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Effects of selective outcome reporting on risk perception

F. Freudenstein [a,b,c,d,*], R.J. Croft [a,c,e], S.P. Loughran [a,c,e], B.M. Zeleke [b,c], P.M. Wiedemann [a,c,e]

[a] Australian Centre for Electromagnetic Bioeffects Research, Illawarra Health and Medical Research Institute, University of Wollongong, Wollongong, NSW, Australia
[b] Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, VIC, Australia
[c] Centre for Population Health Research on Electromagnetic Energy, Monash University, VIC, Australia
[d] Department of Risk Communication, German Federal Institute for Risk Assessment, Berlin, Germany
[e] School of Psychology, Faculty of the Arts, Social Sciences & Humanities, University of Wollongong, Wollongong, NSW, Australia

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ABSTRACT

The current study aimed to investigate how selective reporting of study results indicating increased health effects will influence its receiver's risk perception. Using the example of the Interphone Study from 2010 on mobile phone usage and cancer, an online experiment was conducted separating respondents into two groups. One group of subjects was informed selectively about a relationship between heavy mobile phone use and an elevated risk of glioma (brain cancer) only. The other group of subjects was informed about the full results of the analyses of glioma risk by cumulative call time, which suggests that other than for the heavy users, there were no statistically significant elevated risks related to mobile phone use. The results showed that selective reporting of risk information increased risk perception when compared to receiving the full information. Additionally, the selectively informed subjects revealed a stronger tendency towards overgeneralization of the 'elevated brain cancer risk' to all mobile phone users, although this did not extend to an overgeneralization to other electromagnetic field sources or differences in the perception of a usage time dependency for possible health risks. These results indicate that reporting of full results is an important factor in effective risk communication.

1. Introduction

For a well-founded decision on how to deal with personally relevant issues, people need reliable and understandable information. This is especially important when it comes to risk issues that might affect health. Therefore, it is crucial how a risk message is designed. Ideally, the presented information should be evidence-based (including correctness and completeness), as well as being accessible and understandable. However, there are several sources of potential errors in the building of a risk message, which can lead to misunderstandings. What people conclude from risk information may be influenced by reporting effects. For example, different presentation formats may lead to different perceptions (Gigerenzer et al., 2007). Furthermore, it matters how risks are compared (Covello, 1991; Englich et al., 2006) and framed (Freudenstein et al., 2020). Another issue is selective reporting, when parts of risk findings are highlighted, and others are hidden (Kardes and Sanbonmatsu, 2003). In scientific literature, this issue is addressed by the term 'outcome reporting bias'. The Centre for Evidence-Based Medicine defines this bias as 'The selective reporting of pre-specified outcomes' (Catalogue of Bias Collaboration, 2017). Similarly, according to the Cochrane bias methods group the 'Outcome Reporting Bias occurs when a study in which multiple outcomes were measured reports only those that are significant, ignoring those that were insignificant or unfavorable' (Cochrane Method Bias, 2020). It is one type of bias collectively referred to as 'reporting biases' that undermines the validity of evidence synthesis and the conclusions of systematic reviews (Page et al., 2019).

Empirical research indicates that selective reporting of findings is a widespread phenomenon that leads to biased conclusions. For instance, scientists tend to report their study results less rigorously in press releases than in scientific journals (Rothman et al., 2013). A subtle form of selective reporting happens when authors highlight solely their statistically significant findings in the discussion sections and their abstracts, with their particular messages stirring readers to biased conclusions (Dwan et al., 2013; McGauran et al., 2010). Thus, study findings get a spin. 'Spin' means to trigger inaccurate impressions of study outcomes that may result in misleading conclusions (Boutron and Ravaud, 2018).

* Corresponding author. German Federal Institute for Risk Assessment, Department of Risk Communication, Max-Dohrn-Straße 8-10, 10589, Berlin, Germany.
E-mail addresses: frederik.freudenstein@bfr.bund.de (F. Freudenstein), rcroft@uow.edu.au (R.J. Croft), loughran@uow.edu.au (S.P. Loughran), berihun.zeleke@monash.edu (B.M. Zeleke), pwiedema@uow.edu.au (P.M. Wiedemann).

