the greatest influence on risk perception, subjective knowledge was found to have the greatest influence on Koreans' risk perception of electromagnetic fields in terms of knowledge and risk perception. The results for the psychological factors, particularly in the cognitive domain, support the findings of the European GERoNiMO Project [39] that the risk perception of electromagnetic fields is not controllable. In a schematic way, the Figure 4 summarizes the 4 main types of factors that influence risk perception: Cognitive, Affective, Contextual and Individual[20]:

[20] https://upload.wikimedia.org/wikipedia/commons/c/cb/Factors_of_risk_perceptions._Adapted_from_Godovykh_et_al._%282021%29.jpg

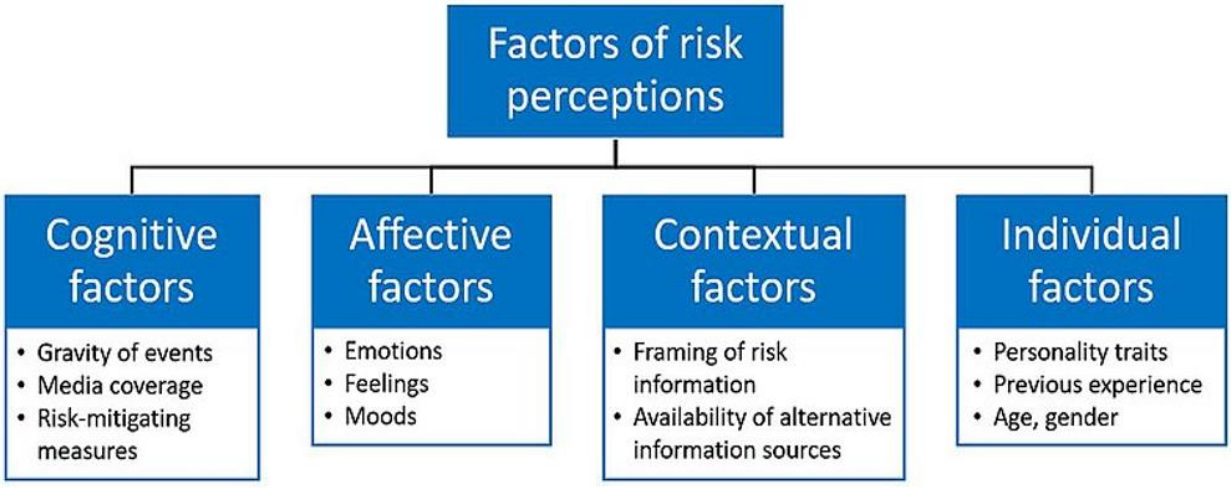

Figure 4: Risk Perception Factors adapted from: Antecedents and outcomes of health risk perceptions in tourism following the COVID-19 pandemic

2.3 Analysis of evidence on the main factors and value drivers that influence the population's confidence and risk perception on the effects of RF-EMF

In order to facilitate the wide adoption of the risk reduction measures and promote trust in science and regulatory public health authorities (UE, WHO, ICNIRP), the value drivers of the risk perception on RF-EMF must be clearly identified.

The citizen needs and concerns about RF-EMF are being undercut by misinformation that undermines public regulations and communication actions and efforts to establish safe limits of exposure to RF-EMF.

To conduct the analysis of the scientific evidence on the perception of risk on RF-EMF we have carried out three searches using the Web of Science database. In the first search, a record of 2,645,297 was obtained considering the eligibility criteria, the results were very dispersed and generalised, making it difficult to synthesise them. For this reason, we conducted a second search (the eligibility criteria also available in the appendix 1). Of the 69 results, 16 articles were reviewed. According to the results of this second search, we can observe that although some studies conclude and relate some symptoms with the RF-EMF exposure, in most of the experimental studies and surveys the conclusion is that there was no difference between the experimental groups regarding their exposure and risk perception.

Finally, due to the fact that the results found were still very general and still confusing, and without obtaining specific conclusions, we decided to limit the search, including only Reviews. We carried out a third search focusing on systematic reviews. The third search focusing on systematic reviews. In this screening the criteria were: trust (Topic) AND risk drivers (Topic) AND 5G technology (Topic) AND radiofrequency (Topic) OR RF-EMF (Topic) AND systematic reviews (Topic) AND meta-analysis (Topic) AND risk perception (Topic), then we further delimit the criteria to: trust (Topic) AND risk drivers (Topic) AND 5G technology (Topic) AND radiofrequency (Topic) OR RF-EMF (Topic) AND meta-analysis (Topic) AND risk perception (Topic).

As a result of these last two searches, we recorded five publications, but when delimiting the search period, 2015 to 2022, only four publications were got and selected. We have selected this period of time, because we have done a search of previous years and the search is very limited, if not at all. We considered that it would be very appropriate to review the studies subsequent to the 2015 SCENHIR review. Table 2 summarizes the results of these studies.

The reviews in this study field are similar in terms of study eligibility criteria. They consider for example, that the article had to be about EMF risk communication, especially in contrast to only being about risk perception, had to be a peer-reviewed journal publication and had to be in English [40].

Risk perception research originated in the late 1960s and 1970s. During the last decades, there has been a controversy over possible health effects of Radiofrequency Electromagnetic Fields (RF-EMF). The International Commission on

Non-Ionising Radiation Protection (ICNIRP) emphasizes that there is no conclusive evidence for any health effects of RF-EMF within the recommended exposure reference limits [41].

Regarding the methodology used by the review studies in this field, there is the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [42] and COSTER recommendation (Recommendations for the conduct of systematic reviews in toxicology and environmental health research) [43]. The PRISMA methodology provides updated reporting guidance for systematic reviews that reflects advances in methods to identify, select, appraise, and synthesis studies, and COSTER recommendation provides a set of recommended practices for the planning and conduct of SRs in the environmental health sciences.

In a recent review, Bosch et al, present the systematic review protocol of experimental studies in humans assessing the effects of RF-EMF on symptoms. The main objective is to assess the effects of exposure to electromagnetic fields (compared to no or lower exposure levels) on symptoms in human subjects, and also, assess the accuracy of perception of presence of exposure in volunteers with and without idiopathic environmental intolerance attributed to electromagnetic fields (EMF) [23].

According to Bosch, several literature reviews have been carried out to assess whether RF-EMF levels below regulatory limits may cause symptoms or may be perceived by volunteers with and without intolerance attributed to electromagnetic fields, but no evidence for an effect of the exposure has been found in these reviews that included population-based observational studies.

Some people report several types of non-specific symptoms such as headache or sleep disturbances, which they relate to exposure to RF-EMF. The types of reported symptoms vary between individuals, and the most commonly reported symptoms are headaches, sleep disturbances and tinnitus, but to date, cluster analyses have not identified specific symptom clusters related to specific EMF exposure sources or to EMF exposure in general [44] and the pattern of symptoms does not seem to be part of any recognized syndrome [45].

In the review study by Boehmert et al., 2020, all risk communication studies about RF-EMF were analysed, i.e., communication about potential health effects of human exposure to RF-EMF from mobile communication devices. In many of the studies, the perception of RF-EMF is described as a danger or as a concern [40]. Some researchers applied a 2×2×2 design in which they manipulated the existence of a risk (risk vs. no risk), the source of the RF-EMF (mobile phone vs. base station) and the outcome (cancer versus effect on well-being), however, they did not find a main effect of outcome manipulation [46].

In the Boehmert study, it is commented that the different studies about assessment of risk perception are carried out by double-blind experiments, providing messages on RF-EMF and assessing the perception before and after said exercise, or through the application of surveys, etc., but as far as we know, the results are very different and the results are not significant, in most cases, it depends on the information that the participant has on this issue.

Dömötör, et al., 2019 [46] provide a comprehensive understanding of Modern Health Worries (MHWs) and associated factors on people's concerns related to the potential harmful effects of modern technologies. This study suggests that female gender, age, somatic symptom distress and idiopathic environmental intolerances, holistic thinking, and paranoid beliefs are positively associated with MHWs. Dömötör, et al. suggest that more longitudinal studies are required to demonstrate the temporal association between MHW and the subsequent appearance of idiopathic environmental intolerances (IEI).

According to Siegrist 2021 [28], the research about risk perception can be grouped according to the characteristics of hazards, the characteristics of risk perceivers, and the application of heuristics to inform risk judgments. Meta-analysis studies show that precautionary recommendations increase the general public's perception of risk, however the effect size is very small.

Table 2: Summary of the results of the review studies on the factors the influence people's confidence and risk perception of RF-EMFs

Publication	Objective	Methodology	Type of study	Conclusions
Boehmert et al., 2020 [40]	Research on risk communication regarding radiofrequency electromagnetic fields (RF-EMF) of mobile communication technologies is systematically reviewed	For information about precautionary measures, the evidence was combined in a meta-analysis.	Systematic review	Mean effects showed a significant increase of risk perception regarding mobile phones and mobile phone base stations due to information about precaution for mobile phone risk perception.
Bosch-Capblanch et al., 2022 [23]	Assess the effects of exposure to electromagnetic fields (compared to no or lower exposure levels) on symptoms in human subjects. We will also assess the accuracy of perception of presence of exposure in volunteers with and without idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF).	Review according to WHO Handbook for Guideline Development, COSTER (Recommendations for the conduct of systematic reviews in toxicology and environmental health research) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Relevant literature sources for randomized trials and randomised crossover trials of RF-EMF exposure that have assessed the effects on symptoms.	Systematic review and protocol	In this review, the evidence on systematic reviews related to RF-EMF risk perception is presented and a protocol to follow for such reviews is proposed. The strength of evidence will be assessed for each outcome. The overall confidence in the association between each outcome and type of exposure is rated from high to very low.
Dömötör et al., 2019 [46]	Provide comprehensive, yet integrated understanding for MHWs and associated factors.	Following the PRISMA guideline was conducted based on 48 empirical articles published between 2001 and 2018 (Prospero registration number: CRD42018103756). All empirical studies were included that (1) used the MHWS or any of its sub-scales, and (2) assessed associations between MHWs and other constructs and/or compared criterion groups.	Systematic review	Suggest that female gender, age, somatic symptom distress and idiopathic environmental intolerances, holistic thinking, and paranoid beliefs are positively associated with MHWs, whereas educational qualification and the five major dimensions of personality appear not to be.

Publication	Objective	Methodology	Type of study	Conclusions
Siegrist and Árvai, 2020 [47]	Describe and reflect upon some of the lines of research that we feel have been important in helping us understand the factors and processes that shape people's risk perceptions.	We can be grouped according to three dominant perspectives and, thus, approaches to study design: the characteristics of hazards, the characteristics of risk perceivers, and the application of heuristics to inform risk judgment.	Narrative review	The importance role of risk perceptions in people's subsequent judgments and decisions must not be taken for granted. However, future research should focus on the relationships between risk perceptions and other variables that influence judgment.

The Siegrist and Árvai, narrative revision [47] summarised research on risk perception in three main perspectives:

1) The characteristics of hazards

2) The characteristics of risk perceivers

3) The application of heuristics (mental shortcuts) to inform judgements in line with Kahneman's theories [48]. Kahneman reveals where we can and cannot trust our intuitions and how we can tap into the benefits of slow thinking.

Understanding the factors that influence risk perception is important because it conditions behaviour and the acceptability or rejection of new technologies. The authors ask why people are so wary of hazards that experts consider harmful and so tolerant of their exposure to those that are known to cause a large number of deaths per year and are type 1 carcinogens such as alcohol, tobacco, air pollution from vehicle exhaust fumes, and so many others.

Siegrist and Arva recall Kanheman's question [47]: why it is so difficult for us to think statistically, the answer is because associative, metaphorical, and casual thinking is more generalised, easier. Statistical thinking, on the other hand, "requires thinking about many things at once, in a more logical, slow and leisurely way, using System 2 thinking, something that System 1 thinking (emotional and intuitive) is not designed for".

According to another interesting narrative review [49] there is still a long way to go before we fully understand psychological drivers of misinformation belief and its resistance to correction. These authors recommend not relying on small-scale studies conducted in laboratories or on a small number of online platforms, often with participants who are not representative of the population. In addition, behavioural measures, rather than attitudes obtained from self-report questionnaires, should be further explored. Most existing work has focused on explicit misinformation and written materials but the cognitive effects of other subtler types of misinformation such as "paltering" (deception while technically telling the truth) are unknown. Manipulated images, deep fake videos, and extreme patterns of disinformation (bots). Finally, these authors recommend further long-term research into the causation of disinformation and corrections to beliefs and behaviours.

