ESRI
SURVEY AND STATISTICAL REPORT SERIES
NUMBER 126
AUGUST 2024

PUBLIC PERCEPTIONS OF ELECTROMAGNETIC FIELDS AND ENVIRONMENTAL HEALTH RISKS

SHANE TIMMONS, ALEXANDROS PAPADOPOULOS AND PETE LUNN

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

PUBLIC PERCEPTIONS OF ELECTROMAGNETIC FIELDS AND ENVIRONMENTAL HEALTH RISKS

Shane Timmons

Alexandros Papadopoulos

Pete Lunn

August 2024

ESRI SURVEY AND STATISTICAL REPORT SERIES

NUMBER 126

Available to download from www.esri.ie

https://doi.org/10.26504/sustat126

ABOUT THE ESRI

The Economic and Social Research Institute (ESRI) advances evidence-based policymaking that supports economic sustainability and social progress in Ireland. ESRI researchers apply the highest standards of academic excellence to challenges facing policymakers, focusing on ten areas of critical importance to 21st Century Ireland.

The Institute was founded in 1960 by a group of senior civil servants led by Dr T.K. Whitaker, who identified the need for independent and in-depth research analysis. Since then, the Institute has remained committed to independent research and its work is free of any expressed ideology or political position. The Institute publishes all research reaching the appropriate academic standard, irrespective of its findings or who funds the research.

The ESRI is a company limited by guarantee, answerable to its members and governed by a Council, comprising up to 14 representatives drawn from a cross-section of ESRI members from academia, civil services, state agencies, businesses and civil society. Funding for the ESRI comes from research programmes supported by government departments and agencies, public bodies, competitive research programmes, membership fees, and an annual grant-in-aid from the Department of Public Expenditure NDP Delivery and Reform.

Further information is available at www.esri.ie.

THE AUTHORS

Pete Lunn is a Research Professor at the Economic and Social Research Institute (ESRI) and an Adjunct Professor of Economics at Trinity College Dublin (TCD). Shane Timmons is a Senior Research Officer at the ESRI and an Adjunct Associate Professor of Psychology at TCD. Alexandros Papadopoulos is a former Research Assistant at the ESRI.

ACKNOWLEDGEMENTS

This research was funded by the Environmental Protection Agency (EPA) as part of Phase IV of the EPA-ESRI Research Programme. We are especially grateful to Andy Fanning, David Fenton and Javier Vila at the EPA for helpful input on the study design.

This report has been accepted for publication by the Institute, which does not itself take institutional policy positions. The report has been peer reviewed prior to publication. The authors are solely responsible for the content and the views expressed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

EMFs	Electromagnetic fields
RF EMFs	Radiofrequency electromagnetic fields

GLOSSARY

5G	The 'fifth generation' of technology for mobile networks, 5G allows data to be uploaded and downloaded faster than previous technology (e.g., 4G) and is more reliable, particularly in busy places or where multiple devices are connected to the same network.
Carbon monoxide	Carbon monoxide (CO) is a colourless, odourless gas that can build up in poorly ventilated spaces. CO can inhibit oxygen intake, leading to poisoning and death.
E. coli	Escherichia coli (*E. coli*) is a bacteria found in the intestines. It can contaminate water supplies through run-off from animal waste on farms and lead to illness and infection in humans.
Electromagnetic fields	Electromagnetic fields (EMFs) are invisible areas of energy associated with the use of electricity.
Ionise	Some forms of radiation can 'ionise' atoms in cells, meaning they separate atoms into ions which can damage or kill cells. X-rays can ionise cells, whereas EMFs do not.
Microplastics	Microplastics are tiny plastic particles less than 5 millimetres in size. They come from the breakdown of larger plastic items and can be found in water sources and the food chain, potentially leading to harm to human health.
Nitrous oxide	Nitrous oxide is a gas emitted by burning fuel at high temperatures and is emitted by non-electric vehicles. It is a greenhouse gas that is poisonous to humans.
Particulate matter	Particulate matter (PM) is a mixture of tiny particles and droplets in the air. PM comes from various sources like car exhausts and can damage the lungs and human health.
Radon	Radon is a colourless, odourless gas that is emitted by decaying chemicals in soil and rock (e.g., uranium). It can accumulate in buildings and cause lung cancer if inhaled.
Telecommunication mast	Telecommunication masts are structures that support antennas for broadcasting (e.g., TV and radio). They enable wireless communication (e.g., for phone networks).
Transmitter	A transmitter is a device that sends out signals to communicate information. They are used for broadcasting.
UV radiation	Ultraviolet (UV) radiation is a type of energy from the sun. It helps produce vitamin D in the skin but can also lead to cancer.

EXECUTIVE SUMMARY

Electromagnetic fields (EMFs) are invisible fields of energy generated when electricity flows through wires or a device. Radiofrequency EMFs (RF EMFs) are a specific type of EMF generated by telecommunications masts and devices. There is no scientific evidence that RF EMFs lead to negative health outcomes, particularly at the levels observed in public spaces in Ireland, but previous surveys suggest that substantial minorities of the public may hold concerns about exposure. This study employs methods from behavioural science to measure perceptions of risk from EMFs among the general public. To contextualise perceived risk, we also record perceptions of other environmental hazards with known health consequences (e.g., carbon monoxide, particulate matter).

A nationally representative sample of 800 adults took part in an online survey in September 2023. The study produced the following findings:

- Very few people (2.7%) mentioned EMFs when asked in a free text question about environmental hazards they are aware of. The most commonly generated hazards were outdoor air quality (59.7%), risks from cars and traffic (29.5%) and weather hazards (e.g., UV radiation; 22.8%). Other hazards with known health consequences were generated less frequently, including water contaminants (16.4%), radon gas (4.6%), noise (4.1%) and indoor air quality (3.7%).

- Responses to rating scales, informed by the psychology of risk perception, implied moderate levels of concern about EMFs. When asked about the perceived probability of exposure to harmful levels of EMFs, the consequences of exposure and general worry about them, the average response was close to the midpoint of seven-point rating scales. However, a fictitious risk included in the survey showed a closely similar response pattern. Thus, the results imply that, for unfamiliar risks, survey respondents may apply a precautionary principle in their answers, which biases responses towards the midpoint of scales. The exception to this response pattern was a question about how often individuals think or talk about an individual hazard, which generated very low levels of daily relevance for EMFs (2 out of 7).

- Rating scales for other environmental risks revealed that the perceived risk from carbon monoxide and water contaminants (lead, *E. coli*) was greater than for microplastics, nitrous oxide and particulate matter. The pattern suggests low levels of familiarity with specific air pollutants in particular.

- At the end of the survey, participants completed a short quiz about EMF exposure and reported on any mitigation action they take to reduce their exposure. Despite low levels of concern about EMFs, responses to the quiz displayed a bias towards assumptions of harm. Many participants (40%) wrongly assumed telecommunication masts to be a greater source of EMF

exposure than mobile phones. The majority also incorrectly reported that technology such as 5G has substantially increased RF EMF exposure in public spaces (65%), that the level of exposure in urban areas is above suggested limits (60%) and that RF EMFs can damage human cells (58%).

- Respondents who held misconceptions about RF EMFs were more likely to perceive higher risk and to take day-to-day action to mitigate exposure (12.7% of those with above-average scores for a misconception index compared to 7.1% of those below). However, very few people reported taking day-to-day action to reduce their exposure to telecommunication masts (1.7%). Those who did take action mostly reported limiting the use of mobile phones or altering their placement.

The findings have implications for communications about environmental hazards. Public concern about RF EMFs appears (appropriately) low. There nevertheless remains a possible risk that misconceptions about health effects could be exploited. To avoid drawing unnecessary attention to a relatively benign hazard, it may be worthwhile ensuring that accurate scientific information on the effects of RF EMFs is readily accessible. The findings also point to environmental hazards that may warrant greater communication priorities, such as radon and noise pollution. The results further show the benefit of using principles from behavioural science to inform how policy-relevant concepts are measured.

CHAPTER 1

Introduction

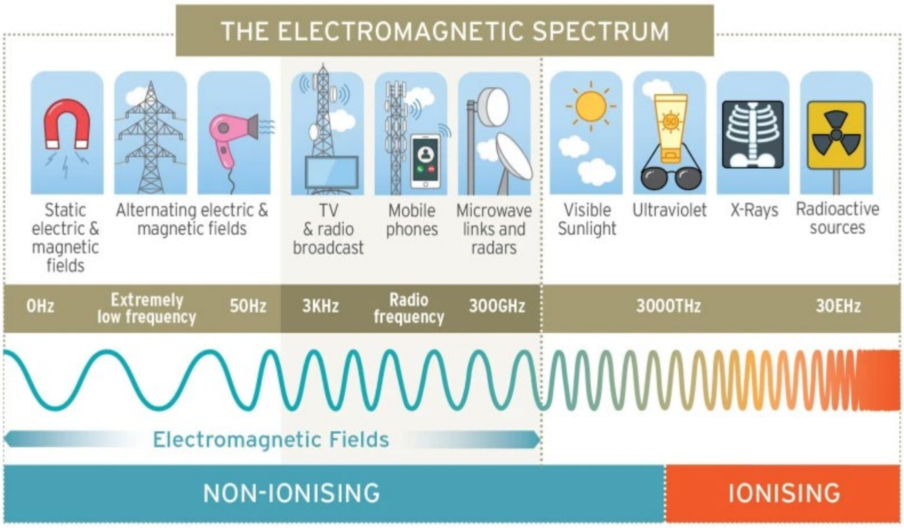
Inaccurate perceptions of environmental health hazards can result in misdirected efforts to mitigate harm. On the one hand, if a risk is underestimated, people may not take necessary steps to avoid it. On the other, if a risk is overestimated, mitigating it may be mistakenly prioritised relative to risks with more severe health outcomes. Whereas technical assessments of the harm caused by environmental hazards might involve estimating deaths or hospitalisations following exposure, measuring the accuracy of perceived risk is more difficult. Benchmarks against other hazards are often required; if the public reports greater concern about a hazard that results in negligible health outcomes than one that leads to very many deaths, it is reasonable to conclude that perceptions of at least one of these hazards are inaccurate. This conclusion is important because designing policy tools to counter misconceptions requires them first to be identified and measured.