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One example is to report the study findings in a dramatized way by focusing only on elevated risks or otherwise favored findings (Mahtani, 2016).

While the prevalence of the outcome reporting biases are well documented in medical research (Jones et al., 2015; Saini et al., 2014), there is only limited research on reporting biases in social science (Pigott et al., 2013). As far as we know, regarding risk perception, the effects of outcome reporting bias have not yet been studied.

A prominent issue where selective reporting might be studied concerns the health effects of electromagnetic field (EMFs) from mobile phones (cell phones). The EMF health controversy gained considerable public attention when the International Agency for Research on Cancer (IARC, an arm of the World Health Organization) evaluated EMFs from mobile phones as 'possibly carcinogenic to humans' (IARC, 2011). A crucial argument for this categorization came from the Interphone Study from 2010 (Cardis et al., 2010). The Interphone Study revealed that the risk[1] for brain tumors (i.e., the risk for glioma) was 40% higher compared to non-users. But that elevated risk was true for only one particular group of heavy mobile phone users (cumulative call time >1640 h). For all other mobile phone user groups, there was no elevated risk. For some user groups, there even was a protective effect as, e.g., for those with the second most frequent cumulative call time of 735 h–1639 h for mobile phone users, which had a 29% lower risk for glioma.

A sole focus on the statistically significant elevated glioma risk in the heavy mobile phone user group could create a biased picture of possible health risks for other mobile phone usage patterns. Indeed, this happened when IARC released a notice about its classification of RF EMFs. In this release, the elevated risk for heavy mobile phone users was highlighted. Even stating that the working group considered hundreds of scientific articles the effect was that most of the media reports focused on the risk increase based on one particular group in the Interphone Study and omitted the other findings (Freudenstein, 2012).

The current study aimed to test, for the first time, whether selective reporting affects the risk perception of RF EMF. Based on the Interphone study from 2010, we investigated whether providing only the information about the statistically significant increased risk of the heavy mobile phone user group resulted in higher, and an overgeneralized risk perception, in comparison to a comprehensive reporting that provided the risks for all user groups. From a psychological perspective, we were interested in two aspects of overgeneralization: First, whether selective risk reporting, i.e., focusing only on a single group (heavy users), was generalized to all other mobile phone users; Second, whether the elevated risk for heavy users was generalized to all other RF EMF applications such as WiFi (Wireless Fidelity) or mobile phone towers (base stations).

1.1. Hypotheses

Our empirical analysis was guided by the following four hypotheses:

Respondents just receiving information about the 40% risk increase for heavy mobile phone users (group G1), relative to respondents receiving comprehensive reporting of full study results (group G2) will:

Hypothesis 1:. ... perceive higher risks for heavy mobile phone users.

Rationale: As shown by Schwarz (2012), fluency of information processing due to its simplicity enhances the credibility of the information. We argue that this is the case for risk information given to group G1, but not for group G2. Hence, the selective information given to group G1 offers a more convincing base for an amplified risk perception.

Hypothesis 2. ... have higher scores with respect to the perception that all mobile phone users are at risk.

Rationale: Group G1 will be more inclined than group G2 to overgeneralize the single risk result concerning heavy mobile phone users because other findings do not challenge it. The subjects in group G1 perceive a salient risk (Lee et al., 2020). In contrast, the subjects in group G2 may recognize that the risk varies considerably depending on the frequency of using a mobile phone. Therefore, group G2 should be more cautious regarding a general conclusion for all mobile phone user groups.

Hypothesis 3. ... will perceive higher health risks of electromagnetic fields in general.

Rationale: Subjects who only get information about the risk of heavy mobile phone users will tend to overgeneralize the risk to RF EMF in general. This propensity to overgeneralization is due to the enhanced availability of the distinctive and unchallenged risk information in group G1 (Risen et al., 2007).

Hypothesis 4. ... will have lower scores in the belief that the usage time of mobile phones impacts the health risks.