2.4 European legislation on RF-EMF exposure

As outlined in section 2.6 of NextGEM deliverable D2.1 (EMF value drivers towards stakeholders needs on real case studies) the implementation of the EU Recommendation for the general public varies among the European member states[21]. Also, EU member states differ in policies regarding RF-exposure [50].

2.4.1 European Union EMF Legislation

EMF exposure standards in the EU and many other countries are based on the same scientific data but for the general public they may vary from country to country due to differences in interpretation.

[21] https://www.nextgem.eu/public-deliverables/

The EU Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)[22] sets the basic restrictions and reference levels for exposure of the general public to EMF. These limits and reference levels are based on the guidelines published by ICNIRP 2020. Most countries follow these guidelines.

In response to the questionnaire sent to the Member States in 2000[23], all Member States have informed the Commission that they have implemented the provisions of the Council Recommendation. However, as mentioned above, individual Member States or their regions may still adopt stricter limits.

For occupational exposure, the EU Council and the European Parliament adopted a revised EMF Directive (2013/35/EU) on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (EMF) [51]. The limits for radiofrequency fields are also derived from the 1998 ICNIRP guidelines. This required the development of a non-binding guidance document on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) for all sectors, including magnet resonance imaging (MRI) technology. (The corresponding guideline entered into force in 2016).

ICNIRP has issued new guidelines for RF-EMF between 100 kHz and 300 GHz in 2020 [41]. The main differences are higher reference levels for frequencies below 30 MHz, a higher power density basic restriction for frequencies above 6 GHz (both due to new dosimetric insights) and a longer averaging time (30 minutes) for whole body exposures longer than 6 minutes. Furthermore, new limits have been defined for exposure shorter than 6 minutes and local exposure, when the energy has not yet been redistributed throughout the body. These additional limits also matter for exposure to the higher frequencies associated with 5G, where the energy is more superficially deposited in the body. However, these new guidelines have not yet led to changes in the EU Recommendation for the general public and in the EU Directive for workers.

In July 2021, the Directorates-General CNECT, EMPL and SANTE of the European Commission requested the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) to issue an Opinion on the need for (technical) revision of the Annexes in the EU Recommendation and the EU Directive in the light of the latest available scientific evidence, in particular ICNIRP 2020. SCHEER published a Preliminary Opinion on its website on August 22, 2022, and requested feedback from the scientific community and stakeholders, with a deadline of September 25, 2022 [52]. The 2020 ICNIRP guidelines add new dosimetric quantities and limits that more effectively protect people from EMF from new wireless technologies. SCHEER therefore advises, in the preliminary opinion, positively for a technical revision of the appendices with limits for radiofrequency EMF in the EU Recommendation and the EU Directive. Some of the EU member states have already implemented the exposure limits from ICNIRP 2020 in their national legislation or are planning to do so.

In December 2018, the European Parliament and Council of the EU issued Directive 2018/1972 establishing the European Electronic Communications Code (EECC) [53]. This revises the regulatory framework for electronic communications networks and services in the EU, with the aim to provide incentives for investment in high-speed broadband networks, bring a more consistent internal market approach to radio spectrum policy and management, deliver conditions for a true internal market by tackling regulatory fragmentation, ensure effective protection of consumers, a level playing field for all market players and consistent application of the rules, as well as provide a more effective regulatory institutional framework. Under the Electronic Communications Code, member States may provide for proportionate and non-discriminatory restrictions to the types of radio network or wireless access technology used for electronic communications services, where this is necessary to protect public health against electromagnetic fields, taking utmost account of the EU Recommendation.

The European Parliament and Council of the EU have also issued Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment [54] to ensure the protection of health and safety of persons. The European Committee for Electrotechnical Standardisation

[22]https://osha.europa.eu/en/legislation/guidelines/council-recommendation-1999-519-ec-on-the-limitation-of-exposure-of-the-general-public-to-electromagnetic-fields-0-hz-to-300-ghz

[23]https://health.ec.europa.eu/publications/implementation-report-council-recommendation-limiting-public-exposure-electromagnetic-fields-0-hz_en

(CENELEC), in liaison with the European Telecommunications Standards Institute (ETSI), has developed harmonised standards for measurement and calculation of EMF exposure which can be used to demonstrate that the essential requirements set in the directives are met. The EC published in November 2022 a summary list of titles and references of harmonised standards under Directive 2014/53/EU on radio equipment [55].

Two recent standards (May 2022) that are especially relevant to the work in NextGEM are:

- Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) - Part 1: Measurement procedure (IEC/IEEE 63195 1:2022).
- Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) - Part 2: Computational procedure (IEC/IEEE 63195 2:2022).

In October 2021, the European Commission registered a citizens' initiative entitled 'Stop 5G – Stay connected but protected'[24]. This citizens' initiative calls on the Commission to develop legislation that protects all life forms against harmful effects of EMF and microwaves and against perceived effects of 5G and related digitization on the environment, security, and privacy. If the initiative garners one million signatories within a year (by 1 March 2023), the Commission will have to make an official response and decide whether or not to follow up on the request. On February 1, 2023, there were approximately 49,000 signatories.

On July 20, 2020, the European Commission Implementing Regulation 2020/1070 defining the characteristics of small-area wireless access points ('small-area wireless access points') came into force in all EU Member States [56]. The implementing regulation follows from the European Electronic Communications Code and stipulates that small cells for local wireless communication must be concealed (or meet a range of other structural conditions) and must comply with European standard EN 62232:2017 'Provision of the RF field strength and SAR in the vicinity of base stations for radio communications (transmitter poles) for the purpose of human body exposure assessment'. This standard, and Recitals (3), (7) and (14) in the Implementing Regulation refer to the exposure limits in the EU Recommendation. In an explanation on its website, the Commission indicates that small cells are crucial for a timely roll-out of 5G networks and that the implementing regulation facilitates license-free roll-out, while national authorities continue to monitor this.

2.4.2 National Regulations

In 2018 the National Institute of Public Health and the Environment (RIVM) in the Netherlands published a report on the comparison of international policies on electromagnetic fields (power frequency and radiofrequency fields) [57]. That report gives an overview of the policies in EU member states until July 2017. In this section examples are given of changes in national regulations in the four years since the publication of the RIVM report in 2018.

2.4.2.1 Latvia, Lithuania & Poland

Three EU member states that previously had no legal EMF limits (Latvia) or applied precautionary limits that were stricter than those in the EU Recommendation (Lithuania, Poland) have adopted the basic restrictions and reference levels in the EU Recommendation. For Latvia, the EU limits apply to EMF of all frequencies between 1 Hz and 300 GHz since 2018. For Lithuania, the EU limits apply to frequencies between 10 kHz and 300 GHz since 2020. For Poland, the EU limits apply to frequencies between 1 kHz and 300 GHz since 2019.

2.4.2.2 Ireland & Malta

In Ireland, the Commission for Communications Regulation, in its Conditions for the provision of Electronic Communications Networks and Services (2018) makes the most recent ICNIRP limits compulsory for obtaining a license. Authorised spectrum users have to comply with any radiation emission standards adopted and published by ICNIRP or its successors from time to time, in effect making the 2020 ICNIRP limits for RF EMF applicable. Malta's Electronic Communications Networks and Services (General) Regulations (2021) state that the Malta Communications Authority may impose restrictions on electronic communications networks where necessary to protect public health against electromagnetic fields, taking due account of the EU Recommendation and guidelines adopted by ICNIRP or

[24] https://signstop5g.eu/en

by the relevant national authorities. The conditions for permit holders also explicitly stated in previous versions of the Regulations that they must comply with the exposure limits in any guidance document adopted and published by ICNIRP. This dynamic reference makes the 2020 ICNIRP limits legally applicable for radio frequency EMF in Malta. The associated mandatory procedures for field strength measurements in publicly accessible places to demonstrate compliance with the limits have also been published by the Malta Communications Authority in 2021.

2.4.2.3 Spain

In Spain it is mandatory the 1999/519/EC: Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz). In 1999, the Committee of Independent Experts (CEI) was created and prepared a report, published in 2001, on the scientific evidence on electromagnetic fields and public health. One of its recommendations was to establish the limits of ICNIRP and the aforementioned Recommendation as mandatory. An update of this report was published in 2003-2004. The exposure limits for this recommendation were made mandatory by Royal Decree (RD 1066/2011). Since the publication of this law the problems, protest and demonstrations against base station started to decline. This is the main public health action adopted by the Ministry of Health. In 2005 was published the Report of the Ministry of Health and Consumption on the application of RD 1066/2001 was published, the main conclusions of this report were:

1) The implementation of RD 1066/2001 has made it possible to ensure the health of citizens in the face of exposure to radiofrequency electromagnetic fields 2) The levels measured throughout the territory are well below the limits considered as safe by the limits considered safe by national and international committees and organizations national and international organizations. 3) At present, in the light of scientific knowledge, there are no health reasons that would justify a change in the exposure limits established Royal Decree 1066/2001. 4) The risk perception of some social sectors, although legitimate, does not correspond to the available scientific evidence, which has not observed any adverse observed no adverse health effects from exposure to EMF from base stations.

On the other hand, the RD1066/ 2001, published in close coordination with other Ministry competent in the authorization of base station, established an open and free web about the level of exposure[6], whatever citizen can consult. This website reports the exposure limits of all authorized antennas in the country. According to the 2022 report, after the 1.454.893 measurements carried out in areas where people usually stay, the levels of radioelectric exposure derived from radiocommunication services are significantly lower than the exposure limits regulated in Real Decreto 1066/2001, of September 28, established for the health protection of people.

No specific surveys on risk perception of RF-EMF have been published.

In relation with workers (the INSST, Spanish Institute of Workers Security and Health), have published a good guide.

2.4.2.4 Belgium

In July 2021, the government of the Brussels-Capital Region approved in first reading a preliminary draft amending ordinance that relaxes the existing precautionary limit for the electric field strength of radio frequency EMF from transmission installations from 15% to 22% (inside buildings) or 35% (outside buildings) of the reference level in the EU Recommendation. The decision must then go through the usual route through advisory bodies and approval by the Brussels parliament. The proposal to increase the limits was partly made following recommendations from an ad hoc consultation committee of the Brussels-Capital Region on the roll-out of 5G in June 2021. This committee also recommended that the limits be applied to EMF from radio and television transmitters (excepted so far), that a public monitoring and information system be set up for non-ionising radiation, examining the possibility of keeping zones without 5G in Brussels (to allow a comparison between zones with and without 5G), prioritising the use of fibre networks over 5G, to take into account conclusive scientific studies on the effects of 2G to 5G on the environment and to study the recognition of electrohypersensitivity (EHS) as a disease. In 2021, two more decisions were also adopted in the Brussels region, incorporating in Brussels legislation various administrative provisions from the EECC and changes in measurement and calculation methods for determining the field strength.

In December 2022, the government of the Walloon region amended its ordinance on the protection against harmful effects of non-ionising radiation generated by stationary antennas, based on the advice of an expert group with members from government institutions and the Superior Health Council. The amendment increases the existing precautionary limit for the electric field strength per operator inside buildings from 7% to 22% of the reference level in the EU Recommendation. In addition, a cumulative limit for the total field strength for all antennas per site is introduced, which is 45% of the reference level in the EU Recommendation. These limits thus have become the same

as in the legislation of the Flemish region. Furthermore, as a precaution, the Walloon government decided to exclude the use of millimetre waves for the roll-out of 5G because the scientific knowledge about health effects is insufficient. The government has also decided to establish a continuous monitoring of the population's exposure and a longitudinal study of possible health effects, and to allow municipalities to request an exposure check.

2.4.2.5 Italy

In July 2020, the Italian Parliament passed a new law 'for simplification and digital innovation', which is also intended to compensate for the negative economic consequences of the Covid-19 epidemic. Regarding EMF, the law states that while local governments may adopt regulations for the placement of infrastructure and limit exposure in 'sensitive locations', they may not impose general restrictions on the placement of mobile phone base stations in public areas and may set alternative local exposure limits. The authority to determine exposure limits for EMF was already reserved to the national government through previous legislation. Furthermore, the new law makes it easier to install temporary transmission installations (e.g., for events or security) with self-certification, which can be done simultaneously with installing the transmission installation.