Our aim was to measure the public's perception of a benign environmental hazard that, according to some survey evidence, appears to have generated disproportionate concern: electromagnetic fields (EMFs). Although EMFs were our focus, we compared perceptions against other environmental hazards, such as air and water pollutants, and so we also measured how the public perceives a wide range of environmental hazards with varying health impacts. In the remainder of this chapter, we briefly outline what EMFs are, the evidence for exposure levels in Ireland and surveys of public concern. We then describe the challenge of measuring perceptions of risk accurately.

1.1 ELECTROMAGNETIC FIELDS

EMFs encompass a broad spectrum of energy waves generated when electrically charged particles interact, such as when they flow through wires or when they move through the air (EPA, 2023a). Sources of EMFs include power lines, electrical appliances, telecommunication devices and natural phenomena like lightning. EMF waves range from low frequency, such as those emitted by power lines, electrical appliances and mobile phones, to high frequency, including UV rays and X-rays (Figure 1.1). Lower-frequency waves do not have sufficient energy to penetrate and damage molecules (i.e., they are 'non-ionising'), whereas high-frequency waves are 'ionising' and can damage human cells.

FIGURE 1.1 THE ELECTROMAGNETIC SPECTRUM



Source: *www.epa.ie/environment-and-you/radiation/emf/emf-monitoring-programme*

Radiofrequency (RF) EMFs are a type of non-ionising EMF used for telecommunications, such as TV and radio broadcasts and mobile phones. They have been in use in Ireland since the late 1800s. Within RF EMFs, different frequency ranges are used to transmit different telecommunication media, although newer technology often co-opts frequencies used for older technology. For example, 5G technology is currently allocated to 700 MHz and 3.6 GHz bands, which were previously in use for 4G and analogue television, respectively.

Exposure to non-ionising EMFs at very high levels can cause increases in body temperature (very high-intensity EMFs are the basis for microwave ovens) (Saunders, Kowalczuk and Sienkiewicz, 1991). The International Commission on Non-Ionizing Radiation Protection provides guidelines for exposure limitations to RF EMFs (GSMA, 2021). These recommendations follow a precautionary principle, such that public exposure levels are advised to remain within bounds that are evidenced as safe. This does not imply that there is evidence for harm above these thresholds, but rather the evidence of health effects is too limited to inform policy. The guidelines depend on the RF EMF frequency: the recommended 'whole body'[1] exposure limit for frequencies between 10 and 400 MHz is 28 volts per metre (V/m); for frequencies between 400 MHz and 2 GHz the exposure limit is between 28 and 61 V/m; and above 2 GHz the exposure limit is 61 V/m. In essence, any electric field that measures below 28 V/m is below the recommended exposure limit.

RF EMF levels in busy urban spaces in Ireland are around 1 V/m (EPA, 2023b). Even close to transmitters, compliance tests by the Commission for Communications Regulation (ComReg) have recorded RF EMF levels far below recommended exposure limits at all sites (ComReg, 2022). Thus, despite the potential for negative

[1] Exposure limits for specific body parts differ from those for whole body exposure. For example, holding a mobile at ear can generate exposure levels of 100 V/m, which is about half the recommended exposure threshold for head exposure.

health effects from high levels of RF EMF exposure, the public in Ireland is in practice exposed to very low levels.

Survey evidence nevertheless suggests that many members of the public will express concern about RF EMFs or specific related technology. A special Eurobarometer survey conducted in 2006 found that around half the public (47%) reported being fairly or very concerned about the health risks of EMFs (European Commission, 2007). More recently, Deloitte's 2020 Digital Trends Survey reported that 20% of the public believed there are health risks associated with 5G and a further 25% were unsure (Deloitte, 2022). The COVID-19 pandemic may have exacerbated concerns, with global conspiracies proposing a link between 5G technology and the spread of the virus (e.g., Flaherty, Sturm and Farries, 2022). In April 2020, telecommunication masts were destroyed in Donegal because of the purported link to the virus (McDermott, 2020). The government subsequently clarified that no such link exists, following warnings that such conspiracy theories could hamper the roll-out of 5G infrastructure (Bray, 2020; McConnell, 2020). By 2022, one in ten of the Irish public reported believing that COVID-19 symptoms could be linked to 5G networks (Duffy et al., 2022).

However, it is not clear how to interpret these survey results. Measuring perceptions of risk is not straightforward, particularly for hazards associated with new technology (Binder et al., 2012; Bruin de Bruin, 2011; Siegrist and Árvai, 2020). The findings outlined above may partly reflect biases that can inflate estimates of perceived risk. For example, the simple act of asking the question can lead some participants to report belief in a risk, based on the inference that the question wouldn't be asked if there were no grounds for concern (e.g., Wiedemann et al., 2017). In the next section, we briefly outline further challenges with measuring perceived risk.

1.2 MEASURING PERCEIVED RISK

While technical assessments of objective risk rely on metrics associated with the probability of experiencing negative consequences from exposure, how 'risky' the public perceives a hazard to be is influenced far more by psychological factors (Kahneman and Ritov, 1994). People often rely on the emotions or 'affect' they experience when thinking about the risk rather than evaluating the reality of the level of risk posed (Slovic et al., 2013). For example, people report far greater perceived risk from very low probability hazards (e.g., plane crashes) than risks with much higher probabilities of negative consequences (e.g., developing lung cancer from smoking) (Slovic, Fischhoff and Lichtenstein, 2016; Sunstein, 2003).

Relatedly, perceptions of risk are closely tied to uncertainty. Familiar hazards are, in general, perceived as safer, regardless of their 'real' risk. This familiar-safe association has been linked to perceptions of risk across multiple domains, including new technology (e.g., Richardson, Sorenson and Soderstrom, 1987). Moreover, for less familiar hazards, single-item surveys (e.g., 'how risky do you think RF EMFs are?') tend to generate high levels of random noise in responses

(Binder et al., 2012). Rather than engaging in a deliberate cognitive assessment of risk level, individuals rely on mental shortcuts (i.e., heuristics) to guide their judgement. These heuristics can be influenced by events (e.g., recent news coverage, trends on social media), meaning that the same individual can respond differently depending on how readily they can bring to mind potential risks associated with a hazard (Folkes, 1988). For hazards that have low baseline levels of risky belief (e.g., that 5G technology causes COVID-19 symptoms), additional noise is more likely to inflate estimates than to depress them.

Unfamiliar risks are sometimes referred to as 'switching risks', which only become cognitively activated when prompted by external stimuli. In other words, people do not think about these risks in their daily life and only reflect on them when prompted to by, for example, surveys. Zwick (2005) found that few people mentioned technology-related risks (e.g., mobile phone radiation) during open-ended interviews about daily health risks they face, but the same risks elicited moderate and high ratings of perceived risk when asked about directly via survey items. Similarly, in one of the few international papers on perceptions of EMF risk, Wiedemann et al. (2017) showed that although most participants expressed high levels of perceived risk from EMFs on standard survey items, very few indicated thinking or talking about EMFs in their day-to-day life. Greater reported 'daily relevance' of EMFs was associated with stronger affective reactions. The authors conclude that surveys that fail to measure this daily relevance dimension of risk are likely to overestimate actual levels of perceived risk among the public.

1.3 CURRENT STUDY

Given these previous research findings, we took multiple steps to mitigate measurement bias in perceived risk from RF EMFs. First, we began the survey by eliciting open text responses about environmental health hazards. This is similar to Zwick's (2005) approach, but in place of semi-structured interviews, we deployed free text survey questions, which allow data to be gathered from larger, representative samples. Open text responses are resource-intensive to analyse and are typically employed only with small samples, but have multiple benefits over standard closed questions, such that responses are not constrained or prompted by pre-set options (Ferrario and Stantcheva, 2022). The logic here is that, if the concern about RF EMFs expressed in the surveys cited above is not a result of measurement bias, RF EMFs should also feature in responses to an open-ended question by 20–50% of the public. A further benefit is that, by analysing the other responses generated by participants, we could provide broader insight into environmental risks perceived by the public.

Second, we complemented the open text question with traditional survey questions but informed the design of these questions using the psychology of perceived risk. We treated risk perception as multi-dimensional and thus employed multiple items (Ferrer et al., 2016). Following Wilson, Zwickle and Walpole (2019), we explicitly prompted cognitive assessments of risk (i.e., how likely respondents think exposure is and how bad they think the consequences of exposure would be) and recorded affective reactions (i.e., how worried a risk makes respondents feel). We also measured daily relevance, as recommended by Wiedemann et al. (2017).

Third, we asked about multiple environmental hazards. By doing so, we established benchmarks for the perceived risk of relatively familiar environmental hazards, such as *E. coli*, against which to compare the perceived risk of EMFs. The additional hazards were other hazards under the remit of the EPA: carbon monoxide, lead (in drinking water), *E. coli*, microplastics, nitrous oxide and particulate matter. We also included a fictitious hazard ('airborne chrolium'), allowing us to benchmark EMFs against a hazard we can be sure respondents have never encountered information on previously.

Fourth, we ended the survey with another open text question about mitigative behaviour (i.e., by asking participants if they take any steps to reduce their exposure to RF EMFs). Again, the logic here was that if a substantial proportion of the population is genuinely concerned about RF EMF exposure in public spaces, we would be likely to record a corresponding amount of mitigative behaviour.

A secondary aim was to measure the degree to which the public hold misconceptions about RF EMFs. To achieve this, we developed a short quiz about RF EMFs, in consultation with the EPA, to probe beliefs about their sources and the level of public exposure in Ireland. Performance on this quiz further allowed us to test whether holding misconceptions about EMFs is linked with higher perceived risk and more mitigative behaviour.

CHAPTER 2

Method

The study was run online using Gorilla Experiment Builder and was laptop, tablet and mobile compatible (Anwyl-Irvine et al., 2020). The design and analysis plan were pre-registered on the Open Science Framework.[2] The full study contained multiple stages. This report describes the findings from stages that measured perceptions of environmental risks and knowledge of EMFs. Findings from other stages, which answered different research questions, are reported in Timmons, Papadopoulos and Lunn (2024). As the study involved primary data collection with non-vulnerable adults on topics other than sensitive issues, the requirement for approval by the ESRI Research Ethics Committee was waived.