Rationale: Group G2 should be better able to perceive a usage time dependency of the health risk than group G1. This is because fully informed subjects are capable of recognizing that only the most frequent users have an elevated risk. Yoon et al. (2020) reported a similar finding on the success of information-based debiasing interventions.

2. Methods

2.1. Sample

The professional survey company SSI (SSI; Shelton, CT, USA) conducted an online survey in 2017/2018 with a total of 769 participants from Australia using odds representative of the Australian public. SSI maintains a panel of people who regularly participate in research studies. Members of the panels were invited to participate in the study via email from the market research company. Additionally, participants could find the study by themselves when they logged onto the market research company's web platform. After quality control, 597 respondents' data remained for analysis (participants were excluded due to non-realistic response times, invalid answers to the current year and day of the week (as an indicator for respondents not reading the questions), not completing the questionnaire, and not accepting the consent to be included in the study. The mean age was approximately 46 years, (18–84 years) with 49% male, 50% female, and 1% other. The mean education of the respondents was 14.6 years. Regarding employment, most of the respondents were in paid work (52%, including employees, self-employed, working for the family business, and in community or military service), 20% retired, 7% of the respondents were unemployed, 5% were in education, and 15% in other working conditions, i.e., household, looking after children or other persons, permanently sick or disabled or specified in an additional text box). Regarding residence, 75% of the respondents lived in a big city or the suburb of a big city, 18% in a small town or city, and about 7% in a small village or countryside, see Table 1 for group specific distribution.

2.2. Procedure

A randomized 1-factorial design with 2 levels was used (for experimental setup see Fig. 1). The subjects were randomly assigned to one of the two groups before the start of the experiment. This random allocation means that known and unknown influencing or disruptive factors are distributed equally among the groups, so that differences between the groups are likely to be due to the intervention. On the landing page candidates were informed about what participation in the study involved and completed a consent form. A consent statement at the end

[1] Note that, as is common in epidemiological publications, the term 'risk' is used here to denote a statistical association that does not, in and of itself, infer that there is hazard.

Table 1
Distribution of socio demographic data per group. Age, sex, education, employment, and residence are indicated.

Variable	G1 (n = 298)	G2 (n = 299)
Age (years: M, R)	45.7, R = 18 - 82	46.1, R = 18 - 84
Sex (female %)	49.0%	51,8%
Education (years: M)	M = 14.9	M = 14.4
Employment (%)	Paid work = 55.0%	Paid work = 49.1%
	Retired = 19.1%	Retired = 21.7%
	Unemployed = 8.1%	Unemployed = 6.4%
	Education = 5.0%	Education = 5.0%
	Other = 12.8%	Other = 17.7
Residence (%)	Big city/suburb = 74.5%	Big city/suburb = 74.2%
	Small town = 19.1%	Small town = 17.4%
	Small village/countryside = 6.4%	Small village/countryside = 8.3%

G = Group; n = number of participants per G; Statistics in: % = percentage, M = mean or the R = range.

of the page asked participants to click a box if they consent to participate, which had to be 'checked' before the program allowed them into the questionnaire itself. Once confirmed they were provided with background information on RF EMF, namely:

"Being surrounded by sources of man-made EMF (electromagnetic fields) has become part of our daily lives. Such fields are created, for example, by using mobile phones, whose use has constantly increased over the past years. But, what effects might this exposure have on the human body? Addressing this question, in 2011 the International Agency for Research on Cancer (IARC) classified RF EMF (radiofrequency electromagnetic fields) as "possibly carcinogenic". A decisive scientific basis for this categorization was the Interphone Study from 2010. That research was conducted by the Interphone International Study Group, made up of 21 scientists, and included data from 13 countries around the world."