2.4.2.6 Greece

In 2020 a new basic restriction confirmed the current exposure limits for publicly accessible places for EMF from antenna installations. For power density these are 70% of the basic restrictions in the EU Recommendation and 60% for antennas within 300 m of sensitive destinations (schools, nurseries, hospitals, care homes). No antennas may be placed at all on top of the sensitive destinations themselves. There is still a notification obligation for installations with a capacity greater than 100 W and the measurement procedures remain in force, but the permit procedures have been simplified. New is the establishment of a committee that can review the limits in a procedure involving opinions from experts, market parties and interest groups.

2.4.2.7 Netherlands

Due to increased data requirements a further densification of the mobile telecom networks is expected, especially at a local level where small cell antennas will make their way into the street scene. Many citizens expressed their concerns about the radiation from antennas, also as a result of the introduction of 5G. According to the ministry of Economic Affairs and Climate Change[25] citizens must be offered as much certainty as possible that the electromagnetic fields from antennas do not pose a threat to health in the living environment, even if there are several antennas in the immediate vicinity (on lampposts, bus shelters, advertising objects, etc.). Also, according to the ministry, it is important for operators that the roll-out of 5G networks, including the small cells, can take place under a nationally uniform EMF regime. In the Netherlands telecommunication companies have set limits even more restrictive than those set by ICNIRP, in order to respect the limits of the EU Recommendation in places accessible to the public. Because the EU Recommendation is not anchored in legislation, a process has been started to implement 2020 ICNIRP in the Telecommunications Act. To give providers and citizens certainty about the rules that apply, it is important to maintain uniformity and to set standards in law.

[25] https://www.tweedekamer.nl/downloads/document?id=2018D37596

3 Support of Public Authorities & Regulators with good scientific evidence

The topic "electromagnetic fields and health" is characterized by a complex interaction between risk perception, research, hazard/risk assessment, communication of the scientific evidence and risk management. Scientific knowledge evolves over time and prevention policies based on scientific evidence follow the circular trend of this process (Figure 5).

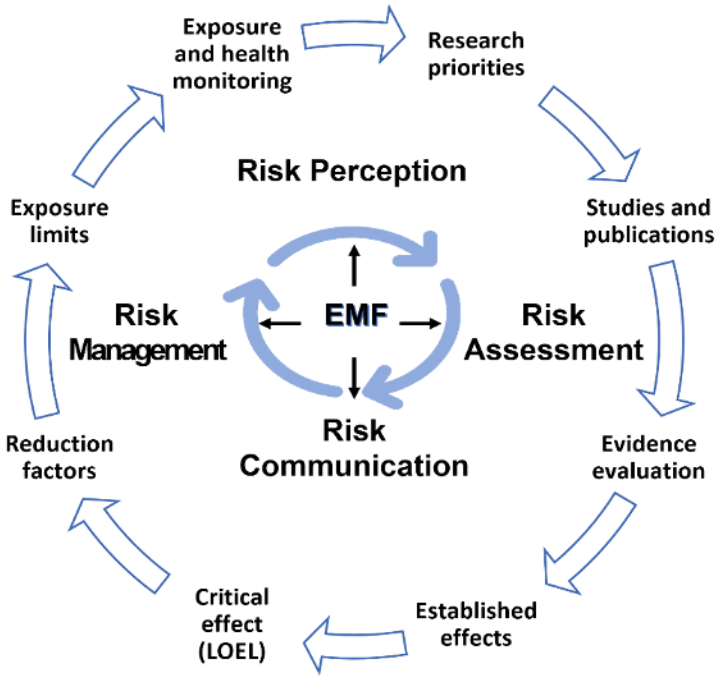

Figure 5: Health hazards & Risks from exposure to electromagnetic fields

The exponential growth of scientific information, the proliferation of open access journals, and the wide accessibility by the public at large (the information paradox) makes it very difficult to select, summarize, and assess the evidence capable to inform effective public health decision-making.

We understand scientific evidence to be the body of knowledge, relevant to a given topic, and informative regarding a specific public health question.

The relevance, quality, and informativeness of a body of evidence depend on many factors. Several screening criteria are proposed below.

a) **The background**: Sound and clearly formulated research priorities are of pivotal in catalysing new waves of pertinent scientific studies.

b) **The vehicle**: Publications from journals of recognized scientific prestige that are subject to objective criteria of quality assessment (peer review, adherence to international reporting guidelines, suitable design and analytical methods, ethical publication standards, impact indexes, etc.).

c) **The collections**: Indexing in acknowledgeable literature databases (either general or topic/method specific) is an additional warranty.

d) **The assessors**: Multidisciplinary expert panels, especially when charged of answering clearly defined questions and following a priori defined inclusion/exclusion criteria and transparent systematic and critical review methods, provide the most reliable source of information for health protection measures.

Scientific evidence is verifiable because it is based on experimentation and study designs using a scientific method that are verifiable and reproducible by any qualified researcher.

3.1 International Organization and guidelines

The quality of the evidence indicates the extent to which we can be confident that the effect estimator is correct, and the strength of a recommendation shows the extent to which we can be confident that implementing the recommendation carries more benefit than risk. Analysing the quality of studies allows us to rank the weight of evidence and the strength of their recommendations. Not all studies that are labelled or disseminated as scientific are equally valid. For example, well-designed human studies (randomised and blinded), systematic reviews and meta-analyses have more scientific rigor and therefore more value than single case studies or studies in cells or the opinions of an "expert".

The decisions of public health regulatory authorities in setting RF-EMF exposure limits are based on best scientific evidence (Evidence Based Public Health -EBPH), which is the application of the best available evidence, precise, valid and relevant scientific knowledge in setting public health policies and practices. The implementation of such public health policies requires good evidence on feasibility, efficacy, effectiveness, efficiency, cost, acceptability to the target population, and careful analysis of ethical and political implications.

Using this methodology, competent organisations, agencies, scientific societies, academies, universities, and scientific committees develop their recommendations and guidelines for the protection of health from electromagnetic fields.

At the international level, many public health agencies in Europe and elsewhere perform hazard and risk assessment for EMF, these bodies include the World Health Organisation[26] (WHO), Scientific Committee on Emerging and Newly Identified Health Risks [58] (SCENIHR); the International Commission on Non-Ionising Radiation Protection (ICNIRP) [59], Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) [52] and the Institute of Electrical and Electronics Engineers (IEEE) [60].

At the national level, there are agencies and committees that have published systematic reviews on EMF risk assessment, including the following: l´Agence nationale de sécurité sanitaire de l´alimentation, de l´environnement et du travail (ANSES, France) [61], 2018, 2022; the Health Council of the Nederlands (HCN) [62], Comité Científico Asesor en Radiofrecuencias y Salud (CCARS, Spain) [63] 2020; Federal Commission Communications (FCC) (USA) [64]; Strålsäkerhetsmyndighetens (SSM, Sweden) [65], Istituto Superiore di Sanità (ISS, Italy) [66], Stellungnahme der Strahlenschutzkommission (SSK, Germany) [67], and Joint Research Center (JRC) 2021 [68].

ICNIRP and IEEE are real regulatory bodies; a critical review of the scientific evidence is the starting point, followed by a cascade of steps leading to the formulation of exposure limits for workers and the general population. Such limits are periodically revised, to account for advances in knowledge.

The conclusions of these agencies state that there is no scientific evidence that exposure to emission levels, below those set out in the Recommendation of the Council of Health Ministers of the European Union on Public Exposure to Electromagnetic Fields and by the International Commission on Non-Ionising Radiation Protection (ICNIRP) guidelines, produces health effects in the population.

Below are some of the conclusions of these agencies and committees that support the decisions of public health authorities.

3.1.1 World Health Organization (WHO)

The WHO has established that to date and after extensive research, no adverse health effects related to exposure to wireless technologies have been observed [69]. Conclusions on health effects have been drawn from studies of the entire RF spectrum; so far, very few studies have been conducted on 5G as its deployment is in its infancy. The WHO is conducting an EMF risk assessment which will be published when it is finalised.

3.1.2 Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)

The SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) is the independent scientific committee that advises the European Commission. Its reports are used to set the European Commission's public health policies.

[26] https://www.who.int/news-room/questions-and-answers/item/radiation-5g-mobile-networks-and-health

This committee concluded [58] that the results of multiple double-blind provocation studies yielded a strong overall weight of evidence that such effects are not caused by RF exposure, and that the evidence from observational studies weighed against a causal effect between EMF exposure and non-specific symptoms (IEI-EMF).

Recently, SCHEER has stated that this conclusion remains valid. Given the methodological limitations of research in this area to date, this committee is of the opinion that future research should always include objective measures (physical/biochemical/biological markers) of response to EMF exposure alongside other types of psychological measures or subjective reports.

3.1.3 Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)

Following a request from the European Commission, the SCHEER provided the preliminary Opinion on the need of a revision of the annexes in the Council Recommendation 1999/519/EC and Directive 2013/35/EU, in view of the latest scientific evidence available with regard to radiofrequency (100 kHz – 300 GHz) [52].

The SCHEER has considered meta-analyses, systematic reviews, and, when necessary, narrative or scope reviews and single research papers published after and including 2015 on radiofrequency electromagnetic fields (100 kHz to 300 GHz). The SCHEER could not identify moderate or strong level of evidence for adverse health effects resulting from chronic or acute RF EMF exposure at levels below the limits set in the annexes of Council Recommendation 1999/519/EC and Directive 2013/35/EU.

The SCHEER advises positively on the need of a technical revision of the annexes in Council Recommendation 1999/519/EC and Directive 2013/35/EU about radiofrequency electromagnetic fields (100 kHz to 300 GHz), because there is a need to recognize the recently introduced dosimetric quantities and establish limits for them.

3.1.4 French Agency for Food, Environmental and Occupational Health & Safety (ANSES)

According to a systematic review [45] of ANSES (2018) in relation to electromagnetic hypersensitivity, published studies do not provide convincing evidence of a causal relationship between exposure to radiofrequency fields and symptoms reported by people claiming to be hypersensitive to them, and there is currently no scientific basis for linking exposure to electromagnetic fields and such symptoms.

In relation to 5G ANSES [61] has estimated that its deployment in the 3.5 GHz frequency is "unlikely" to present new health risks, although for the 26 GHz frequency band - which is planned to be launched later - the data are not yet "sufficient" to draw conclusions.

ANSES investigated whether exposure to different frequencies of electromagnetic radiation causes biological abnormalities and concluded that at the 3.5 GHz frequency there is no "significant increase in exposure in the population". It notes that exposure induced by 5G deployment in the 3.5GHz frequency band does not constitute a new health risk (page 18/27).

3.1.5 Health Council of the Netherlands (HCN)

The Dutch Health Council in a recent review on 5G and health [62] has formulated 4 recommendations.

-Since it is already known that the lower frequencies of 5G do not produce adverse health effects, there is no reason to stop or restrict the use of these frequencies. At the same time, it recommends monitoring exposure levels during and after the deployment of the 5G network in order to estimate its long-term effects.

- Conduct further epidemiological research on the relationship of 5G to tumour incidence and other health effects, experimental studies in the 26 GHz bands and studies on human exposure to 3G, 4G and 5G networks.

- Do not use 26 GHz frequencies until potential health effects are investigated.

- Apply ICNIRP guidelines in the Netherlands with a precautionary approach and keep exposure as low as possible.

Exposure to 5G will be more variable than at present, depending on the distance between the antenna and the terminal, the beam focus of the steerable antenna, the number of beams controlled by the antenna and the exposure time (use of the terminal).

3.1.6 Comité Científico Asesor en Radiofrecuencias y Salud (CCARS)

CCARS has published in 2020 its triennial report to update the highest quality scientific evidence during the period from July 2016 to December 2019 [63]. The report conclusions confirm the evidence observed in the previous CCARS report regarding the scientific evidence to date, showing that there is no evidence of risk to human health under normal levels of personal exposure to RF EMF. The scientific information (evidence) is obtained from clinical and epidemiological studies that provide the greatest weight of evidence, depending on the study design, methodology, quality, validity, consistency, and reproducibility. This report is not a systematic review or meta-analysis, but has followed a methodology similar to that of a scoping review-

The report includes an extensive chapter dedicated to dosimetry and assessment of exposure to new 5G-based technologies and wi-fi systems. A review of epidemiological cohort and case-control studies on the relationship between mobile phone use and brain tumours confirms that no increased risk is observed.