2.1 PARTICIPANTS

Eight hundred participants aged 18 and over were recruited using quota sampling (by age, gender, region and social grade[3]) from an online panel held by a leading market research and polling agency.[4] For a detailed discussion on the pros and cons of this sampling method, see Chapter 2 in Ó Ceallaigh et al. (2023). Participants were paid €4 for completing this study and an unrelated one on diet and transport behaviour, to be reported separately. Together the studies took 20 minutes to complete on average. Data collection ran between 5–19 September 2023.

In line with best practice, we pre-registered the study, employed mid-survey attention checks and analysed response quality following data collection. The attention check was an instructed response question and was failed by 29 respondents, who were automatically excluded from the study and thus did not form part of the final 800. An additional 48 participants started the study but did not complete it. Half of these exited the survey during an experimental choice task, with the remainder distributed throughout the study. Hence, the total attrition among those who started the study was 8.8%. Of the final 800, five were observed to have 'straightlined' their responses to some rating scale questions (i.e., did not vary their responses) although there is little change to the figures reported here if they are excluded. For completeness, we retain the full sample.

The socio-demographic characteristics of the sample are presented in Table 2.1. Descriptive analyses reported in Chapter 3 are weighted by participant age, gender, educational attainment and living in an urban or rural area[5], based on population estimates from the 2022 Census. We used iterative proportional fitting

[2] https://osf.io/jspu3

[3] Social grade is a demographic classification system routinely used in market research as a proxy for socio-economic status. Respondents choose a category based on the occupational level of their household's chief income earner (e.g., junior managerial, skilled manual worker, casual worker).

[4] www.redcresearch.ie/product/red-c-live

[5] Note that we use educational attainment for weighting despite basing quotas on social grade. This is because population estimates for social grade are not available. Urban-rural estimates are based on 2019 data due to changes in classification systems used in Census 2022.

('raking'), with weights restricted between 0.5 and 2. Weighting had a greater impact on educational attainment and living area than gender and age because the former were not used in the quotas set by the market research agency.

TABLE 2.1 PARTICIPANT CHARACTERISTICS

		Sample – Unweighted	Sample – Weighted	CSO Estimate
Gender	Men	48.6	49.0	49.0
	Women	51.3	50.9	51.0
	Non-binary/Other	0.1	0.1	-
Age	18–39 years	37.1	36.8	36.8
	40–59 years	36.0	36.5	36.5
	60+ years	26.9	26.7	26.7
Educational Attainment	Leaving Certificate or below	31.6	43.9	43.9
	Tertiary Education below degree	30.9	28.6	28.6
	Degree or above	37.5	27.5	27.5
Living Area	Urban	61.6	68.6	68.6
	Rural	38.4	31.4	31.4

Source: Authors' analysis and CSO (2019, 2023).
Note: The Census does not record non-binary as a gender. The discrepancy between the CSO estimate and our unweighted sample is due to the use of social grade instead of education in the quota sampling applied by the market research agency.

2.2 MATERIALS AND DESIGN

Materials are available in the Appendix and on the project's Open Science Framework page. Participants were first informed that the study was about how factors in the environment can affect health and that some can have an immediate impact, whereas others can contribute to long-term health conditions. The first task was an open text task, in which participants were asked to list any environmental factors that they were aware of that can impact health, with a clarification that the question referred to anything potentially harmful that someone can be exposed to in their home, at work or in public spaces. They could list up to five factors.

The next stage of interest for this report presented participants with a series of rating scales about different environmental risks. They rated seven hazards (carbon monoxide, *E. coli*, EMFs, lead in drinking water, microplastics, nitrous oxide and particulate matter) along the four dimensions of perceived risk: general worry, perceived probability of being exposed, perceived severity if exposed, and daily relevance. Each was rated on a rating scale from 1 to 7 with higher scores indicating greater perceived risk. The environmental risks were included based on discussions with officers from the EPA. We also included a fictitious risk ('airborne chrolium') to provide a benchmark for the other risks. Participants were debriefed that this risk was fictitious at the end of the study.

Participants then completed an incentivised EMF comprehension assessment. The assessment focused on radio frequency EMF. Each participant was entered into a raffle for one of two €100 Mastercard gift vouchers, unless they opted out. For each question they answered correctly, they were awarded an additional entry into the raffle. There were eight questions, which probed understanding of the factors that contribute to the average person's level of RF EMF exposure, the relationship between radio broadcast antennae and mobile phone masts, the implications of new technologies (e.g., 5G) for EMF exposure, the differences between RF EMFs and other forms of radiation (e.g., X-rays) and the level of RF EMF in public places in Ireland. Full questions are presented on the charts alongside responses in Chapter 3. Participants were debriefed on the correct answers at the end of the study.

Lastly, participants were asked if they take precautions to limit their exposure to EMFs, completed socio-demographic questions, indicated whether they experienced any issues with the study and read the debrief form.

CHAPTER 3

Results

In this chapter, we first present findings from the open text responses to the question about environmental health risks perceived by the public. These risks were unprompted by the survey materials and thus give insight into the kinds of hazards that people spontaneously raise. We next present the responses to the rating scales for the seven environmental hazards and one fictitious risk. We then present descriptive statistics for the results of the EMF quiz. We use scores on the quiz to test for the association between perceived risk from EMFs and holding more misconceptions about it. Lastly, we report on the behaviours the public reports to mitigate their exposure to EMFs.

3.1 OPEN TEXTS

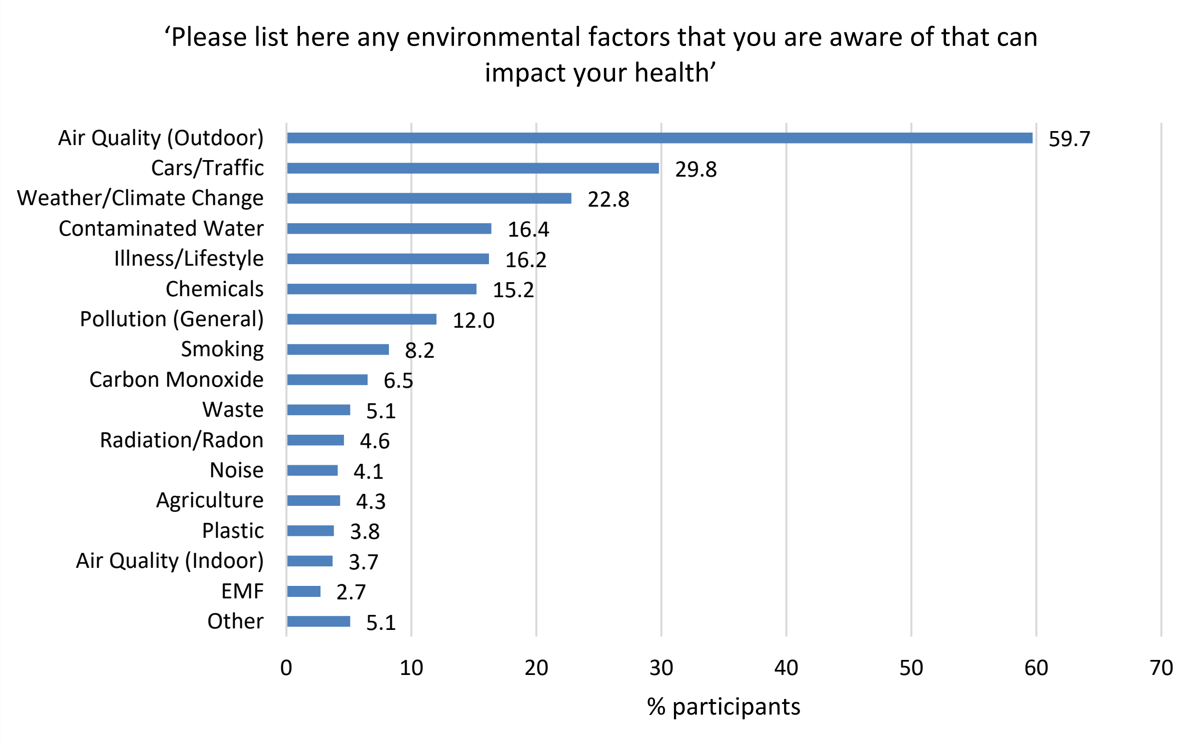
Participants wrote on average 4.2 (*SD* = 1.31) environmental health hazards with the vast majority (97.6%) writing at least one. Entries were qualitatively coded into different hazards, using the framework presented in Table 3.1. Although references to cars and traffic pertain to air quality, we categorised them separately because of the volume of entries that related to cars. While our interest was in substances that have the potential to cause adverse health events, some participants referenced exposure to pathogens, such as COVID-19, and some mentioned features of lifestyles that have long-term health implications, such as being highly sedentary. We classify these in an 'Illness/Lifestyle' category. We grouped other hazards for which there were very few observations into one 'Other' category.

TABLE 3.1 OPEN TEXT CODING FRAMEWORK

Category	Example
Agriculture	*'Slurry spreading is common around my walking route'* *'Pollution from farming'*
Air Quality (Indoor)	*'Mould indoors'* *'Damp'* *'Poor air circulation'*
Air Quality (Outdoor)	*'Burning coal'* *'Pollution in the air'* *'Smog'*
Carbon Monoxide	*'Carbon monoxide'*
Cars/Traffic	*'Air pollution from poorly maintained vehicles'* *'Motor fumes'*
Chemicals	*'Weedkiller and other garden feeds and sprays'* *'Chemicals in our food'*
Contaminated Water	*'Dirty potable water'* *'Water pollution'*
EMFs	*'Electric pylons'* *'Mobile phone masts'*
Illness/Lifestyle	*'Antibiotic-resistant bacteria'* *'COVID'* *'Lack of places to walk'*
Noise	*'Noise'*
Plastic	*'Plastic'* *'Microplastics'*
Pollution (General)	*'Pollution'*
Radiation/Radon	*'Radon gas'*
Smoking	*'Passive smoking'*
Waste	*'Dumping'* *'Waste mismanagement'*
Weather/Climate Change	*'Climate change'* *'Sun exposure'* *'Extreme heat'*
Other	*'Asbestos'* *'Scented candles'*

Figure 3.1 shows the proportion of participants who listed at least one hazard in each category. Outdoor air quality clearly dominated as an environmental health hazard. Most participants (59.7%) specifically mentioned at least one feature of outdoor air quality, even with pollution from cars excluded. Cars then followed as the second most-listed hazard (29.8%). Perhaps unexpectedly, the next most common hazard related to weather, such as UV rays from the sun, with many participants in this group specifically listing climate change as a health hazard. Contaminated water, pathogen exposure and lifestyle factors, and exposure to chemicals (e.g., for cleaning) were listed by approximately one in six. Radon, noise, agricultural pollution, microplastics, indoor air quality and EMFs were listed by less than 5% of respondents.