Thereafter study results from the Interphone Study 2010 (Cardis et al., 2010) were presented to participants including a text module and a table using the following experimental manipulations: Group 1 (G1) received selective information about heavy mobile phone users with a cumulative call time of more than 1640 h in the last 10 years and a resulting 40% increase of cancer risk. Group 2 (G2) received information about all results for all investigated categories of cumulative mobile phone usage times in the last 10 years reported by the Interphone Study. Exploratory text modules as well as tables showing the cumulative usage time, numbers of cases and controls as well as odds ratios (for better understanding translated into increase/decrease/no significant increase or decrease) were presented (see Table 2). To verify that the correct understanding of the text presented for the experimental variations was achieved, a comprehension check was used: "*Regarding the data presented, is there an increase of cancer risk for people who used their phone in the last 10 years for* ≥1640 hours?" (Yes/No) for group 1, and the same text but for all categories for G2: 5–12.9 h, 13–30.9, 31–60.9, 61–114.9, 115–199.9, 200–359.9, 360–734.9, 735–1639.9, ≥1640 h. Whenever an answer was given that was inconsistent with the study results provided, respondents got an error warning and had to read the study results (text module and table) and answer the question again: "*Your answer is wrong, please read the text again.*" Only after correctly interpreting the study results respondents were able to continue the survey, which resulted in a more time-consuming procedure for G2.

To measure the trustworthiness of the presented text respondents were asked: "*How trustworthy do you consider the presented information?*", using a 5-point Likert scale, from 1 = Not at all trustworthy, to 5 = Absolutely trustworthy. To investigate differences between the treatment groups, four dependent variables were tested: (1) Respondents' risk perception of heavy mobile phone usage was measured on a 4-point Likert scale using the following question, which included a pictorial description of the scenario: "*How dangerous do you consider using a cell phone (like the person pictured above) for 30 min per day over a 10-year period?*", from 1 = Not dangerous, to 4 = Very dangerous. The presented picture showed a person using the mobile phone for a voice call at the side of the head; (2) a question about the certainty to which they believed that all mobile phone users are at risk, i.e., for assessing overgeneralization with respect to all user groups: "*How confident are you that **all** cell phone users are at risk?*", on a scale from 0 to 100, with 0 = I am 0% confident that **all** cell phone users are at risk and 100 = I am 100% confident that **all** cell phone users are at risk; (3) an item created to measure general EMF risk perception, i.e., the overgeneralization from mobile phones to all EMF sources :"*How concerned are you about the potential health risks of electromagnetic fields in general*", from 1 = Not at all concerned, to 4 = Very concerned; and (4) a question about the belief in dependency of the risk on usage time: "*How confident are you that the potential health effects caused by mobile phones are dependent on the usage time?*", on a scale from 0 to 100, with 0 = I am 0% confident that the potential health effects caused by mobile phones are dependent on the usage time and 100 = I am 100% confident that the potential health effects caused by mobile phones are dependent on the usage time.

G1, who received incomplete information about the Interphone Study results, received full information (that which G2 received) in a short debriefing at the end of the survey.

2.3. Statistical analyses

All statistical analyses were conducted with IBM SPSS (Statistical Package for the Social Sciences, V26, Armonk, New York). A MANOVA was used, testing for differences between G1 and G2 in the combined dependent variables score, and for group differences in each of the single dependent variables (one-tailed). Risk perception of heavy mobile phone usage, risk perception of all mobile phone users, risk perception of potential health effects of EMF in general and the belief in dependency of the risk on the usage time were used as dependent variables. A *t*-test was used, investigating possible differences in trust in the presented information between G1 and G2. To avoid misleading results regarding trust in the presented information, the MANOVA was double-checked using trust in the presented information as a covariate. Descriptive statistics are presented as means and standard deviations. For all analyses, $p < 0.05$ was considered statistically significant. Due to the justified critique on the misuse of significance tests (Greenland et al.,