Analysis of trends in the incidence rates of CNS tumours over long periods of time can help to identify risk factors related to the etiology (causes) and prevention of the disease. No relationship is observed in Spain between the number of mobile phone users and the incidence of brain tumours, according to data published by REDECAN (Spanish Network of Cancer Registries).

Meta-analyses for the risk of cancer from epidemiological studies of the following tumours: head, malignant (gliomas), benign (meningiomas), acoustic neuromas, pituitary glands and salivary glands, compared with prolonged use (at least 10 years) of mobile phones does not show any increased risk. Although some case-control studies have reported significant increases in risk in people with moderate mobile phone use, these observations are not consistent with brain tumour incidence rates over time, despite increased exposure.

Experimental provocation studies with volunteers who claim to have an Idiopathic Environmental Intolerance attributed to electromagnetic fields (IAI-EMF) fail to demonstrate they are capable of detecting EMF when exposed to them.

3.1.7 Swedish Radiation Safety Authority (SSM)

In its last report [65] it is stated that no new established causal relationships between EMF exposure and health risk have been identified. The new evidence indicates that there is no risk to the health of the population exposed to RF from BS, wireless networks, radio and TV transmitters, or wireless data networks used in schools or homes.

Regarding electromagnetic hypersensitivity (HE), the SSM has already established (2016) in previous reports that the studies analysed do not provide evidence that exposure to EMF is a causal factor. In experimental challenge studies, both people suspected of having HE and healthy volunteers have been exposed to real or fictitious EMF. No differences in the prevalence of observed symptoms were observed between actual and simulated exposure. The thesis that the nocebo effect explains the symptoms of this type of people with HE is insisted on. symptoms they express are not due to RF exposure. However, these symptoms occur or can be aggravated in some people when they think they are exposed. This is the well-known nocebo effect, and it is one of the reasons that invalidates the supposed effects indicated in some observational studies based on specific surveys in population groups alarmed by the presence of antennas.

3.1.8 Italian Istituto Superiore di Sanità (ISS)

According to a systematic review report and meta-analysis of studies published between 1999 and 2017 [66], it is ensured that there is no scientific evidence that exposure to radio frequencies "can cause cancer in humans or animals."

According to current epidemiological evidence, the use of mobile phones is not associated with the incidence of neoplasms in the areas most exposed to radiofrequency during voice calls."

The possible association between exposure and cancer risk has been weakened and does not require "changes in the configuration of current protection standards." According to the authors, compared with studies published in the last 20 years, "no increased risks of malignant (glioma) or benign (meningioma, acoustic neuroma, salivary gland tumours) are detected in relation to long-term use (10 years) of mobile phones". However, further studies are underway to clarify the remaining uncertainties. The Italian ISS has only an advising role for the relevant government Ministries (Health, Environment, Communications…), and the report ISTISAN 19/11 does not present any conclusion (it only quotes the evaluations made by the IARC in 2013 and, afterwards, by several expert panels).

3.1.9 German Commission on Radiological Protection (SSK)

A recent scientific literature review study has been published by the SSK (Strahlenschutzkommission) [67].

This new report updates a previous report published in 2011 on radio frequencies but in this case, it is dedicated to the update of knowledge on the new mobile phone network using 5G technology.

The report stresses that the use of 5G technology makes the exposure to radiation and magnetic fields much more dependent on the receiving devices (mobile phone) than on the transmitting base stations (antenna network). It is even mentioned that this improvement in radio communications leads to a reduction of the overall personal exposure.

In Chapter II, the effects that Radiotelephony signals can have on biology and health are reviewed. Based on the current state of research concerning the biological aspects of HF emissions, it can be assured that for FR1 frequencies (currently 2G, 3G and 4G) and in the future also for 5G and considering the regulations and maximum values set in Germany, there are no health risks for exposed persons (within the framework of the maximum values set for base stations and receiving apparatus).

However, further research is needed in certain areas, especially to expand the data base. There is relatively little good quality epidemiological data on long-term effects.

The authors again insist that the greatest risk comes from receiving devices ("near-body") and not from base stations. They indicate that 88% of the exposure of the human brain comes from the mobile phone (smartphone).

In order to establish any health risk, the level of exposure must be known, and this is not possible because the 5G network is still in the introduction phase.

3.1.10 European Commission's Joint Research Centre (JRC)

In June 2021 the JRC published a technical report [68] focusing on studies published in the last years on exposure to RF-EMF from mobile phone networks and possible adverse health impacts.

According to the authors of this paper, the deployment of the new 5G networks has generated, in some sectors of society, a reaction of rejection to the installation of the new antennas due to fears that they could increase overall RF exposure. The paper notes that there are many citizens who perceive the risk of RF as likely or possibly severe although they do not provide data or sources to confirm these fears. Among the causes of this level of apprehension, according to the JRC report, there are misinformation circulating in the media, the dissemination of news about scientific studies with unconfirmed and unreplicated results that reinforce suspicions about as yet undiscovered dangers or that are deliberately concealed.

This study was commissioned by the EU's DG CNET (Directorate General for Communications Networks, Content and Technology) to identify possible links between the proliferation of mobile communication networks and possible health effects. The European Commission aimed to act proactively to public concern and for this reason promoted an independent scientific study based on transparency as a prerequisite for public confidence. The EU also intends to validate the scientific evidence on which ICNIRP has been based in order to update its 2020 guidelines.

Their results confirm that the exposure of the European population is well below the levels considered safe by the 1999 European Recommendation and ICNIRP (1998 and 2020).

The authors suggest that other toxic agents (e.g., pollution) may act as promoters, with a cumulative impact (adverse health effect) and should be considered when assessing the risk of health effects of RF EMF emissions.

- No adverse health effects from electromagnetic emissions from mobile phone networks have been observed in this study.

- No correlation has been detected between mobile phone use and the incidence of brain and central nervous system tumours.

Cancer is associated with age; the older you are, the more likely you are to get a tumour. This fact is unquestionable, the official statistics (Morbidity and mortality statistics, Cancer registries, etc.) are the ones that should be consulted to assess whether it is true that there is an increase or whether it is simply a normal presentation of cases.

An international epidemiological case-control study [70] analysed the relationship between the use of mobile and fixed wireless phones and the risk of brain tumours in 900 young people (matched for sex, age and region with 1900 controls,

i.e., participants without the disease of interest, which in our study were young people with appendicitis) from 14 countries. Despite being the largest study to date, the research found no causal association between brain tumours and lifetime use of these phones.

3.1.11 International Commission on Non-Ionizing Radiation Protection (ICNIRP)

In a recent publication, the ICNIRP [59] explains, in a very effective way, its charter and activities, the meaning of "scientific evidence", and the need for a critical assessment of the relevant literature: "ICNIRP provides guidance only based on scientifically substantiated effects. In general, an effect needs to be observed in more than one study, and different types of studies. (Epidemiological or experimental) are considered. An obvious requirement is that studies are performed according to accepted scientific practice and quality criteria. Some criteria are common for all types of study, while others are specific for study type. For experimental studies these include, but are not limited to, adequate dosimetry and inclusion of a sham-exposed group. For epidemiological studies minimization of bias is essential, which includes an adequate description of the investigated population group, well-defined exposure contrasts, and adequate identification and control of confounding factors. For all types of studies, the analysis of data should be performed using appropriate statistical procedures. Overall, this means that the results should also be explicable more generally within the context of the scientific literature. In the ICNIRP documents, "evidence" is used within this context, and "substantiated effect" is used to denote reported effects that satisfy this definition of evidence.".

All agencies, institutions, and competent authorities in assessing the health risks of people exposed to RF-EMF agree that no evidence of health risks derived from exposure to RF EMF emitted by radio stations has been observed. In Table 3, we summarize all the revision cited about Guidelines and Systematic reviews on health effects of RF-EMF.

Against this position there are some opinions (Hardell group and self-proclaimed International Commission on the Biological Effects of Electromagnetic Fields-ICBE-EMF- https://icbe-emf.org/) that do not accept the limits recognized by the WHO, EU, ICNIRP, IEEE, FCC. etc. and they consider that EMFs are dangerous to health even though there is no rigorous evidence and, therefore, they demand drastic measures to reduce exposure.

Despite the unanimity of the scientific bibliography that reflects the state of science, there are always, on this issue as on any other, organizations, people, appeals, etc. who resort to works that find some biological effect or alarm about possible future health consequences of new technologies. A similar example is the rejection of vaccines by some groups. The current evidence of clinical and epidemiological results does not allow us to establish the existence of a solid causal relationship between exposure to radio frequencies from mobile telephone masts and adverse effects on health. The disclosure of some results of works that have not used a proven scientific methodology, with serious methodological deficiencies that invalidate their results, generates an uncertainty that is not justified by current evidence.

Table 3: Risk assessment, Guidelines and Systematic reviews on health effects of RF-EMF (100KHz-300GHz) and 5G

Risk assessment, Guidelines and Systematic reviews on health effects of RF-EMF (100KHz-300GHz) and 5G		
ORGANIZATION	METHODOLOGY. TYPE OF STUDY	CONCLUSIONS
WHO 2020	Evidence revision. Statemens.5G	No adverse health effects related to exposure to wireless technologies have been observed on health effects from studies of the entire RF spectrum; So far, very few studies have been conducted on 5G as its deployment is in its infancy. The WHO is conducting an EMF risk assessment which will be published when it is finalised
SCENIHR EU 2015	Systematic review	The results of multiple double-blind provocation studies yielded a strong overall weight of evidence that such effects are not caused by RF exposure, and that the evidence from observational studies weighed against a causal effect between EMF exposure and non-specific symptoms (IEI-EMF).

		The evidence of the relationship between glioma and mobile phone use is weaker since 2011.
SCHEER, EU 2022	Systematic review. A revision of the annexes in the Council Recommendation 1999/519/EC and Directive 2013/35/EU. Meta-analyses, systematic reviews, and, when necessary, narrative or scope reviews and single research papers published after and including 2015 on RF-EMF (100 kHz to 300 GHz).	Not identify moderate or strong level of evidence for adverse health effects resulting from chronic or acute RF EMF exposure at levels below the limits set in the annexes of Council Recommendation 1999/519/EC and Directive 2013/35/EU. Advises positively on the need of a technical revision of the annexes in Council Recommendation 1999/519/EC and Directive 2013/35/EU about radiofrequency electromagnetic fields (100 kHz to 300 GHz).
IEEE 2019	Guidelines. Standards	This standard specifies exposure criteria and limits to protect against established adverse health effects in humans associated with exposure to electric, magnetic, and electromagnetic fields in the frequency range of 0 Hz to 300 GHz.
ANSES France 2018 and 2022	Systematic review 2018 Electromagnetic hypersensitivity Narrative review 5G 2022 Tumours NCS	Published studies do not provide convincing evidence of a causal relationship between exposure to radiofrequency fields and symptoms reported by people claiming to be electromagnetic hypersensitive to them. There is currently no scientific basis for linking exposure to electromagnetic fields and such symptoms. In relation to 5G has estimated that its deployment in the 3.5 GHz frequency is "unlikely" to present new health risks, although for the 26 GHz frequency band - which is planned to be launched later - the data are not yet "sufficient" to draw conclusions. Exposure induced by 5G deployment in the 3.5GHz frequency band does not constitute a new health risk.
HCN Nederland 2020	Narrative review on 5G. Recommendations.	There is no reason to stop or restrict the use of these frequencies. Monitoring exposure levels during and after the deployment of the 5G network in order to estimate its long-term effects. Conduct further epidemiological research on the relationship of 5G to tumour incidence and other health effects, Experimental studies in the 26 GHz bands and studies on human exposure to 3G, 4G and 5G networks. - Do not use 26 GHz frequencies until potential health effects are investigated. - Apply ICNIRP guidelines in the Netherlands with a precautionary approach and keep exposure as low as possible.
CCARS Spain 2020	Narrative and scope revision (2016-2019)	There is no evidence of risk to human health under normal levels of personal exposure to RF-EMF. A review of epidemiological cohort and case-control studies on the