FIGURE 3.1 ENVIRONMENTAL FACTORS LISTED IN OPEN TEXT TASK

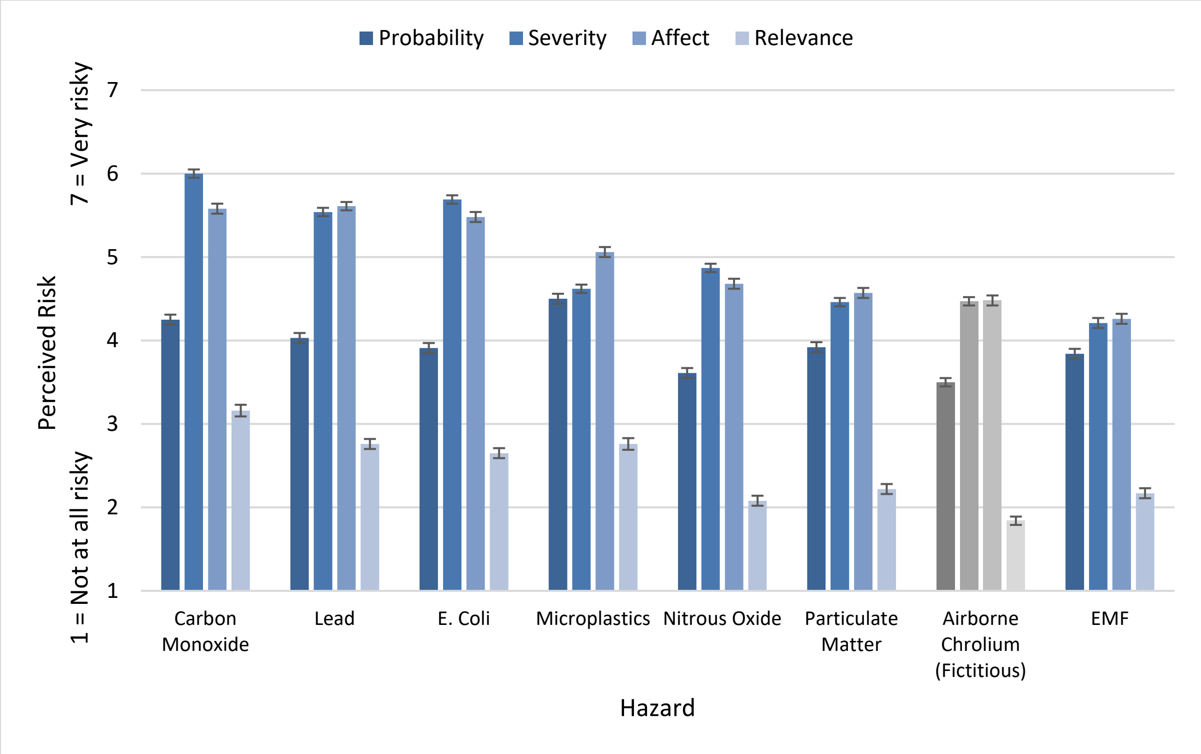


Source: Authors' analysis.

3.2 RATING SCALES

Participants next rated seven target environmental hazards plus one fictitious one on four dimensions of perceived risk: the probability of exposure, the severity of the consequences of exposure, general affect (how worried people feel in general about the risk), and daily relevance. Figure 3.2 presents the mean response on each scale for each hazard.

FIGURE 3.2 AVERAGE SCORES ON RISK PERCEPTION SCALES



Source: Authors' analysis.
Note: Error bars are the standard error of the mean. Bars in grey indicate fictional hazard.

Average perceived probability of exposure was close to the midpoint of the scale to each hazard, including the fictitious one. Participants rated microplastics as the environmental hazard they would be most likely to be exposed to harmful levels of (*M* = 4.5, *SD* = 1.8). Although airborne chrolium was correctly rated as the hazard they would least likely to be exposed to harmful levels of, it was rated far above the lowest point on the scale (*M* = 3.5, *SD* = 1.5). Despite the fact that outdoor air pollution was most likely to be mentioned in the spontaneous, open text responses, this concern did not translate into high ratings for nitrous oxide and particulate matter, both of which are important components of air quality. Table 3.1 presents paired t-tests that establish the statistical significance of the differences in exposure probability between different hazards.

TABLE 3.2 MEAN DIFFERENCES FOR EXPOSURE PROBABILITY RATINGS

	Lead	*E. Coli*	Microplastics	Nitrous Oxide	Particulate Matter	Airborne Chrolium (Fictitious)	EMFs
Carbon Monoxide	0.25***	0.32***	-0.30***	0.61***	0.30***	0.72***	0.39***
Lead		0.07	-0.54***	0.37***	0.05	0.48***	0.15*
E. Coli			-0.61***	0.30***	-0.02	0.41***	0.08
Microplastics				0.91***	0.59***	1.02***	0.69***
Nitrous Oxide					-0.32***	0.11*	-0.22***
Particulate Matter						0.43***	0.10
Airborne Chrolium (Fictitious)							-0.33***

Source: Authors' analysis.
Notes: ****p* < .001; ***p* < .01; ****p* < .05. Paired t-tests used for significance testing. Positive values indicate row hazards are higher; negative values indicate column hazards are higher.

Mean ratings for perceived severity of exposure were above the midpoint for each risk and ranged from 4.2 out of 7 for EMFs to 6.0 for carbon monoxide. Carbon monoxide, lead in drinking water and *E. coli* elicited the highest perceived severity ratings, whereas particulate matter, the fictitious risk and EMFs elicited the lowest. Table 3.3 shows that all pairwise differences are statistically significant, except for the difference between particulate matter and the fictitious risk, which elicited the same mean severity rating. Again, the average rating given to the fictitious risk was well above the lowest point on the scale and exposure was rated as significantly worse than exposure to EMFs.

TABLE 3.3 MEAN DIFFERENCES FOR EXPOSURE SEVERITY RATINGS

	Lead	*E. Coli*	Microplastics	Nitrous Oxide	Particulate Matter	Airborne Chrolium (Fictitious)	EMFs
Carbon Monoxide	0.45***	0.31***	1.38***	1.14***	1.53***	1.53***	1.79***
Lead		-0.14**	0.93***	0.69***	1.07***	1.07***	1.34***
E. Coli			1.07***	0.83***	1.22***	1.22***	1.48***
Microplastics				-0.24***	0.15**	0.15**	0.41***
Nitrous Oxide					0.39***	0.39***	0.65***
Particulate Matter						0.00	0.26***
Airborne Chrolium (Fictitious)							0.26***

Source: Authors' analysis.
Notes: ****p* < .001; ***p* < .01; ****p* < .05. Paired t-tests used for significance testing. Positive values indicate row hazards are higher; negative values indicate column hazards are higher.

Mean ratings for general affect were above the midpoint for each risk and ranged from 4.3 out of 7 for EMFs to 5.6 for carbon monoxide and lead. In general, the pattern of responses is the same as that for perceived severity of exposure consequences. Table 3.4 shows that all pairwise differences are statistically significant, except for the difference between carbon monoxide and lead and *E. coli*. Again, there was no significant difference between ratings of particulate matter and the fictitious risk. The average rating given to the fictitious risk was well above the lowest point on the scale and significantly higher than that given to EMFs.

TABLE 3.4 MEAN DIFFERENCES FOR AFFECT RATINGS

	Lead	*E. Coli*	Microplastics	Nitrous Oxide	Particulate Matter	Airborne Chrolium (Fictitious)	EMFs
Carbon Monoxide	-0.05	0.08	0.49***	0.88***	0.98***	1.08***	1.31***
Lead		0.13**	0.54***	0.92***	1.03***	1.13***	1.36***
E. Coli			0.41***	0.79***	0.90***	0.99***	1.23***
Microplastics				0.39***	0.49***	0.59***	0.82***
Nitrous Oxide					0.11*	0.20***	0.44***
Particulate Matter						0.10	0.33***
Airborne Chrolium (Fictitious)							0.23***

Source: Authors' analysis.
Notes: ***$p < .001$; **$p < .01$; ***$p < .05$. Paired t-tests used for significance testing. Positive values indicate row hazards are higher; negative values indicate column hazards are higher.

Ratings for the daily relevance dimension were below the midpoint for all risks, indicating that participants do not often think about the environmental hazards. Ratings ranged from 1.2 out of 7 for the fictitious risk to 3.2 for carbon monoxide. Table 3.5 presents t-tests comparing all risks. The fictitious risk elicited lower ratings than all other hazards.

TABLE 3.5 MEAN DIFFERENCES FOR DAILY RELEVANCE RATINGS

	Lead	*E. Coli*	Microplastics	Nitrous Oxide	Particulate Matter	Airborne Chrolium (Fictitious)	EMFs
Carbon Monoxide	0.43***	0.52***	0.39***	1.09***	0.95***	1.34***	1.01***
Lead		0.09	-0.04	0.66***	0.52***	0.91***	0.58***
E. Coli			-0.13*	0.58***	0.44***	0.82***	0.50***
Microplastics				0.71***	0.57***	0.95***	0.63***
Nitrous Oxide					-0.14***	0.24***	-0.08
Particulate Matter						0.39***	0.06
Airborne Chrolium (Fictitious)							-0.33***

Source: Authors' analysis.
Notes: ****p* < .001; ***p* < .01; ****p* < .05. Paired t-tests used for significance testing. Positive values indicate row hazards are higher; negative values indicate column hazards are higher.