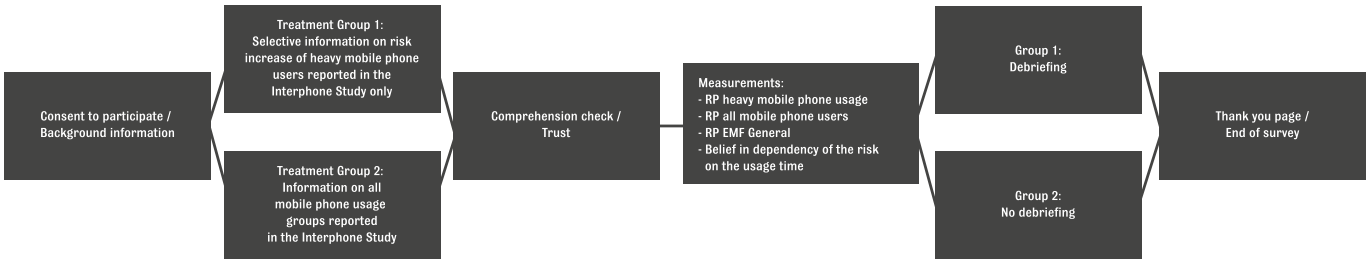

Fig. 1. Overview of experimental setup
RP = risk perception, EMF = electromagnetic fields.

Table 2
Additional text modules provided to respondents after the background information, for the different groups.

<table>
<tr><th>Group</th><th>Module</th></tr>
<tr><td>G1 (selective information)</td><td>Please read the following text carefully:
The Interphone study from 2010 suggests a 40% increased risk of glioma (brain cancer) for heavy cell phone users with a cumulative call time of more than 1640 hours in the last 10 years. This is displayed in the following table:
<table>
<tr><th>Cumulative call time with no hands-free devices (h)</th><th>Cases</th><th>Controls</th><th>Result</th></tr>
<tr><td>≥1640 h</td><td>210</td><td>154</td><td>40% increase of cancer risk</td></tr>
</table>
h=number of hours device was used
Cases=number of people with glioma
Controls=number of people without glioma</td></tr>
<tr><td>G2 (full information)</td><td>Please read the following text carefully:
The Interphone study from 2010 suggests a 40% increased risk of glioma (brain cancer) for heavy cell phone users with a cumulative call time of more than 1640 hours in the last 10 years.
The 40% risk increase found in this study was only for this particular group of heavy users. For most other cumulative usage time groups there was no significant increase, or even a ‘protective effect’ for regular mobile phone use, i.e., less proportion of glioma patients in phone users compared to non-users. See the following table:
<table>
<tr><th>Cumulative call time with no hands-free devices (h)</th><th>Cases</th><th>Controls</th><th>Result</th></tr>
<tr><td>Never regular user</td><td>1042</td><td>1078</td><td>-</td></tr>
<tr><td><5 hours</td><td>141</td><td>197</td><td>30% decrease of cancer risk</td></tr>
<tr><td>5-12.9 h</td><td>145</td><td>198</td><td>29% decrease of cancer risk</td></tr>
<tr><td>13-30.9 h</td><td>189</td><td>179</td><td>no significant increase or decrease</td></tr>
<tr><td>31-60.9 h</td><td>144</td><td>196</td><td>26% decrease of cancer risk</td></tr>
<tr><td>61-114.9 h</td><td>171</td><td>193</td><td>no significant increase or decrease</td></tr>
<tr><td>115-199.9 h</td><td>160</td><td>194</td><td>27% decrease of cancer risk</td></tr>
<tr><td>200-359.9 h</td><td>158</td><td>194</td><td>no significant increase or decrease</td></tr>
<tr><td>360-734.9 h</td><td>189</td><td>205</td><td>no significant increase or decrease</td></tr>
<tr><td>735-1639.9 h</td><td>159</td><td>184</td><td>29% decrease of cancer risk</td></tr>
<tr><td>≥1640 h</td><td>210</td><td>154</td><td>40% increase of cancer risk</td></tr>
</table>
h=number of hours device was used
Cases=number of people with glioma
Controls=number of people without glioma</td></tr>
<tr><td>All Groups</td><td>Important: In the table you see the result from the Interphone study as published in 2010. The study compared the chance of getting cancer for people using a phone compared to people not using a phone regularly.</td></tr>
</table>

2016), we prefer a cautious interpretation of statistically significant findings by considering also the effect sizes. Effect sizes were calculated as η^2 where 0.01 = small, 0.06 = medium and 0.14 = large effects (Cohen, 1988).