		relationship between mobile phone use and brain tumours confirms that no increased risk is observed. Experimental provocation studies with volunteers who claim to have an Idiopathic Environmental Intolerance attributed to electromagnetic fields (IEI-EMF) fail to demonstrate they are capable of detecting EMF when exposed to them.
SSM Sweden 2022	Systematic review	No new established causal relationships between EMF exposure and health risk have been identified. The new evidence indicates that there is no risk to the health of the population exposed to RF from Base Stations, wireless networks, radio and TV transmitters, or wireless data networks used in schools or homes. Regarding electromagnetic hypersensitivity, the SSM has already established (2016) in previous reports that the studies analysed do not provide evidence that exposure to EMF is a causal factor.
ISS Italy 2019	Systematic review and meta –analysis of studies published between 1999-2017	There is no scientific evidence that exposure to radio frequencies "can cause cancer in humans or animals. According to current epidemiological evidence, the use of mobile phones is not associated with the incidence of neoplasms in the areas most exposed to radiofrequency during voice calls." The possible association between exposure and cancer risk has been weakened and does not require "changes in the configuration of current protection standards." No increased risks of malignant (glioma) or benign (meningioma, acoustic neuroma, salivary gland tumours) are detected in relation to long-term use (10 years) of mobile phone.
SSK Germany 2021	Narrative and scope revision. FR1 frequencies (2G, 3G, 4G and 5G)	There are no health risks for exposed persons (within the framework of the maximum values set for base stations and receiving apparatus). The greatest risk comes from receiving devices ("near-body") and not from base stations. They indicate that 88% of the exposure of the human brain comes from the mobile phone (smartphone).
JRC EU 2021	Systematic narrative review (last 5 years)	No adverse health effects from electromagnetic emissions from mobile phone networks observed in this study. No correlation detected between mobile phone use and the incidence of brain and central nervous system tumours.
ICNIRP 2020	Narrative systematic revision of scientific evidence. Risk assessment Guidelines.	No adverse health effects from electromagnetic emissions from mobile phone networks at reference levels established by ICNIRP. ICNIRP 2020 guidelines establish no more restrictive exposure levels than the 1998 ones. Additional restrictions have been introduced to take into account situations in which the ICNIRP (1998) restrictions did not adequately account for, due to the appearance of new technological developments since then, such as aspects related to 5G technologies.

3.2 Scientific foundations of the exposure limits & security factor for health protection

The recently updated guidelines from ICNIRP and from IEEE-ICES TC25 are the two documents that have the greatest impact on national regulations on permissible EMF exposure levels for the general public and for occupationally exposed persons. Both these guidelines perform primarily hazard identification and characterization, where the main objective is to determine if there is evidence for adverse health effects due to EMF exposures, and to establish at which minimum exposure levels harmful effects occur. Furthermore, where applicable, action mechanisms are identified. The guidelines are based on information available from major international recent reviews which is collected, summarized, and interpreted by experts in the field. The underlying science is primarily comprised of results from animal studies, computer simulations, and epidemiological studies [71].

For this deliverable, a short overview of the recent ICNIRP guidelines for EMF in the frequency range 100 kHz to 300 GHz suffices to explain how foundations for regulation is obtained.

ICNIRP was founded in 1992 as a successor to previous committees (appointed by inter alia United Nations Environmental Programme, the World Health Organization, and Ionizing Radiation Protection Agency) working on safety issues regarding non-ionising radiation. A first Guideline covering time -varying electric, magnetic, and electromagnetic fields from 1 Hz up to 300 GHz was published in 1998. The most recent guideline is an update of the guideline from 1998. The information is primarily from major international reviews performed during the last decade, including the WHO Technical Document (WHO 2014), the assessment from the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and reports from the Swedish Radiation Protection Authority.

The ICNIRP Guidelines do not include exposure scenarios that pertain to medical procedures or to medical implants. The governing principle is that adherence to the exposure levels suggested by the Guidelines will protect people from harmful effects. The levels in turn are determined from the published scientific literature, where adverse effects have been substantiated. The lowest level of exposure known to cause such effects are determined and complemented by reduction factors (different for the general public and occupationally exposed). After this modification the resultant threshold levels are used to establish the basic restrictions of exposure. If, for technical reasons, measurements of such levels are not feasible, other, more easily measured reference levels are elaborated and act as proxies for the basic restrictions.

The guidelines for the high frequency (RF) range include adverse health effects other than direct effects on nerve stimulation which are appearing due to induced electric fields in the frequency range 100 kHz to 10 MHz. Primarily, electric fields induced in a biological structure by RF EMF exposure ultimately cause heating of tissues since a portion of the EMF energy is exerting forces on polar molecules and free-moving charged particles, which in turn is transformed to kinetic energy, ultimately converted to heat. The guidelines are set so that a temperature increase of $1^{o}C$ or more is not reached. It is thus this temperature increase, and not the absolute temperature, that the Guidelines are protecting against. The threshold levels are furthermore based on time averages, and do not consider momentarily appearing exposure levels above the thresholds, unless they would cause acute effects. Possible long-term effects due to chronic exposures are also not covered by the Guidelines.

Despite the presence of e.g., the ICNIRP guidelines, there is no compulsory international safety standard for exposure to EMF, including RF-EMF. In Europe, the Member States of the European Union are bound by recommendations and guidelines of the European Parliament and the Council (EU recommendation 1999/519/EC for the general public and the EU Directive 2013/35/EU for workers). In both guidance documents, the limits are derived in large part from the recommendations of ICNIRP. In practice the various limit guidelines are implemented in countries´ national recommendations or legally binding regulation.

A comprehensive overview of the different national scenarios is provided by Stam R, 2018 [57]. The focus is on the EU Member States but also some other nations approaches are included. A mixed picture emerges, where countries can be categorized in three different groups: 1. legal limits are derived from EU recommendation, precautionary policy in some countries; 2. no legal limits or limits less strict than in EU recommendation, precautionary policy in some countries; 3. stricter limits than in EU recommendation. This scenario is possible within the EU since Member States comply with limits set in the EU guidelines, although they still can introduce stricter limits if they so wish.

There can be several reasons for that different countries choose to adopt different exposure limits. There is no science currently available that has shown that reduced limits provide additional protection if that is reflected in lower exposure levels. On the contrary, a study by Urbinello et al (2014) [72] compared mean exposure levels in outdoor areas across four different European cities with the regulatory RF-EMF exposure levels in the corresponding areas. All exposure levels were far below international reference levels proposed by ICNIRP. Thus, there were no signs indicating that lower allowed exposure levels led to correspondingly lower actual exposures from mobile phone base stations. However, decisions about the limits that a nation chooses to adopt involve consideration of many issues that are not science-based, and so it is not unexpected that different nations will set different limits.

3.3 Review & analysis of national & international surveys on the perception of risks & hazards of RF-EMF

Risk perception due to RF-EMF has been controversially debated in all the countries for more than 30 years, and it is even more amplified due to the recent deployment of 5G technologies and beyond, which will be more pervasive than the previous communication technologies. How people perceive RF exposure and potential risk is a crucial aspect which necessarily affects the research activities, funding policies and risk management.

The European Commission relies on surveys, conducted on behalf of Directorate-General and in the framework of the Eurobarometer Programme[27], to monitor the public opinion on several current events. The results of the surveys are regularly published in official reports by the European Commission.

Some RP surveys are available that document how the public perceives exposure and the potential risk of RF EMF. Most of these studies have been conducted on the national level, but a few provide comparative data on the international level.

In this paragraph, a summary and analysis of surveys on the RP of RF-EMF are presented together with explanatory documents released by some organizations on this subject.

Two special Eurobarometers were conducted on EMF with the aim to assess the issue of EMF through the eyes of EU citizens. They dated back to 2006 (Special Eurobarometer 272a "Electromagnetic Fields"), and 2010 (Special Eurobarometer 347 "Electromagnetic Fields").

The methodology used follows the Standard Eurobarometer surveys of the Directorate-General Communication[28] Both surveys aimed to collect representative data that show how citizen perceive EMF exposure situation and potential health risk. In particular, the surveys aim to address how much the population knows about EMF and their sources, whether they perceive them as dangerous; how well protected they feel against the potential health risk arising from EMF exposure; which level of public authority should bear responsibility for supervising this protection; which means of communication they prefer; which is the level of satisfaction with the quality or quantity of information received, and in the case of 2010 survey only, which is the views of the EU public on the role the Commission should take in this field.

A summary of the main results of the 2006 Eurobarometer survey[29] is reported as following.

In the perception of the respondents, 30% to 40% of the EU citizens taking part in this poll consider mobile phone masts (36%) and mobile phone handsets (28%) responsible to affect health, with Greeks and Italians particularly concerned for the risk coming from them. For a comparison, it should be mentioned that, in the same survey, more than half the EU citizens consider chemicals (64%), the quality of food (59%), the ambient air (51%) and the quality of drinking water (50%) to affect to a bigger extent.

Most Europeans know that mobile phone, mobile communications masts are sources of RF-EMF, with the level of education being the most significant determinant: citizens with a higher level of education are significantly more aware of that each of the sources mentioned generates EMF.

[27] https://www.gesis.org/en/eurobarometer-data-service/home

[28] https://europa.eu/eurobarometer/screen/home

[29] https://data.europa.eu/data/datasets/s1498_66_2_ebs272a?locale=en

Citizens are divided on the potential health risks of EMF with some of them very much or fairly concerned (48%), and others who are not very concerned or not at all concerned (49%). While 27% of Swedes, 28% of Finns, 30% of Danes and 31% of Czechs, Estonians, Hungarians and Dutch are concerned with this issue, the figure rises to 69% in Italy, 82% in Cyprus and 86% in Greece.

Two-thirds (65%) of EU citizen were not satisfied with the information they receive about potential health risks of EMF, with the main reasons being the insufficient information they receive. Citizens who were satisfied with the information they receive tend also to be less concerned over them.

When they were asked about the preferred medium to receive information on the potential risk of EMF, television was the most popular choice followed by newspapers, magazine, and radio.

There was also a general discontent among citizens regarding the efficiency of public authorities in protecting from potential health risk due to RF exposure. By looking at the figures, just one in every four EU citizens is comfortable with the current situation. It is interesting to note that the level of disappointment was higher amongst citizens who are concerned about the health risks of EMF (69%) and also amongst those who were not satisfied with the information they receive on this subject (71%).

Finally, more than half of Europeans held the opinion that the protection of citizens by public authorities should occur at local, regional, national, and international level.

The results of the 2010 Eurobarometer survey[29] did not change substantially the results from the previous one. Again, the perceived risk due to RF exposure was less extended than the one due to chemicals and quality of food and drinking water. Mobile phones were believed by 26% of respondents to pose a significant threat to human health, which is slightly decreased since the previous survey. In Denmark, the Netherlands and Finland, more than half of the respondents believed that mobile phones do not pose health risk, while respondents in Italy, expressed the higher level of concern than other EU citizens.

Overall, since the previous survey in 2006, there was a slight decrease in the proportion concerned about the potential health risks due to EMF, and there was a noticeable decline in EU respondents' awareness of the sources of EMFs.

Interestingly, public concern appeared to vary more on a country basis than on the level of information received on potential health risk. When focusing specifically on the information, 20% of respondents only said that they received information on the potential effects, and 58% of them were satisfied about the quality with the latter noticeable increased than previous survey. Television remained the most popular channel of information, while internet is growing in importance. About 58% of EU citizen were of the opinion that public authorities are not effective in protecting them from potential health risks. Finally, in the view of 48% of the respondents, the Commission should inform the public on the potential health risk, on setting safety standards and on developing guidance for protection of the citizens.

Since 2010, special Eurobarometer surveys on EMF were not conducted by EU Commission, but other sources of information are considered below.