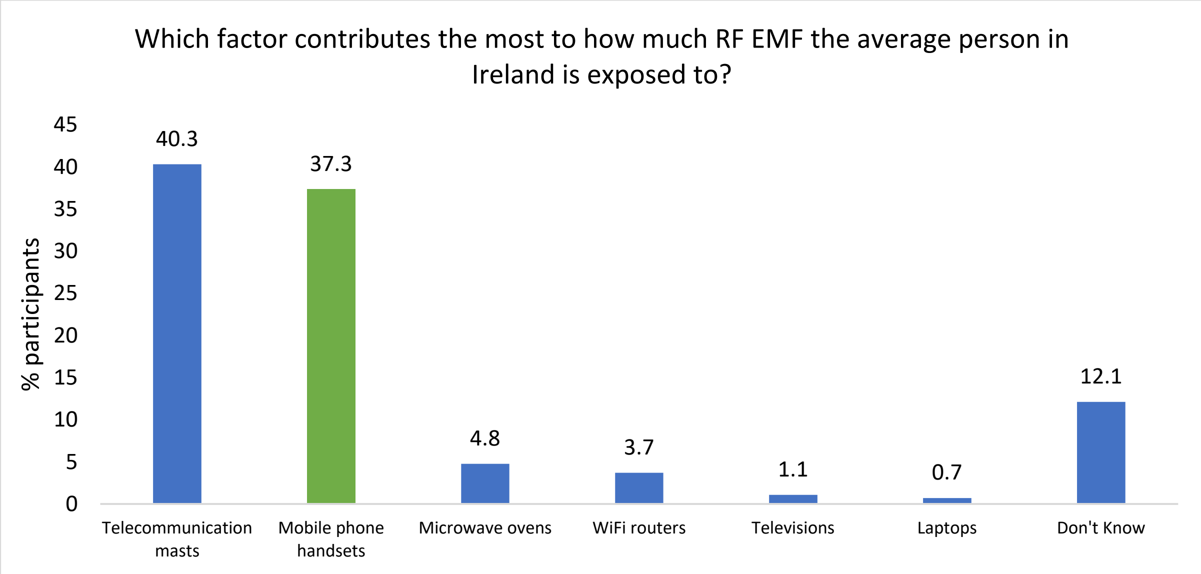
3.3 UNDERSTANDING OF EMFs

Figures 3.3 to 3.6 present weighted responses to the multiple-choice questions about radiofrequency (RF) EMFs. Figure 3.3 shows that, when asked about the primary source of EMF exposure, over one-third of adults correctly chose mobile phone handsets from the provided list. However, the most common answer was telecommunication masts, which was chosen by 40% of respondents.

Turning to how RF EMFs compare to other types of radiation, half of the participants knew that EMFs from mobile phone masts are the same family of radiation as from radio towers (i.e., both are RF EMFs) (Figure 3.4). The majority of adults incorrectly believe that RF EMFs can damage human cells in a similar way to X-ray radiation (Figure 3.4). While the question did not imply that the scale of damage was similar, this misconception could be considered a concern.

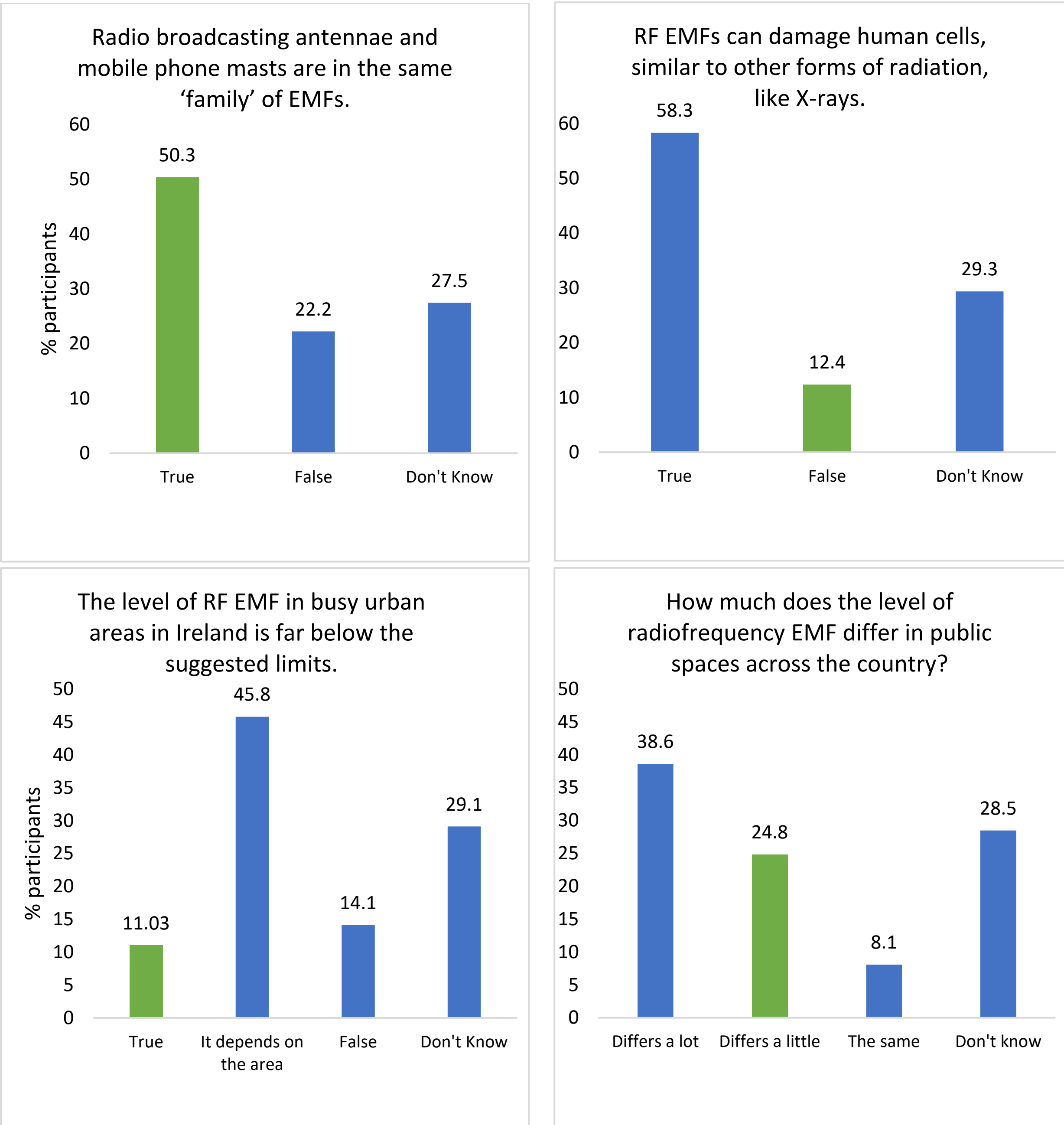
Three questions probed beliefs about RF EMF exposure in public places in Ireland. For each question, just a minority answered correctly. The results show that the public incorrectly believes there is a large variation in RF EMF exposure in public places, that some places have exposure levels above suggested limits and that new technologies have substantially increased the level of RF EMF exposure in public over time (Figure 3.5). The final two questions asked directly about 5G and show that, in general, the public believes that 5G technology emits radiation at a higher frequency than previous technologies and is a new form of EMF (Figure 3.6). Again, these are misconceptions that might be a cause for concern, especially in relation to understanding the impact of new technologies.

FIGURE 3.3 SOURCES OF EMF EXPOSURE



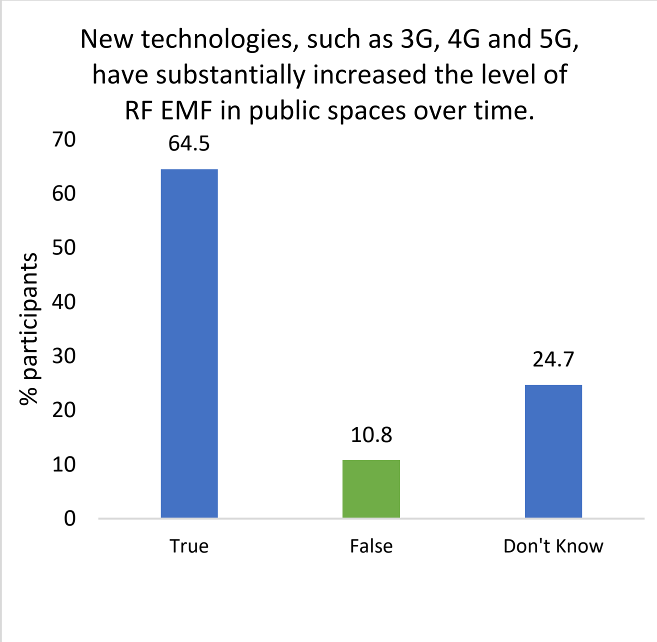
Source: Authors' analysis.
Note: Green bar indicates correct response.

FIGURE 3.4 EMFS AND OTHER SOURCES OF RADIATION



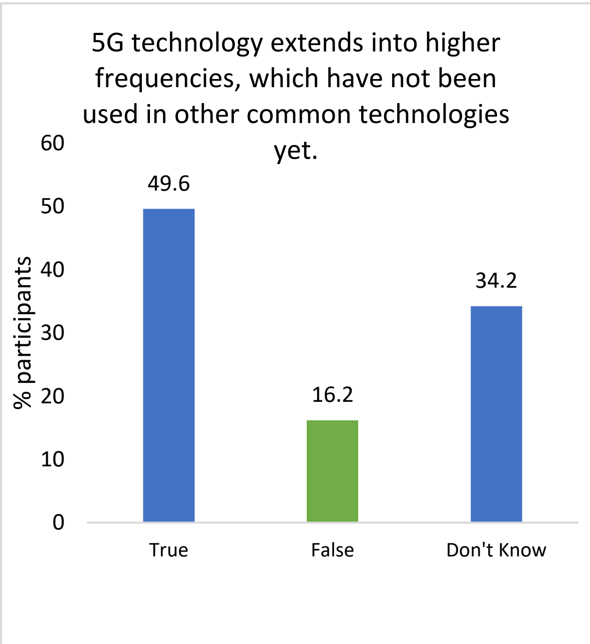
Source: Authors' analysis.
Note: Green bars indicate correct responses.