3. Results

A one-way MANOVA with four dependent variables (Risk perception (RP) mobile phone heavy usage, RP all mobile phone users, RP EMF General, Belief in dependency of the risk on the usage time) differed between the two groups (G1 respondents just receiving the information about the heavy mobile phone usage group, i.e., >1640 h cumulative phone time and G2 who received full study results) Wilks $\lambda = 0.957$, $F(4, 592) = 6{,}62$, $p < 0.001$, partial $\eta^2 = 0.04$.

In detail, group differences for each hypothesis showed the following results: The Hypothesis 1 that the group G1 (selective information) perceived higher risk of heavy mobile phone usage, compared to G2 (receiving full study results) was supported (RP mobile heavy usage: $F(1, 595) = 14.57$, $p < 0.001$).

The Hypothesis 2 concerning the overgeneralization effect that G1 (selective information) has higher confidence that all mobile phone users are at risk compared to G2 (full information) was supported (RP all mobile phone users: $F(1, 584.64) = 14.80$, $p < 0.001$).

The Hypothesis 3 regarding the overgeneralization effect that G1 is more concerned than G2 about the health risks of EMF in general, was not supported (General EMF RP: $F(1, 595) = 2.70$, $p = 0.051$).

The Hypothesis 4 that G1 assesses lower influence of the usage time on potential health risks of mobile phones compared to G1 was also not supported (Belief in dependency of the risk on the usage time: $F(1, 595) = 0.07$, $p = 0.395$), effect sizes for all hypotheses were rather low, see Table 3, and Fig. 2.

To investigate respondents’ trust in the presented information, the two groups were compared regarding their subjective evaluations of trust in the information provided. G1 had statistically significant higher trust in the presented information than Group G2 ($t(595) = 5.4$, $p < 0.001$, G1: mean (M) = 3.35, standard deviation (SD) = 0.88; G2: M = 2.94, SD = 0.96, effect size (η^2) = 0.05), see Fig. 3.

Therefore, an additional MANOVA with trust as a covariate was calculated. It turned out that controlling for trustworthiness did not affect the results (RP all mobile phone users: $F(1, 595) = 6.93$, $p = 0.009$; RP Mobile Phone: $F(1,595) = 5.47$, $p = 0.020$; General EMF RP: $F(1, 595) = 0.145$, $p = 0.704$; Belief in dependency of the risk on the usage time: $F(1, 595) = 1.97$, $p = 0.161$).

4. Discussion

The presented study analyzed whether selective reporting of risk information affects risk perception. The results indicate that provision of selective information relating to health risks of exposure to RF EMF leads to increased and overgeneralized risk perceptions.

The fist finding showed that subjects who were only informed about an elevated risk for heavy mobile phone usage perceived higher risks for that user group than subjects who also received information that the risk for other mobile phone user groups is not elevated. One possible

Table 3
Descriptive and inferential statistics for the variables assessed are shown, where G1 represents the respondents who received selective information about heavy cell phone users only, and G2 those who received full study results.

	G1 (selective info) n = 298	G2 (full info) n = 299	ANOVA	partial η^2
RP heavy mobile phone usage	M = 2.65 SD = 0.77	M = 2.41 SD = 0.79	F(1, 595) = 14.57 p < 0.001	0.03
RP all mobile phone users	M = 55.17 SD = 25.76	M = 46.45 SD = 29.55	F (1, 584.64) = 14.80 p < 0.001	0.02
RP EMF General	M = 2.63 SD = 0.80	M = 2.52 SD = 0.77	F (1, 595) = 2.70 p = 0.051	0.01
Belief in dependency of the risk on the usage time	M = 67.40 SD = 25.34	M = 66.82 SD = 27.54	F (1, 595) = 0.07 p = 0.395	<0.01

Dependent variables: (1) RP heavy mobile phone usage ('How dangerous do you consider using a cell phone for 30 min per day over a 10-year period'), (2) RP all mobile phone users ('How confident are you that all cell phone users are at risk?'), (3) RP EMF General ('How concerned are you about the potential health risks of electromagnetic fields in general?'), (4) Belief in dependency of the risk on usage time ('How confident are you that the potential health effects caused by mobile phones are dependent on the usage time?'), M = mean; SD = standard deviation; G = Group; n = number of participants per G, partial η2 = effect size, ANOVA = analysis of variance, F = test statistics, p = significance level (one-tailed).