The three years EU LEXNET Project funded under FP7 ICT (2012-2015), among the other goals aimed to address public concerns about EMF exposure. A key finding of this project was that base stations were consistently seen as the most intensive EMF exposure source, that network companies could play a key role in reducing exposure, and that a potential market exists for developing low exposure technology. The LEXNET consortium concluded that RP of the general public tends to be guided by subjective EMF-impact models, which underestimate near field exposure and overestimate far field exposure. This explains why people are more concerned about the existence of base stations than about other sources. The project found that RP perception was also influenced by demographic and social factors along with personal attitudes and beliefs. Of most importance is the country of residence and a person's attitude towards technical innovation. Therefore, risk communication should consider cultural factors that provide the context in which EMF sources are evaluated. In the framework of the LEXNET Project, the research group of Peter Wiedemann published the results of an online survey conducted from April 2013 to September 2013 were analysed and discussed. Data were gathered in eight European countries, namely Germany, France, Spain, Portugal, Romania, Serbia, Montenegro, and Belgium, although Belgium and Romania were not considered in the detailed analysis per country due to the small sample sizes. Authors assumed that the effects of any reduction of EMF exposure depend on the subjective link between exposure perception and risk perception and evaluated respondents' RP of different RF EMF sources and their subjective knowledge about various exposure characteristics with regard to their impact on

potential health risks. The results showed that participants were more concerned about base stations than other RF EMF sources. Concerning the subjective exposure knowledge, the results suggested that people have a quite appropriate impact model. The question how RP is actually affected by the knowledge about the various exposure characteristics was tested in a linear regression analysis. The regression indicated that exposure characteristics such as the number of sources, their size, the exposure duration and timing, the field intensity, except the distance from the source, influence people's general RF EMF RP. In addition, when authors analysed the effect of the quality of exposure knowledge on RF EMF RP of various sources, they evidenced a tendency that better exposure knowledge leads to higher RP, especially for mobile phones. The study provides empirical support for models of the relationships between exposure perception and RP. Authors highlighted that it was not the aim to extrapolate the finding of their study to the whole population because the samples were not exactly representative for the general public in the participating countries [27].

The effects of generalization descriptions on risk perception were addressed in a recent paper [73]. In this study, 629 participants were randomly allocated to three groups as follows: group 1 received an excerpted text from an IARC press release on mobile phones and cancer, classifying RF EMF as possibly carcinogenic to humans; group 2 received an additional explanatory text, and group 3 received a rewritten text, with both group 1 and group 3 highlighting that the possible cancer risk only refers to mobile phones. RP regarding cell phones and related personal devices, base stations, and high voltage power lines were used as dependent variables measured before and after text reading. Further, the degree to which participants generalized from cell phone-related to other RF EMF exposures was assessed to determine whether this was predictive of their post-text risk perceptions. Regarding RP, no differences between the three groups were observed after reading the presented texts. Instead, all three experimental groups indicated increased RP for all EMF sources. However, authors found significant differences according to the prevailing risk generalization belief. Respondents expressing a strong risk generalization belief showed significantly higher RP for all tested EMF sources (except mobile phones) than subjects with a weak risk generalization belief.

Regarding more specifically the controversy on the health risk associated with the deployment of 5G technology, in 2021, the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) released the opinion on "Population exposure to electromagnetic fields associated with the deployment of 5G communication technology and the related health effects" [61].

In this report, an exploratory analysis of the public controversy associated with the deployment of 5G was included.

The analysis of the data, gained by several sources such as interviews with several actors; documents from different organizations, individuals, and different media sources, highlighted a number of key aspects.

The most criticized aspects were the controversial intrinsic properties of the technical system as source of potential risk; the deployment of 5G in certain scenarios without public consultation or an expert appraisal of the risks; the societal aspects of the program, which produces huge skepticism in its opponents, in terms of both energy efficiency and uses with a negative impact on the environment. Moreover, the analysis of the press and social media underlined that the debate around 5G technology is a matter of connected society and its implication in terms of proliferation of EMF sources, higher energy and resource consumption driven by a multitude of uses. Finally, the conflict around 5G deployment probably arises from the fact that many people feel that they cannot choose or cannot play any role in the process of 5G deployment [74].

From a report published by the "Ugo Bordoni" Foundation [75] a higher education and research institution under the supervision of the Ministry of Economic Development in Italy, currently the most marked doubts and fears are particularly due to the use of the 26 GHz band. On a scientific level, on the one hand, there is the certainty that EMF at such high frequencies is not able to penetrate inside the human body and cause damage, on the other hand, however, there is no clear evidence of the health risks caused from exposure since these frequencies have not yet been sufficiently studied. Currently, at international level, the effects of exposure to mmWaves have been indicated as research priorities and, in a few years, the first scientific results will be available that probably will tend to confirm the hypothesized absence of long-term effects. In addition, with respect to the need of a more capillary coverage to improve and expand the services provided, this aspect is perceived as having a high risk for human health by non-expert citizens. However, specific studies have shown that the densification of lower power transmitters leads to a decrease in the level of exposure due to the lower radiated power by the individual systems to obtain the same type of coverage.

Despite these reassuring elements, the perception of risk remains high, and thus highlighted that there is something wrong with the process of communication between the scientific world, regulators, administrators on the one hand

and citizens on the other. In general, the scientific world and the world of politics communicate through one unilateral mode which often does not appear to be very effective from the point of view of information transmission.

According to recent sociological theories, the process of risk communication does not imply information transmission only but requires a more complex process of exchanging information/opinions/fears through an interaction that is as transparent and neutral as possible [76].

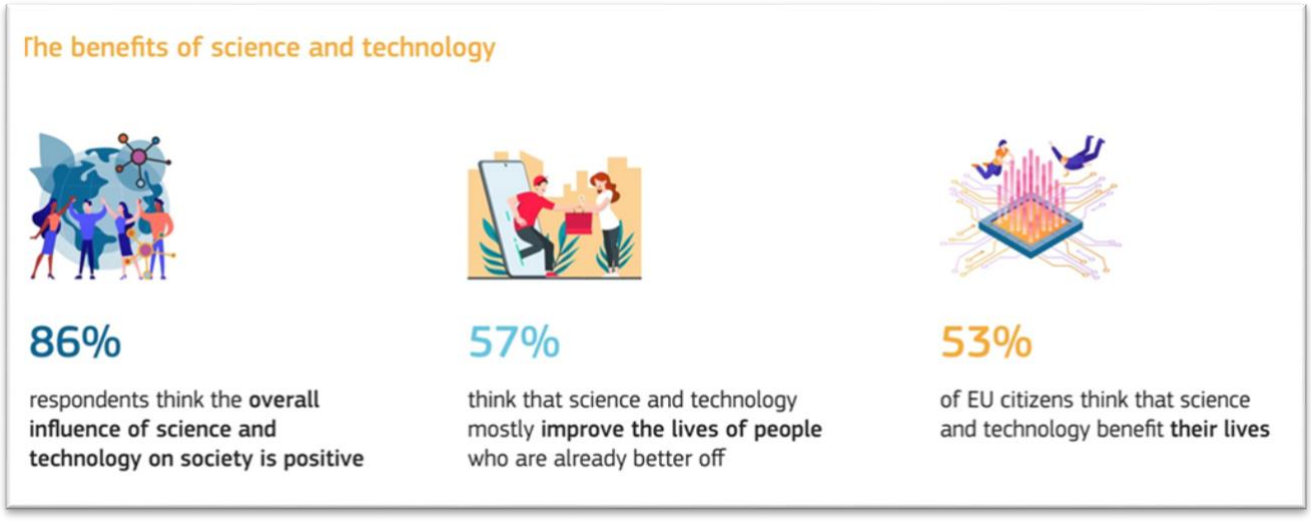

Figure 6: European citizens' knowledge and attitudes towards science and technology

For completeness, the information on public opinion on future innovations, science, and technology, in general, the summary of the largest Eurobarometer survey30 covering the period April 2021 - May 2021, is reported in the following. It highlighted that 86% of EU citizens think that the overall influence of science and technology is positive. Infographic 1. They expect a range of technologies currently under development to have a positive effect on our way of life in the next 20 years (Figure 6).

Furthermore, results revealed a high level of interest in science and technology (82%) and a desire amongst citizens to learn more about it in places like town halls, museums, and libraries (54%). In many areas, EU citizens' interest in, expectations of, and engagement with science and technology have grown in recent years. Respondents most often mentioned health and medical care and the fight against climate change when asked in which areas research and innovation can make a difference. These results are in line with a growing interest in new medical discoveries, which grew from 82% to 86% since 2010. EU citizens have a positive view of scientists, and more than two-thirds (68%) believed that scientists should intervene in political debates to ensure that decisions consider scientific evidence.

[30] https://europa.eu/eurobarometer/surveys/detail/2237

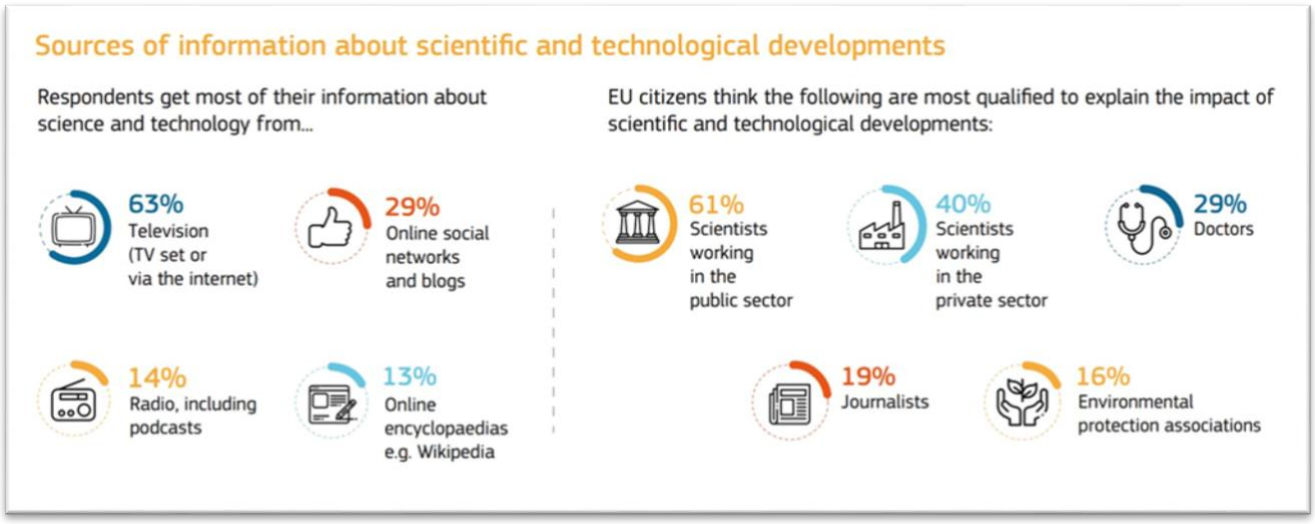

Figure 7: European citizens' knowledge and attitudes towards science and technology

The most popular mean for information is still the television followed by online social networks and blogs (29%) and online or in-print newspapers (Figure 7). Most of the respondents believed that involving non-scientists in research and innovation ensures that science and technology respond to the needs and values of society.

4 Proposals for participatory engagement of key stakeholders

The problematization of official knowledge seems to be one of the most defining issues of our time. Due to introduction of new telecommunication technologies, especially the introduction of 5G, citizens expressed their concerns about the possible health effects due to radiation from antennas. Some citizens challenge the exposure limits; they believe that the current exposure limits do not sufficiently protect against health effects. In NextGEM we want to have stakeholders participate in formulating recommendations on how to build a dialogue between these stakeholders on RF-EMF exposure (limits, measurement methods, health effects). Derivative goals of NextGEM are to increase the understanding by citizens and public authorities of possible risk reduction measures, and to understand factors that influence trust in science and regulatory public health authorities (EU, WHO, ICNIRP). These recommendations will be based on participatory engagement of stakeholders. In this section proposals for the participatory engagement are developed.

4.1 Practical Guidelines

In NextGEM Task 8.2, practical guidelines will be developed for different societal stakeholders for RF-EMF exposure awareness and preventive actions. The focus will be on exposure from 5G systems. With these guidelines we want to contribute to the understanding of RF-EMF exposure limits in society at large, the knowledge on risk reduction measures and trust in science and regulatory public health authorities. We want to increase mutual understanding, and better understand the concerns and the values at stake for concerned citizens and for other stakeholders. Trust in science is a result of a mutual relationship and cannot be enforced. You must be trustworthy as academia, government, industry, etc. but of course there have been good reasons that people have developed distrust, for instance the mixing in science and lobbying by the tobacco industry. There is also wider trust that should be restored and while you may not be able to control that, you need to show that you are aware of it.

The key stakeholders are citizens and public authorities. Citizens are defined as the aggregate of the general public, activist groups, workers, and the vulnerable. Public authorities are the accumulation of administrators, policy makers, and inspectors. One of the challenges in developing specific and practical guidelines are the differences between the participating countries in terms of legislation, the presence of activist groups, workers' organizations, etc. Ideally, you would have to engage an anthropologist/social scientist in each country. Therefore, it is important that the guidelines can be implemented in all different countries. The guidelines will help to put scientific research on RF-EMF exposure and its health risks to good use and ensure societal stakeholders to make well-informed decisions.