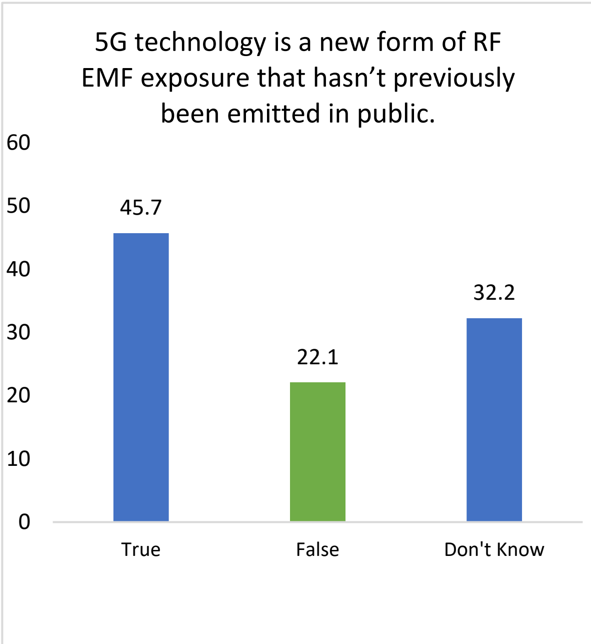
FIGURE 3.5 BELIEFS ABOUT EMF LEVELS IN PUBLIC SPACES



Source: Authors' analysis.
Note: Green bar indicates correct response.

FIGURE 3.6 BELIEFS ABOUT 5G TECHNOLOGY

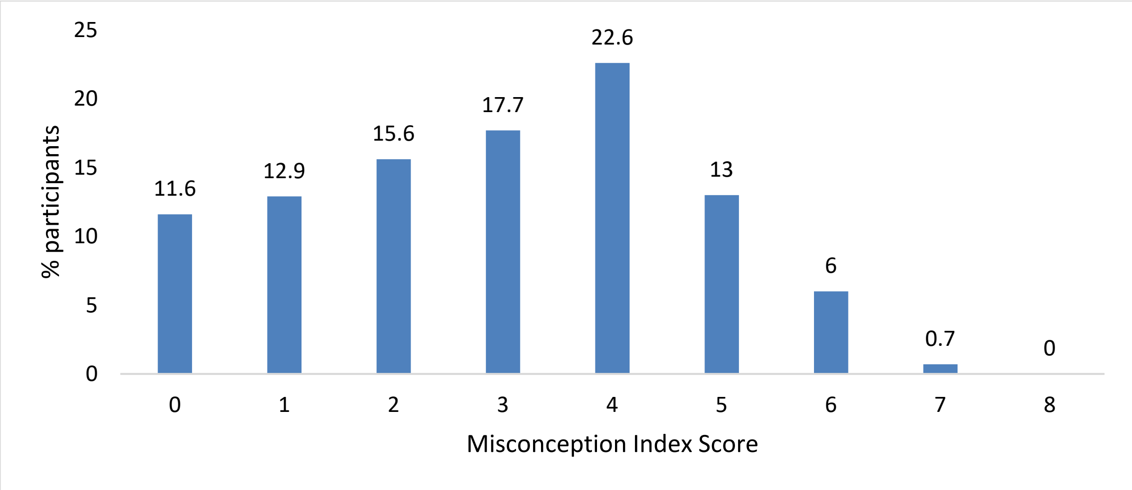




Source: Authors' analysis.
Note: Green bars indicate correct response.

Responses to the comprehension quiz allowed us to test the relationship between misconceptions about EMFs and perceptions of risk. To do so, for each question, participants scored a '1' by responding with a misconception (i.e., not giving the correct answer nor indicating that they did not know the answer) that implied potential harm from EMFs.[6] We then summed these to give each participant a ‘misconception index’ score (Figure 3.7). Participants scored an average of 2.9 out of a possible 8 (*Mdn* = 3, *SD* = 1.76). Table 3.6 presents OLS regression models predicting each risk dimension rating for EMF from the participant’s misconception index score, with controls for gender, age, educational attainment and living area. Across all models, participants who scored higher on the misconception index reported greater perceived risk from EMFs.

FIGURE 3.7 MISCONCEPTION INDEX DISTRIBUTION



Source: Authors’ analysis.

TABLE 3.6 OLS MODELS OF MISCONCEPTION INDEX ON PERCEIVED RISK

	Probability	Severity	Affect	Relevance
Misconception Index	0.18*** (0.03)	0.16*** (0.03)	0.14*** (0.04)	0.11** (0.03)
Man (Ref: Woman)	-0.30* (0.13)	-0.47*** (0.11)	-0.60*** (0.13)	0.01 (0.12)
Age (Ref: under 40)				
40–59 years	0.18 (0.14)	0.06 (0.13)	0.21 (0.15)	0.06 (0.15)
60+ years	-0.06 (0.16)	0.21 (0.15)	0.28 (0.16)	-0.30 (0.16)
Degree (Ref: No degree)	0.06 (0.13)	-0.20 (0.12)	-0.09 (0.13)	-0.09 (0.13)
Urban (Ref: Rural)	0.19 (0.12)	0.05 (0.11)	0.08 (0.13)	0.18 (0.12)
Constant	3.28	3.93	3.97	1.80
Obs.	800	800	800	800

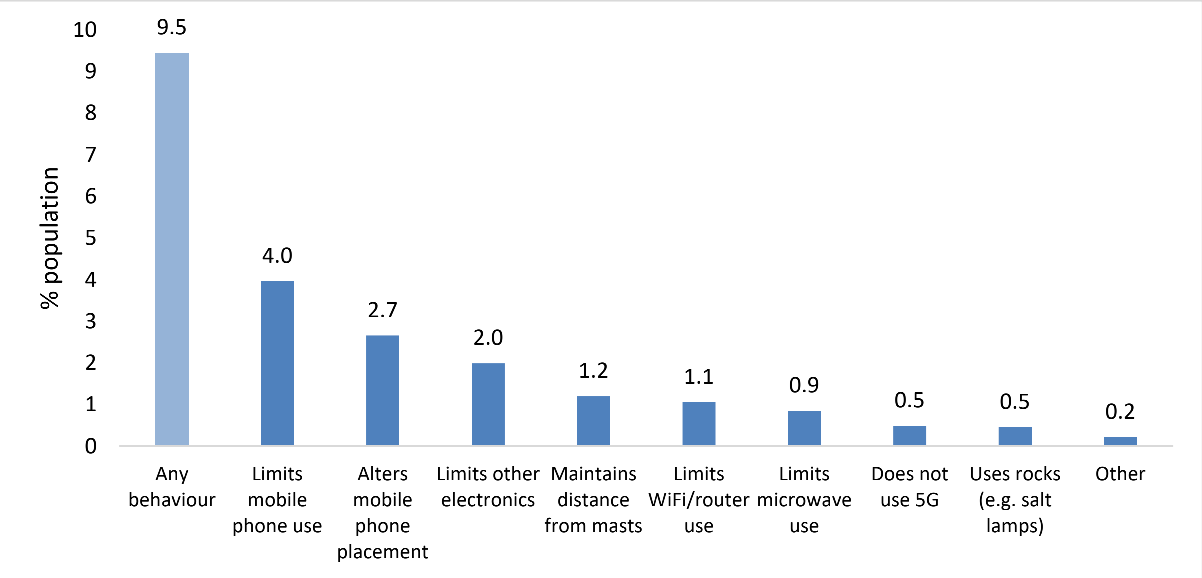
Source: Authors’ analysis.
Notes: ****p* < .001; ***p* < .01; ****p* < .05

[6] For the sources of EMF, only those who indicated ‘telecommunications masts’ scored a 1, and for the question about RF EMF variability in public spaces, those who said it was ‘the same’ were assigned a ‘0’.

3.4 MITIGATIVE BEHAVIOUR

When asked in a final free text question, the vast majority (90.6%) reported that they do not do anything to prevent or reduce their exposure to EMFs. Responses from the remaining participants were then qualitatively coded and are presented in Figure 3.8. Among those who reported mitigative behaviour, the most common responses were to limit mobile phone use or to alter where they leave their phone (e.g., in a separate room at nighttime or to use a hands-free set rather than place their phone to their ear for calls). Table 3.7 presents logistic models predicting mitigative behaviour from the participant's misconception index. Model 1 includes socio-demographic controls and shows that those who hold more misconceptions about EMFs are more likely to engage in mitigative behaviour. The effect holds when perceptions of risk are also included in the model (Model 2). To illustrate the effect size, 12.7% of those with a score above the median on the misconception index reported engaging in mitigative behaviour compared to 7.1% of those below. Of further note is that, out of the four dimensions of perceived risk, just the relevance dimension appears to be predictive of day-to-day behaviour.

FIGURE 3.8 MITIGATIVE BEHAVIOUR



Source: Authors' analysis.

TABLE 3.7 LOGISTIC REGRESSION MODELS PREDICTING MITIGATION

	Model 1	Model 2
Misconception Index	0.29*** (0.07)	0.21** (0.08)
Probability		0.09 (0.10)
Severity		-0.01 (0.11)
Affect		0.20 (0.10)
Relevance		0.33*** (0.08)
Man (Ref: Woman)	-0.05 (0.25)	0.10 (0.27)
Age (Ref: under 40)		
40–59 years	0.41 (0.30)	0.25 (0.32)
60+ years	0.59 (0.33)	0.68* (0.34)
Degree (Ref: No degree)	0.22 (0.26)	.28 (0.27)
Urban (Ref: Rural)	-0.30 (0.25)	-0.45 (0.26)
Constant	-3.40	-5.25
Obs.	800	800

Source: Authors' analysis.
Notes: ***p < .001; **p < .01; ***p < .05

CHAPTER 4

Discussion

Our aim was to investigate the public's perceptions of risk from EMF exposure. In doing so, we also generated evidence about the public's perceptions of multiple environmental health hazards. In this chapter, we first summarise the evidence for public perceptions of risk from EMFs, followed by perceptions of other risks included in the study. We conclude by considering implications for policy.

4.1 PERCEIVED RISK FROM EMFs

Average responses to rating scale questions about perceived risk from EMFs (i.e., perceived probability and severity of exposure and general worry about the risk), were around the midpoint of each of the 7-point rating scales. At first glance, these could be considered to indicate 'moderate' levels of perceived risk. These responses could perhaps reasonably be judged as aligning with other surveys showing large minorities of the public being concerned or uncertain about the health consequences of EMFs and associated technology (e.g., 5G; Deloitte, 2022). However, considering this response pattern in the context of other evidence generated by the survey suggests otherwise.

First, when asked how often they think or talk about EMFs in their daily life, the average response was approximately 2 on the 7-point scale. Thus, EMFs are not a hazard that cause regular concern for the public. This finding supports previous research on risks like EMFs being classified as 'switching risks' that people only consider when prompted to by external stimuli like survey questions (Wiedemann et al., 2017).