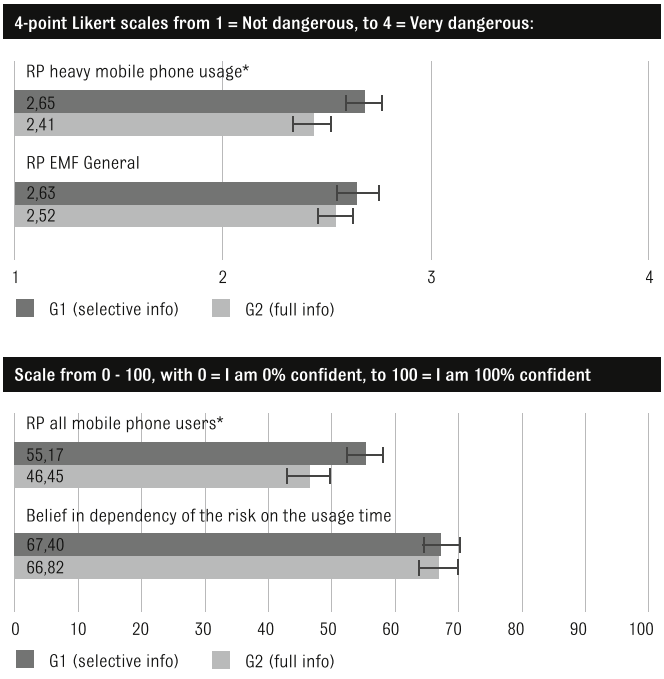

Fig. 2. Group differences for the variables assessed. G1 represents the respondents who received selective information about heavy cell phone users only, and G2 those who received full study results. Dependent variables: (1) RP heavy mobile phone usage ('How dangerous do you consider using a cell phone for 30 min per day over a 10-year period'), (2) RP all mobile phone users ('How confident are you that all cell phone users are at risk?'), (3) RP EMF General ('How concerned are you about the potential health risks of electromagnetic fields in general?'), (4) Belief in dependency of the risk on usage time ('How confident are you that the potential health effects caused by mobile phones are dependent on the usage time?'). G = Group. Error Bars: 95% confidence interval, * = p < 0.05.

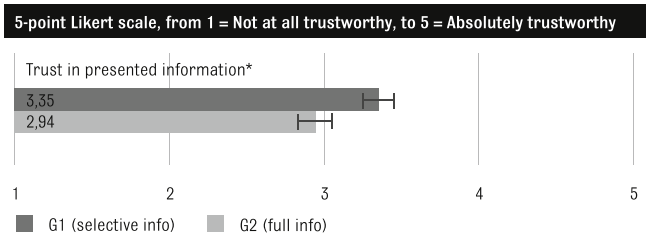

Fig. 3. Trust in presented information. G1 represents the respondents who received selective information about heavy cell phone users only, and G2 those who received full study results.
G = Group. Error Bars: 95% confidence interval. 5-point Likert scale, from 1 = Not at all trustworthy, to 5 = Absolutely trustworthy, * = p < 0.05.

explanation for this difference refers to metacognitive experiences, i.e., experiences that accompany information processing. This means that because concise and salient (i.e., highlighted) information is easy to grasp (the metacognitive experience) it is therefore judged as more credible and viewed as more reliable (Greifeneder and Schwarz, 2014). This was likely the case for subjects who received only selective information on brain cancer risks because it provided a simple and clear picture. They, therefore, tended to have higher risk perceptions than the fully informed subjects.