The goals of the guidelines to be developed are to (1) properly inform all stakeholders on RF-EMF exposure i.e., the current exposure levels and how they are measured, the different exposure scenarios, and the potential health risks; (2) create awareness on risk reduction measures, exposure prevention measures; and (3) disseminate tools to accurately communicate about RF-EMF exposures.

Among the focus points for citizens, we consider differentiating between what is known, what is uncertain, and what can be controlled by the user's own behaviour (auto-induced exposure), and what cannot (environmental exposure). For public authorities, careful attention will be given to potential regulations and how to monitor the compliance therewith, using measurement and monitoring tools, as well as to communication towards other stakeholders.

4.2 Participatory Engagement

The end-products of NextGEM task 8.2 will be a blueprint of the practical guidelines in English, containing the ingredients (scientific information) and instructions on how to implement this information, and one or more national implementations.

The Netherlands is quite advanced in forms of consultation. There is 15 years of experiences with the Knowledge Platform on EMF and Health (KP-EMV) in communicating about EMF and effects on health. In this platform, which is quite unique in the world, experts from six national organisations (National Institute for Public Health and the Environment, the Netherlands Organisation for Applied Scientific Research (TNO), the Arnhem office of DNV (Det Norske Veritas) energy consulting and testing & certification organisation, the Dutch Public Health Service (GGD), the Dutch Authority for Digital Infrastructure (RDI) and The Netherlands Organisation for Health Research and Development (ZonMw)) work together in assessing scientific information on its merits and relevance for society. The Knowledge Platform organizes the national sounding board on EMF (Klankbordgroep) and think-tanks

(Denkgroepen) in order to identify and discuss with NGO's, industry, science and government the relevant scientific and societal issues.

Based on information from literature on risk communication a draft of practical guidelines will be drawn up, which will then be updated through a series of feedback loops. It is proposed that first a panel of national experts on risk communication in the Netherlands will be consulted. Next, a panel of international experts will give their input, followed by multiple panels of end-users from the relevant stakeholders. Finally, end-users can give feedback on the different platforms where they encounter these guidelines (workshops, websites, smartphone application, etc.).

We will engage stakeholders to involve them before, during and after the drafting of practical guidelines.

4.3 Public resistance

Introduction of new technologies often comes with public resistance public resistance (understood as the opposition of some sectors to the implementation of new telecommunication networks). This resistance will be different from country to country, and understanding this resistance is just as important as "sending" adequate and understandable information about exposure and risks to reachable groups in society. It is also important to look at the concerned citizens who firmly oppose the advent of new technologies using RF-EMF. What concerns are there? What values are at stake? What is needed there, goes beyond providing knowledge or information, which requires something else.

Points of attention are experiences with stakeholder involvement in the different countries involved, science about risk communication and risk perception, and scientific and practical knowledge on how to engage in a respectful way in dialogue with partners who have other viewpoints, including the context where they arise from. It will also be considered whether serious games and/or the 'mental models' approach in risk communication' can be used in the panels.

In the panels, we will use the experiences from an ongoing project at RIVM: CONZENT ("Dealing differently with controversies about uncertain adverse effects of new technologies"). The problematization of official knowledge seems to be one of the most defining issues of our time. The aim of this project in a policy context is the issue of dealing (by government and RIVM) with different truth claims about the adverse effects of new technologies. Drawing from Science and Technology studies, using anthropological methods, this study provides a deeper understanding about the processes leading towards polarization in knowledge disputes. How are highly emotional disputes about official knowledge – such as the ones surrounding RF-EMF and health – entangled, for example, with processes of recognition in knowledge practices for policymaking? Ultimately, such deeper insights into knowledge controversies provides perspectives on how to deal more inclusively and productively with diverging knowledge claims and create more socially robust dialogue.

5 Identification and proposal of new strategies to improve risk communication

To improve communication strategies, it is essential to distinguish the differences between hazard and risk. A very frequent mistake in communication is the confusion between these concepts.

A health risk only exists if a dangerous substance is present or if an individual is exposed to a physical agent, and if either the substance or agent are present in sufficiently high quantities. It is therefore necessary to conduct a twin-track analysis when assessing risks to health, consisting of firstly analysing the potential hazard posed by a substance or physical agent and secondly analysing the risk involved. Rather than being treated as two distinct entities, these two analyses are frequently regarded as equivalent, which leads to misinterpretations.

In most cases, the initial step is to identify whether exposure could in principle constitute a hazard, without looking in detail at the intensity of the exposure or the probability of the hazard being present. If it is concluded that it is fundamentally impossible for the exposure to generate effects that are disadvantageous to health, no further analyses are necessary.

For instance, the objective of the IARC monograph program[31] is to identify potential cancer risks, but it does not quantify the concrete risk posed by a specific level or amount of exposure. This means that the IARC classifications merely ascertain whether exposure to a specific substance or physical agent can, in principle, feasibly cause cancer. Similarly, one of the main tasks of the US National Toxicology Program (https://ntp.niehs.nih.gov, NTP) is to identify hazardous substances or physical influences that are carcinogenic to humans. Substances or physical agents are classified as carcinogenic if exposure to them can in principle cause cancer even if this effect is only present at very high dosages. Such classifications can therefore not be used to draw conclusions on the individual risk of developing cancer. Both the IARC and the NTP identify and characterise the carcinogenic potential of exposure to a substance or physical agent but do not quantify the risk of developing an illness.

A health risk can only be accurately quantified when information on the amount or intensity of exposure, tolerable exposure thresholds and a dose-response analysis are available. For example, if in real life people are only exposed to a specific substance or agent at dosage levels that despite intensive research have not been found to have the negative health effect under investigation, the risk of dangerous effects on the individual can be classified as very low or even negligible, even if the substance or agent is known to have disadvantageous effects at higher dosages.

Dose–response assessment examines the quantitative relationships between exposure and the effects of concern. To decide if there is a hazard is often dependent on whether a dose–response relationship is present. In Figure 8, the left orange image signals a danger (strong magnetic fields) whereas the right red image shows a risk if you are wearing an active implanted medical device that could be interfered. Figure 9 from the EFSA, provides us two more clear examples. The confusion between hazard and risk explains much of the mistakes that are made in risk communication about RF-EMF.

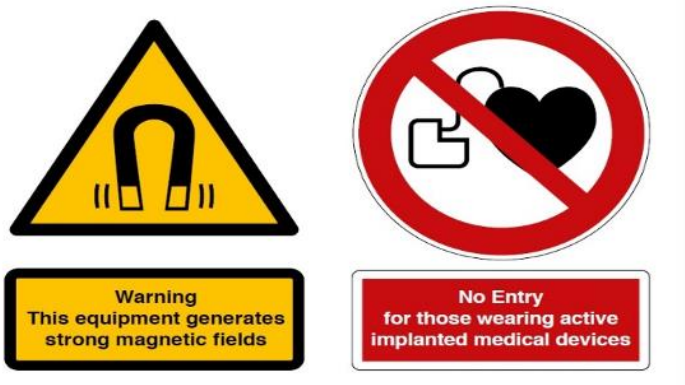

Figure 8: Differences between hazard and risk EMF and implants devices

[31] https://monographs.iarc.who.int

Figure 9: Differences between hazard and risk in EMF (shark and lightning, EFSA)

In order to propose new and appropriate communication strategies, it is necessary to consider the studies that have been carried out on this subject and the experiences that have been accumulated.

A very interesting thesis to understand the perception of risk [77] provides insight into the determinants and differences in perceived risk of EMF and concerns of the public, of people with health complaints attributed to EMF, and of occupationally exposed people and may help to improve the risk communication by experts and may lead to a better-informed public.

This author recalls that in recent years public participation has become a popular approach – almost a panacea – for policymakers, we have to add in some specific countries, dealing with public worries about new technologies. Various academics, however, are wary of assuming that more inclusive forms of decision making will necessarily resolve siting controversies. As a response to these calls, governments have experimented with different ways to involve and engage publics with science and technology in the form of consultation papers, focus groups, stakeholder dialogues and citizens' juries. These initiatives have hardly reached the impact hoped for by governments (support for scientific or technological developments, more public interest in science and technology, etc.), but have foremost shown the limits of these approaches.

Risk perception has been criticised (Slovic 2020) for implying a distinction between 'perceived' (by 'emotive and irrational' 'laypeople') and 'real' (by 'objective' scientists) risks. If not made explicit, one can interpret these findings as drawing a boundary between one superior knowledge base above another inferior one. 'Risk perspective', in contrast, is less ambiguous.

The Eurobarometer (2007 see section 3.2) survey also indicated that individuals were more concerned about base stations compared to mobile phones, a finding that has also been established by risk perception research. Thus, risk

perception studies show that, in the view of engaged citizens, masts are sited involuntary and are thus out of control for them to 'switch off', unlike their phones. Overall, it seemed that once people had made their minds up, they ignored additional information.

For the government it seems important to communicate transparently about economic interest and cooperation with industries, since attempts to withhold this information is likely to reduce trust, raise risk perceptions, and reduce acceptance of installation of public EMF sources. Also, providing people with information clarifying the distance-exposure relationship improves understanding of EMF exposure, thereby preventing uninformed concerns and reducing risk-aversive behavioural intentions.

One Dutch study [78] provides an assessment of EMF information needs from an ensemble of sources by addressing people's existing ideas and beliefs, using a mental models approach. Interviews with 12 lay people followed by a confirmatory survey of the general Dutch public (n=403) reveal not only wide variation in beliefs regarding potential health effects of EMF, but also overestimation of the amount of radiation from public sources relative to personal sources of EMF. People do not feel adequately informed by the government about EMF, and knowledge of government policies on EMF is limited. The authors conclude that "Together, the evidence suggests three focal points for improving EMF risk communications: *providing more clarity regarding the uncertainty of evidence for health effects, illuminating personal EMF exposures in daily life and providing more accessible and transparent information on governmental policies*.

Uncertainty is a crucial issue for any risk assessment and for risk communications. However, the empirical evidence about the effects of uncertainty reporting is sparse and inconclusive.

Therefore, based on examples of potential health risks of electromagnetic fields (EMF), three experiments were conducted [79]. The setups aimed to explore how reporting and how explaining of uncertainty affects dependent variables such as risk perception, perceived competence of the risk assessors, and trust in risk management. The authors concluded that qualitative uncertainty descriptions regarding hazard identification reduce the confidence in the professional competencies of the assessors. In contrast, a quantitative uncertainty description in risk characterisation-regarding the magnitude of the risk-does not affect any of the dependent variables. Concerning risk protection, trust in exposure limit values is not affected by qualitative uncertainty information. However, the qualitative description of uncertainty regarding the adequacy of protection amplifies fears.

One study [80] aimed to investigate for the first time whether framing a risk communication message regarding 'mobile phones and health' as a hazard identification or as a risk assessment affects the reader's risk perception. The way in which risk communication messages are framed can influence recipients' risk perceptions. The results of the study demonstrate the importance of understanding the distinction between a hazard identification and a risk assessment and suggest that radiofrequency electromagnetic field risk communication needs to develop means for empowering the public to differentiate between hazards and risk.

The authors argue that there is a limited understanding of how framing is responsible for influencing risk perception. One particularly important element may be whether a risk communication message is framed as a completed 'risk assessment' (specifying a magnitude of risk to the public as a function of the exposure level), or as a 'hazard identification' (a statement regarding whether an environmental agent could in principle cause detrimental health effects in humans, without addressing whether such effects may occur in practice).

First, it is necessary to define precisely what is meant by risk perception [81] and then to distinguish between affective and cognitive risk perception. Affective perception of risks refers to the more holistic assessment of concern about impending health threats. On the other hand, cognitive risk perception is oriented to assessing the probability of the occurrence of health damage or disorders. Unfortunately, the equation of hazard with risk triggers enhanced fears of risk. Therefore, risk communication practitioners should be aware of hazard framing. For evidence-based risk communication, it is essential to communicate the difference between risk and hazard.

One of the most interesting experiences in Europe is the Knowledge Platform on Electromagnetic Fields and Health[32] that provides clarity on public questions and concerns about possible health effects related to electromagnetic fields. Because of the social organisations involved, the KP-EMV is well-informed of these concerns, enabling it to comprehensibly present scientific knowledge, while taking the various sensitivities into account. In doing so, this platform contributes to social debate by providing clarity. The KP-EMV helps citizens and workers to understand and

[32] https://www.kennisplatform.nl/english/

access the relative merits of scientific research into the relationship between electromagnetic fields and human health. This alliance of six national organisations knows that questions related to possible health effects will continue to arise, especially due to technological developments and increases in mobile communications. From this perspective, also provides people with information they may use when taking protective measures.

Along the same lines of providing clear and transparent information, several countries have accessible and free Information Systems on the emission levels of base stations: In the Netherlands[33] and Spain[34]. We do not know the objective impact of these national information systems on the level of concern or risk perception of the population in these countries compared to other countries without such information systems.

There is a worryingly large chasm between scientific consensus and popular opinion. Roughly one third of Americans are sceptical that humans are primarily responsible for climate change; rates of some infectious diseases are climbing in the face of anti-immunization beliefs; and significant numbers of the population worldwide are antievolution creationists.

According to surveys, it is very likely that similar percentages of unscientific beliefs and the persistence of myths, misconceptions, and fears about the effects of EMFs exist in Europe. Some 25% of the population hold these false beliefs and use confirmation bias to continue to hold them. Behavioural psychologists have a name for this: confirmation bias. We separate out information that does not match our beliefs and stick with only what we agree with. Social networks are the spaces where these biases are most evident. Bubbles form of people reinforcing their own biases. It is easy to assume that resistance to an evidence-based message is a result of ignorance or failure to grasp evidence (the "deficit model" of science communication).

If people are motivated to reject science, then repeating evidence will have little impact. The authors of a study [82] introduce the notion of "attitude roots." Attitude roots are the underlying fears, ideologies, worldviews, and identity needs that sustain and motivate specific "surface" attitudes like climate scepticism and creationism. It is the antiscience attitude that people hear and see, but it is the attitude root—what lies under the surface—that allows the surface attitudes to survive even when they are challenged by evidence. We group these attitude roots within 6 themes—worldviews, conspiratorial ideation, vested interests, personal identity expression, social identity needs, and fears and phobias—and review literature relevant to them. We then use change by aligning with (rather than competing with) these attitude root.

New social technologies, which facilitate rapid information sharing and large-scale information cascades, can enable the spread of misinformation. How do truth and falsity diffuse differently, and what factors of human judgment explain these differences

As noted by other authors, as Siegrist, 2020 [47], people who oppose the manipulation of nature show less support for technologies (GMOs, pesticides, geoengineering) than those who accept them [47]. People with higher levels of anxiety may perceive more risks compared to those with lower levels of anxiety. People with higher levels of emotional stability tend to perceive fewer risks associated with various hazards. These authors point out that the lack of ability to assess and understand hazards is compensated for using heuristics.

Regarding social media communication one study [83] investigated the differential diffusion of all of the verified true and false news stories distributed on Twitter from 2006 to 2017. The data comprise ~126,000 stories tweeted by ~3 million people more than 4.5 million times. The authors classified news as true or false using information from six independent fact-checking organizations that exhibited 95 to 98% agreement on the classifications. Falsehood diffused significantly farther, faster, deeper, and more broadly than the truth in all categories of information, and the effects were more pronounced for false political news than for false news about terrorism, natural disasters, science, urban legends, or financial information. Contrary to conventional wisdom, robots accelerated the spread of true and false news at the same rate, implying that false news spreads more than the truth because humans, not robots, are more likely to spread it. They hope that their work inspires more large-scale research into the causes and consequences of the spread of false news as well as its potential cures.

[33] https://www.antenneregister.nl/Html5Viewer/Index.html?viewer=Antenneregister_extern

[34]Ministerio de Asuntos Económicos y Transformación Digital. https://avancedigital.mineco.gob.es/inspeccion-telecomunicaciones/niveles-exposicion/Informesanuales/2021_niveles_exposicion_radiolectrica_informe_anual.pdf

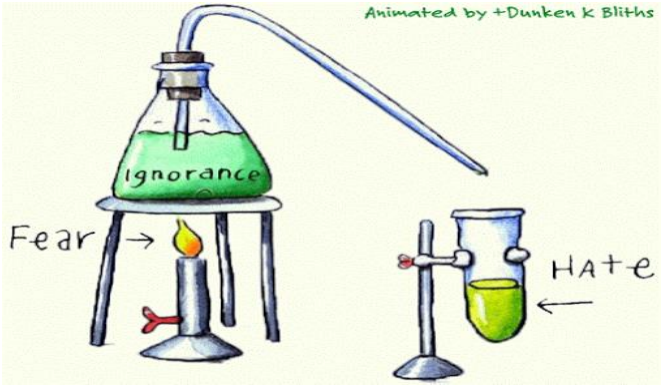

Figure 10: Not surprisingly, the mixture of fear warms ignorance and distils hate, rejection and denialist attitudes to quality scientific evidence

To improve communication on RF-EMFs some authors recommend to include information clarifying the distance–exposure relationship to improve understanding of exposure [36].

According to Boffeta et al. [18] caution should be applied in the communication of results to the media and the general public, because "positive" findings tend to attract the media and public attention, whereas findings that do not confirm a previously reported association or do not indicate a new association often receive no attention. These authors recommend to users of epidemiological results outside the scientific community (e.g., regulatory agencies, stakeholders, media, advocacy groups, trial lawyers, the general public) should be aware of the fact that statistically significant or positive results are often false, in particular when they are not supported by related studies or other lines of evidence.

In risk communication, the possible influence of ChatGPT must be considered.

ChatGPT is a conversational agent (chat bot) designed using a computer model capable of parsing and creating human language text called Generative Pre-trained Transformer 3 (GPT-3)[35].

GPT is a form of artificial intelligence with which we can "chat" via the web. In a few seconds we can obtain answers to any question, text summaries, stories, poems, etc.

ChatGPT learns by human feedback: reinforcement learning from human feedback. Text generation is based on the development of statistical "language models" that operate on probabilities. This application can reduce time in many tasks, e.g., text creation, and increase productivity. This implies that some activities and professions will be affected, including journalism, communication, marketing, scientific production, and certain literary formats.

The ChatGPT breakthrough may have a significant impact on current communication and information systems.

One of the main objectives of communication should be empowering risk literacy of the general public. Risk perception varies according to many social, demographic, psychological, educational, and political variables. The role of good communication on RF-EMFs is to increase people's knowledge so that they can make more informed and balanced judgements about the different risks they face in everyday life. But in addition to being a technical advance, ChatGPT involves a number of dangers that need to be assessed and monitored. one of them is the abusive targeting to feed mass influence or disinformation campaigns by generating phrases adapted to each context, especially to social networks and internet forums. At the same time, it could potentially contribute to fostering biases, stereotypes, or discriminatory ideas. ChatGPT raises many questions that we need to consider, especially in the area of communication on the relationship between exposure to environmental factors and their relationship to human health.

As we have seen rumours, fake news and conspiracy theories spread faster on the internet (5G- SARS Co-2, "antimask" and antivaccine protesters). Also, we know that hoax and rumour completely eclipse truth and fictions tend to dominate the narrative (Vausoughi 2018). We need to recognise that a healthy scepticism is our best protection against damaging fiction about our health to improve our societal critical thinking skills [84].

[35] https://www.ta-swiss.ch/en/chatgp

As we have seen in the previous sections, numerous studies have been published describing a wide heterogeneity of results on the factors that influence risk perception and risk communication and that affect the sender, the message, and the channels of information transmission. Moreover, it is very difficult to assess the efficacy, effectiveness, and efficiency of risk communication on RF at the population level.

What indicators can be used? how can the usefulness and effectiveness of communication on RF-EMF in different countries that have implemented continuous and proactive measures be compared to countries that have not adopted similar measures? Have the concerns and risk perceptions of the population that has received more communication been reduced?

No significant changes or trends seem to be observed, if only a slight decrease in risk perception in some surveys (Belgium, Germany, Eurobarometer) although we do not have regular representative samples of European citizens as the last Eurobarometer was published in 2010.

On a report commissioned by the WHO Regional Office for Europe as part of the Health Environment Research Agenda for Europe (HERA) project, funded by the European Commission's Horizon 2020 grant) on effective risk communication for environment and health (Effective risk communication for environment and health: a strategic report on recent trends, theories, and concepts [85]) risk communication has been defined as follows: "The real-time exchange of information, advice and opinions between experts or officials and people who face a threat (hazard) to their survival, health or economic or social wellbeing. Its ultimate purpose is that everyone at risk is able to take informed decisions to mitigate the effects of the threat (hazard) such as a disease outbreak and take protective and preventive action (WHO, n.d.)"

For the WHO, the main changes that have influenced communication on environmental factors in recent decades are the following: increasingly complex, global, and uncertain risks, decreasing trust in experts and authorities, a shift from one-way to multi-directional communication, loss of influence of traditional media and fragmentation of channels, the danger of fake news, disinformation and infodemics, and the importance of risk communication highlighted by COVID-19.

Finally, in the light of the evidence reviewed in this deliverable and the good practices proposed by the WHO we can formulate the following recommendations to improve communication on RF-EMFs:

- Inform and educate all parties involved about the differences between hazard and risk.
- To promote objective information, in a transparent manner, on the criteria for the installation and deployment of telecommunications infrastructures (telephone antennas, Wi-Fi networks, etc.), and on the levels of exposure to which the population is subjected in their daily lives.
- To include information clarifying the distance-exposure relationship to improve understanding of exposure and the difference between hazard and risk.
- Messaging must reflect the concerns of the public and recognizes their diversity and needs emotions and compassion to counter outrage.
- Selecting and managing the appropriate channels to reach and reassure the public.
- Understanding who has influence on the public and optimizing it. The health expert must compete with other "influencers." For some publics polarizes by partisan beliefs and conspiracy theories the health will never be a reference.
- Involving the public and stakeholders early and adopting two –way and multidirectional communication.
- Measuring risk communication to understand progress.
- Risk communication requires a multidisciplinary approach.
- Messages of caution or prevention of RF-EMF exposure can increase the perception of risk (fear) and the nocebo effect in people previously concerned about the effects of RF-EMF. We must carefully evaluate the cost benefit of this type of recommendation.
- Risk communication should be embedded within scientific studies, from the conception to dissemination of findings. Researchers must be cautious in the communication of results to the media and public.
- To promote a healthy scepticism and critical thinking to improve the societal thinking skills about the scientific studies results.
- To be effective in communication we must take these variables into account.

6 Conclusions

Deliverable D2.3: "Health risks, citizen´s concerns and international guidelines" is part of NextGEM's WP2, Task 2.3. The goal of this task is to identify needs, problems, and concerns of the population on the real effects of the real exposure to EMF as documented in exposure monitoring campaigns, in an environment where sometimes contradictory and confusing information is delivered and thus causing uncertainty.

We have defined the requirements and specifications for the identification of the main drivers of risk perception and formulates appropriate proposals on participatory engagement of stakeholders in compliance with the objectives set out in NextGEM WP2.

With the applied methodology based on the information obtained through a specific questionnaire, a scoping review, an analysis of the scientific basis of the international guidelines on RF-EMF exposure limits and an overview has been possible to obtain the best scientific evidence on the main factors and value drivers that influence the population´s confidence and risk perceptions on the effects of RF-EMF.

The results of this deliverable will contribute to a better understanding of the population's attitudes and behaviours towards the hypothetical health effects of RF-EMF. Scientific evidence on the main factors (cognitive, affective, contextual, and personal) influencing risk perception, facilitates the adoption of public health measures that consider citizens' needs, issues and concerns.

Best practices and recommendations for developing the involvement of all stakeholders in RF risk management and risk communication have been identified. Consequently, the current document provides the technical background for improve the risk communication of key stakeholder (public authorities, civil organizations, scientific agencies, academia and appropriate tools to explain the RF-EMF safe exposure limits approved by relevant international organisations and agencies (ICNIRP, IEEE; EU, WHO, SCHEER; etc.).

The knowledge acquired in this document allows to improve RF risk management and risk communication skills and strategies in a contradictory and confusing environment caused by the rapid spread of rumours, false beliefs, and misconceptions.

The role of good communication on RF-EMFs is to increase people's knowledge so that they can make more informed and balanced judgements about the different risks they face in everyday life.

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