A second, and perhaps more convincing, point is the comparison between EMF risk perceptions and the fictitious risk that we also included in our study. Although high levels of statistical power mean most comparisons are statistically significant, the differences in ratings between EMFs and the fictitious risk were small. The direction of the effects is also important. While the public reported believing that exposure to high levels of EMFs was slightly more likely than exposure to our fictitious risk, and that they think slightly more often about EMFs in their daily life, they nevertheless judged the likely consequences from the fictitious risk to be, on average, more severe than EMF exposure. They also, in general, reported feeling more worried about the risk they have never heard of before.

These findings suggest that survey participants may respond to hazards they are uncertain about or unfamiliar with using a precautionary principle, gravitating towards the midpoint of scales instead of responding with low levels of perceived risk. As such, they point towards the kinds of measurement bias that can hamper inferences from standard survey measures of perceived risk discussed in Chapter 1. This implies that the responses to questions about the risks of EMF exposure do not so much reflect genuine public concern about the risk, but rather an expression of caution when faced with not knowing about something.

Responses to the open text questions provide further evidence that concern about EMFs is low. Less than 3% of the public produced EMFs as an environmental factor they are aware can impact their health, with greater shares mentioning issues that are not targets for misinformation, such as noise pollution (Gallagher, O' Connor & Visser, 2023). A larger minority (just under 10%) reported taking daily action to mitigate their exposure to EMFs. However, most of this group specified actions related to the use or placement of their mobile phone. These precautions are more credible than actions related to telecommunication masts; the level of exposure from an at-ear mobile phone call can be around 100 V/m,[7] much higher than levels recorded in public spaces. Just 1% reported taking action to reduce their potential exposure in public spaces (i.e., maintaining distance from masts).

Despite evidence that concern about EMFs is not high among the general public, our assessment of public understanding of EMFs suggests widespread misconceptions, with a bias towards suspecting greater harm than in reality. Slightly more of the public (40%) incorrectly believe telecommunication masts to be the source of greatest EMF exposure rather than the correct source (mobile phones; 37%). The majority also believe that RF EMFs can damage human cells in a similar way to X-rays (58%), that the level of exposure in urban areas is above suggested limits (60%), that new technologies such as 5G have substantially increased the level of RF EMFs in public spaces (65%) and that they extend into frequencies that humans have not yet been exposed to (50%). Importantly, believing these misconceptions is linked to perceiving greater risk from EMFs and being more likely to engage in everyday mitigative behaviour. Together, the results imply that, although spontaneous concern about EMFs appears low, there may be scope for both mis- and disinformation to exploit misconceptions and generate unnecessary worry about RF EMFs and newer technologies.

4.2 OTHER ENVIRONMENTAL HAZARDS

As noted in Chapter 1, although we aimed to measure perceptions of EMFs, our method allowed us to generate evidence on public perceptions of other environmental hazards. Responses to the open text question at the start of the survey are of particular interest, as they reflect the kinds of environmental health factors that the public are most aware of.

Outdoor air quality was the only hazard spontaneously mentioned by the majority of respondents (60%), showing widespread recognition of the health implications of poor-quality air (e.g., Nolan, 2023). Interestingly, a large minority (30%) further specified cars and traffic as impacting on their health. Although we could have classified these responses within the air quality category, the volume of responses that specified cars warranted separation. These findings thus may have

[7] Exposure limit recommendations for specific body parts are different to those for 'whole body' exposure. The at-ear limit is 200 V/m.

implications for debate on the utility of policy efforts to reduce traffic congestion in urban areas.

Of further interest are the hazards that were produced by only a low proportion of the public, despite their health implications. For example, water contamination was listed by just 16% of the public, despite strong links to negative health outcomes, particularly for children and older people (e.g., Mohan and Lyons, 2022). Noise pollution was identified as a health risk by just 4% of the public, despite growing evidence of direct and cumulative adverse effects, similar to the effects of chronic stress (e.g., Mac Domhnaill et al., 2022; Murphy and King, 2022). Indoor air quality and specific indoor air contaminants (e.g., radon) were also referenced by only small minorities (approx. 4%), despite real and potentially severe adverse outcomes and recent widespread coverage of the importance of adequate indoor ventilation (Dempsey, Lyons and Nolan, 2018; Jones, 1999). This overall pattern implies shortcomings in public understanding.

The rating scale responses provide additional insight into public perceptions of risks. Carbon monoxide emerged as the hazard with the highest average ratings on all dimensions of perceived risk, followed by the three water contaminants (lead, *E. coli* and microplastics). Estimating the accuracy of these perceptions is not straightforward, but technical assessments can provide some context. For example, whereas carbon monoxide is estimated to cause six deaths in Ireland per year, around 481,000 people are estimated to be at risk of contaminated drinking water in Ireland. Moreover, despite high levels of awareness of the importance of air quality for health, the two specified pollutants (nitrous oxide and particulate matter) were close in perceived risk ratings to the fictitious risk and EMFs. This discrepancy likely reflects a lack of awareness of the scientific terms for air pollutants and poor understanding of the specific threats to health involved, thus supporting efforts to engage the public in citizen science projects on air quality (Nolan and Hoy, 2023).

4.3 POLICY IMPLICATIONS

The primary implications for policy relate to guiding communications to inform public perceptions of environmental risks. The findings on perceptions of EMF risks suggest that concern about RF EMFs in public spaces is (appropriately) low, but that misconceptions about RF EMFs could possibly be exploited to generate unnecessary concern. Evidence on the psychology of misinformation suggests that it is more effective to pre-empt misinformation (i.e., to ‘pre-bunk’) than to try to correct its impact after exposure. However, raising the salience of RF EMFs in public spaces via communications campaigns may lead to increased perceptions of risk (Timmons et al., 2024). Perhaps a reasonable balance between these competing risks is to ensure that reliable information appears close to the top of internet search outputs, particularly when there are sharp increases in searches linked to misinformation trends (e.g., Nsoesie et al., 2020).

The findings may also be used to identify where communications campaigns should be prioritised. For example, given the health consequences of noise pollution but low levels of awareness of it as impacting health, increased public communication about its effects may help some people to mitigate their exposure. Communication campaigns also need to take into account how familiar the public is with specific technical terms and concepts. For example, although the majority generated air quality impacts on health spontaneously when asked in the open text question, perceptions of risk from specific pollutants that have serious health impacts (e.g., particulate matter) were closer to our fictitious risk. Better public understanding of the air quality and its effects might be important also for informing public debate on car use and traffic management.

The findings have broader implications for how policymakers interpret evidence from surveys. In Chapter 1, we presented a brief summary of limited evidence on public perceptions of the risk from EMFs. Independent surveys conducted almost 20 years apart appear to suggest that a strong minority of individuals worry about how EMF exposure affects their health. Our findings suggest that much of this concern may have resulted instead from measurement error and biases in surveys. Measuring perceptions of risk is difficult and we don't seek to criticise previous studies unduly. However, for policymakers faced with trade-offs when deciding where to direct limited resources, the design of such surveys would benefit from incorporating behavioural science techniques to help contextualise results.

4.4 CONCLUSION

Our aim was to investigate public perceptions of risk from EMFs and other environmental hazards. By employing multiple measurement techniques and relying on best international practice for measuring risk perception, we show that perceived risk from EMFs is much lower than implied by previous surveys. A small minority of the public (less than 3%) spontaneously identified EMFs as an environmental health hazard, with the majority instead focusing on issues related to outdoor air quality. Respondents to standard surveys appear to respond to questions about unfamiliar risks (e.g., EMFs and hazards not previously encountered) by employing a precautionary principle rather than responding that they perceive the level of risk to be low. Measuring daily relevance also helps to contextualise results. More broadly, the findings support the application of behavioural science techniques to tricky measurement challenges.

REFERENCES

Anwyl-Irvine, A.L., Massonnié, J., Flitton, A., Kirkham, N., and Evershed, J.K. (2020). 'Gorilla in our midst: An online behavioral experiment builder', *Behavior Research Methods*, Vol. 52, pp.388–407, https://doi.org/10.3758/s13428-019-01237-x.

Binder, A.R., Cacciatore, M.A., Scheufele, D.A., Shaw, B.R., and Corley, E.A. (2012). 'Measuring risk/benefit perceptions of emerging technologies and their potential impact on communication of public opinion toward science', *Public Understanding of Science*, Vol. 21, No. 7, pp.830–847, https://doi.org/10.1177/0963662510390159.

Bray, J. (2020, August 8). 'Conspiracy theories "may hamper" roll-out of 5G', *The Irish Times,* www.irishtimes.com/news/politics/conspiracy-theories-may-hamper-roll-out-of-5g-1.4325024.

Bruin de Bruin, W. (2011). 'Framing effects in surveys: How respondents make sense of the questions we ask', *Perspectives on Framing,* Keren, G. (Ed.), pp.303–325, London, UK: Taylor & Francis.

Commission for Communications Regulation (2022). *2022 Programme of Measurement of Non-Ionising Radiation,* www.comreg.ie/media/2022/09/ComReg-2279.pdf.

Deloitte (2022). *2020 Digital Trends Survey,* www.deloitte.com/ie/en/Industries/tmt/research/digital-consumer-trends/digital-consumer-trends-attitudes-towards-5G.html.

Dempsey, S., Lyons, S., and Nolan, A. (2018). 'High radon areas and lung cancer prevalence: Evidence from Ireland', *Journal of Environmental Radioactivity*, Vol. 182, pp.12–19, https://doi.org/10.1016/j.jenvrad.2017.11.014.

Duffy, B., Malcolm, F., May, G., and Hewlett, K. (2022). *Public Attitudes Towards the COVID-19 Pandemic,* www.kcl.ac.uk/policy-institute/assets/peritia-covid-19-pandemic.pdf.

Environmental Protection Agency (2023a). *What is EMF?*, www.epa.ie/environment-and-you/radiation/emf/what-is-emf/#d.en.84412.

Environmental Protection Agency (2023b). *Radiofrequency electromagnetic fields in public spaces in Ireland*, www.epa.ie/publications/monitoring--assessment/radiation/emf/Radiofrequency-EMF-in-public-spaces-in-Ireland-21-22---Summary-Report.pdf.