The second finding refers to an overgeneralization of the risk of heavy mobile phone users to all mobile phone users. We assume that the metacognitive experiences - triggered by the focused information about an elevated risk for the heavy user group - pushed people to make generic generalizations. In this particular case, they strengthened the belief that all mobile phone users are at risk.

The third finding alludes to the effects of selective risk reporting on the generalization to other RF EMF exposure sources, including such applications as WiFi or base stations. However, our findings could only indicate a (statistically non-significant) trend towards higher risk perceptions for respondents receiving the information about the heavy user group only. Further research is needed to clarify this issue. One possible explanation of the lack of a clear difference between the groups G1 and G2 could be that both groups were informed that the IARC classification refers to RF EMF in general and not RF EMF from cell phones only (see background information).

Finally, we failed to find differences between fully and selectively informed subjects regarding the perception of whether the duration of mobile phone usage affects health risks. The subjects who received information on how the risks differ depending on the duration of using a mobile phone were not better able to detect any time dependency (i.e., the impact of the duration of exposure) than subjects who received only selective information about an elevated risk. A possible explanation for difficulties in discerning a clear pattern in this dependency could be explained by the fact that there is no linear relationship between duration of mobile phone use and the level of risk in the Interphone Study findings, which were presented to the fully informed subjects (see Table 1). However, it also could be that a better explanation of the underlying issue could have had a more substantial impact on the answers to the question about the exposure time dependency.

A possible limitation of our study refers to the relatively small effect sizes of our experimental variation, i.e., the effects of selective versus full reporting on the chosen risk perception variables. However, without appropriate norms derived from distributions of effect sizes of comparable studies, it isn't easy to give a substantial and fair interpretation of the given effect sizes (Funder and Ozer, 2019). Therefore, the research

context counts: Considering that selective outcome reporting is viewed as a deviation from good study reporting (Moher et al., 2014), even a rather moderate effect size does not speak against a risk communication practice that gives a comprehensive picture of full study results and helps to develop more appropriate risk perceptions. Furthermore, it is worthwhile to consider our findings in the context of the previous research. Other studies have revealed that non-experts have difficulties assessing and comparing the exposure for various RF EMF sources. When people are not aware about their actual level of personal exposure to RF EMF and are not adequately informed about the conditions this may lead to biased risk perception (Ramirez-Vazquez et al., 2019; Zeleke et al., 2019). It seems that these difficulties may have contributed to the effects we have found in our present study. When people don't know that the strength of RF EMF exposure is decisive for the magnitude of a related heath risk, and they are not informed about it either, then they tend to overgeneralize available findings.

Overall, the current study applied for the first time an experimental approach to investigate reporting bias and its effects on risk perception using the example of RF EMF. Insights from this study can be used in creating new study designs for evidence-based communication and for improving current risk communication guidelines.

5. Conclusions

Our study adds empirical support to the frequently voiced warnings about selective outcome reporting (Dwan et al., 2013; Higgins et al., 2020). We could indicate that this malpractice distorts risk perception. More precisely, an outcome reporting bias in favor of an elevated risk pushes towards elevated risk perceptions across all exposure groups.

The challenge of designing risk communication messages is to avoid triggering those distorted perceptions about health risks that emerge from focusing only on data indicating an elevated risk. Instead, the whole range of study results should be made available and properly explained. This may also include a variety of presentation formats to adequately inform the audience, as various target groups need different types of information.

In particular, we suggest that further risk communication research should be conducted on how to deal with information disorder as well as how to correct biased beliefs (see Farrell et al., 2019; Lazer et al., 2017; van der Meer and Jin, 2020). In practice this means that public communications of scientific bodies should scrutinize their messages for any misleading reporting of results, particularly in terms of potential selectivity of reporting.

Author contribution

Freudenstein, F.: contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript, Croft, R.J.: contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript, Loughran, S.P.: contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript, Zeleke, B.M.: contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript, Wiedemann, P.M.: contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript

Ethics

The study was approved by the University of Wollongong Human Research Ethics Committee (HE: 2017/172).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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