European Commission (2007). *Special Eurobarometer: Electromagnetic Fields.* https://ec.europa.eu/health/ph_determinants/environment/EMF/ebs272a_en.pdf.

Ferrario, B., and Stantcheva, S. (2022, May). 'Eliciting people's first-order concerns: Text analysis of open-ended survey questions', *AEA Papers and Proceedings,* Vol. 112, pp.163–169, https://doi.org/10.1257/pandp.20221071.

Ferrer, R.A., Klein, W.M., Persoskie, A., Avishai-Yitshak, A., and Sheeran, P. (2016). 'The tripartite model of risk perception (TRIRISK): Distinguishing deliberative, affective, and experiential components of perceived risk', *Annals of Behavioral Medicine*, Vol. 50, No. 5, pp.653–663, https://doi.org/10.1007/s12160-016-9790-z.

Flaherty, E., Sturm, T., and Farries, E. (2022). 'The conspiracy of COVID-19 and 5G: Spatial analysis fallacies in the age of data democratization', *Social Science & Medicine*, Vol. 293, 114546, https://doi.org/10.1016/j.socscimed.2021.114546.

Folkes, V.S. (1988). 'The availability heuristic and perceived risk', *Journal of Consumer Research*, Vol. 15, No. 1, pp.13–23, https://doi.org/10.1086/209141.

Gallagher, A., O' Connor, C., and Visser, F. (2023). Uisce Faoi Thalamh: An investigation into the online mis- and disinformation ecosystem in Ireland. *Institute for Strategic Dialogue,* https://www.isdglobal.org/wp-content/uploads/2023/11/Uisce-Faoi-Thalamh_Platform-Analysis.pdf

GSMA (2021). *International EMF Exposure Guidelines,* www.gsma.com/publicpolicy/wp-content/uploads/2021/10/GSMA_International_EMF_Exposure_Guideline_Oct21.pdf.

Jones, A.P. (1999). 'Indoor air quality and health', *Atmospheric Environment*, Vol. 33, No. 28, pp.4535–4564, https://doi.org/10.1016/S1352-2310(99)00272-1.

Kahneman, D., and Ritov, I. (1994). 'Determinants of stated willingness to pay for public goods: A study in the headline method', *Journal of Risk and Uncertainty*, Vol. 9, pp.5–37, https://doi.org/10.1007/BF01073401.

Mac Domhnaill, C., Douglas, O., Lyons, S., Murphy, E., and Nolan, A. (2022). 'Road traffic noise, quality of life, and mental distress among older adults: Evidence from Ireland', *Cities & Health*, Vol. 6, No. 3, pp.564–574, https://doi.org/10.1080/23748834.2022.2084806.

McConnell, D. (2020, April 14). 'Government: No link between spread of COVID-19 and roll out of 5G telephone masts', *Irish Examiner*, www.irishexaminer.com/news/arid-30993906.html.

McDermott, S. (2020, April 5). 'Mast destruction: How community opposition paved the way for the 5G coronavirus hoax', *TheJournal.ie*, www.thejournal.ie/5g-masts-destruction-coronavirus-hoax-5074056-Apr2020/.

Mohan, G., and Lyons, S. (2022). 'The association between *E. coli* exceedances in drinking water supplies and healthcare utilisation of older people', *Plos One*, Vol. 17, No. 9, e0273870, https://doi.org/10.1371/journal.pone.0273870.

Murphy, E., and King, E.A. (2022). *Environmental Noise Pollution: Noise Mapping, Public Health and Policy.* Elsevier: The Netherlands.

Nolan, A. (2023). 'The healthcare costs of poor air quality in Ireland: An analysis of hospital admissions', ESRI Working Paper No. 769, www.esri.ie/system/files/publications/WP769.pdf.

Nolan, A., and Hoy, A. (2023). 'Clean Air Together Dublin: Impact on air quality awareness, attitudes and behaviour', ESRI Survey and Statistical Series Report No. 120, https://doi.org/10.26504/sustat120.

Nsoesie, E.O., Cesare, N., Müller, M., and Ozonoff, A. (2020). 'COVID-19 misinformation spread in eight countries: Exponential growth modeling study', *Journal of Medical Internet Research*, Vol. 22, No. 12, e24425, https://doi.org/10.2196/24425.

Ó Ceallaigh, D., Timmons, S., Robertson, D., and Lunn, P. (2023). 'Measures of problem gambling, gambling behaviours and perceptions of gambling in Ireland', Economic and Social Research Institute (ESRI) Research Series No. 169, https://doi.org/10.26504/rs169.

Richardson, B., Sorensen, J., and Soderstrom, E.J. (1987). 'Explaining the social and psychological impacts of a nuclear power plant accident[1]', *Journal of Applied Social Psychology*, Vol. 17, No. 1, pp.16–36, https://doi.org/10.1111/j.1559-1816.1987.tb00290.x.

Saunders, R.D., Kowalczuk, C.I., and Sienkiewicz, Z.J. (1991). *Biological effects of exposure to non-ionising electromagnetic fields and radiation: III radiofrequency and microwave radiation* (No. NRPB-R--240), National Radiological Protection Board.

Siegrist, M., and Árvai, J. (2020). 'Risk perception: Reflections on 40 years of research', *Risk Analysis*, Vol. 40, No. S1, pp.2191–2206, https://doi.org/10.1111/risa.13599.

Slovic, P., Finucane, M.L., Peters, E., and MacGregor, D.G. (2013). 'Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk and rationality'. *The Feeling of Risk*, Slovic, P. (Ed.), Routledge: London.

Slovic, P., Fischhoff, B., and Lichtenstein, S. (2016). 'Cognitive processes and societal risk taking', *The Perception of Risk*, Slovic, P. (Ed.), Routledge: London.

Sunstein, C.R. (2003). 'Terrorism and probability neglect', *Journal of Risk and Uncertainty*, Vol. 26, pp.121–136, https://doi.org/10.1023/A:1024111006336.

Timmons, S., Papadopoulos, A., and Lunn, P.D. (2024). 'Survey instructions bias perceptions of environmental health risks', ESRI Working Paper 775.

Wiedemann, P.M., Freudenstein, F., Böhmert, C., Wiart, J., and Croft, R.J. (2017). 'RF EMF risk perception revisited: Is the focus on concern sufficient for risk perception studies?', *International Journal of Environmental Research and Public Health*, Vol. 14, No. 6, p.620, https://doi.org/10.3390/ijerph14060620.

Wilson, R.S., Zwickle, A., and Walpole, H. (2019). 'Developing a broadly applicable measure of risk perception', *Risk Analysis*, Vol. 39, No. 4, pp.777–791, https://doi.org/10.1111/risa.13207.

Zwick, M.M. (2005). 'Risk as perceived by the German public: Pervasive risks and "switching" risks', *Journal of Risk Research*, Vol. 8, No. 6, pp.481–498, https://doi.org/10.1080/1366987050006415.

APPENDIX

APPENDIX 1 SURVEY MATERIALS

Thank you for agreeing to participate in this study.

This part of the study is about how factors in the environment can affect our health. Some environmental factors can have an immediate impact, while other factors can contribute other long-term health conditions.

Before this part of the study begins, please list **here any environmental factors that you are aware of that can impact your health**. By this we mean anything potentially harmful that you can be exposed to in either your home, at work or in public spaces. If you don't know any, please feel free to say so.

[Open text boxes]

– next page –

Thank you for your responses so far. The next stage is a series of questions about different environmental risks. Please try to answer these questions as honestly as possible. There are no right or wrong answers.

Response Scales

[Environmental risks are: airborne chrolium, carbon monoxide, *E. coli*, EMFs, lead in drinking water, microplastics, nitrous oxide and particulate matter]

Daily relevance

How often in your daily life do you think about the potential health effects of:

[environmental risk]?

- 1-7 (Never – Every day)

Risk probability

How likely do you think it is that you will be exposed to harmful levels of:

[environmental risk]?

- 1-7 (Not at all likely – Very likely)

Risk severity

If you were to experience negative health effects from any of the following, how severe do you think they would be?

- 1-7 (Not at all severe – Very severe)

Affect towards environmental risk

How would you say [environmental risk] makes you feel?

- 1-7 (very positive – Very negative)

– next page –

The next section has 8 factual questions specifically about radiofrequency electromagnetic fields (RF EMFs). RF EMFs are emitted by mobile phones and broadcasting antennae (usually on masts and towers). We are interested in what the public knows about RF EMFs.

Some of the questions may be difficult, but we would like you to try your best to answer each one. If you don't know the answer, please select the option 'don't know'. For this task, you have the opportunity to be entered into a draw for a €100 Mastercard gift card. For every correct answer in this part of the study, you will receive an additional entry in the raffle.

– next page –

Which factor contributes the most to how much RF EMFs the average person in Ireland is exposed to?

- Telecommunication masts
- Mobile phone handsets
- Microwave ovens
- Laptops
- Televisions
- WiFi routers
- Don't know

Radio broadcasting antennae and mobile phone masts are in the same 'family' of EMFs.

- True
- False
- Don't know

How much does the level of radiofrequency EMF differ in public spaces across the country?

- The level of RF EMF is the same in all public spaces
- The level of RF EMF differs slightly across public spaces
- The level of RF EMF differs a lot across public spaces
- Don't know

RF EMFs can damage human cells, similar to other forms of radiation, like X-rays.

- True
- False
- Don't know

5G technology extends into higher frequencies, which have not been used in other common technologies yet.

- True
- False
- Don’t know

5G technology is a new form of RF EMF exposure that hasn’t previously been emitted in public.

- True
- False
- Don’t know

New technologies, such as 3G, 4G and 5G, have substantially increased the level of RF EMF in public spaces over time.

- True
- False
- Don’t know

The level of RF EMF in busy urban areas in Ireland is far below the suggested limits.

- True
- It depends on the area – some areas have much higher RF EMF than others
- False
- Don’t know

– next page –

In general, do you do anything to prevent or reduce your exposure to electromagnetic fields (EMFs)?

- Yes
- No

[If Yes:] Could you briefly write down these actions?

[open text response]

[Socio-demographics]

Whitaker Square,
Sir John Rogerson's Quay,
Dublin 2
Telephone **+353 1 863 2000**
Email **admin@esri.ie**
Web **ESRI.ie**
Linkedin **Economic & Social Research Institute (ESRI)**
X **@ESRIDublin**

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE