Letter to the Editor

Do People Understand IARC's 2B Categorization of RF Fields From Cell Phones?

Peter M. Wiedemann,[1] Franziska U. Boerner,[1]* and Michael H. Repacholi[2]

[1]Karlsruhe Institute of Technology (KIT), Institute for Technology Assessment and Systems Analysis (ITAS), Science Forum EMF, Berlin, Germany
[2]Department of Information Engineering, Electronics and Telecommunications (DIET), University of Rome "La Sapienza", Roma, Italy

In May 2011, the International Agency on Cancer in Research (IARC) issued an official statement concluding that cell phone usage was "possibly carcinogenic to humans." There have been considerable doubts that non-experts and experts alike fully understood what IARC's categorization actually meant, as "possibly carcinogenic" can be interpreted in many ways. The present study is based on an online survey indicating that both the characterization of the probability of carcinogenicity, as well as the description of the risk increase given in the IARC press release, was mostly misunderstood by study participants. Respondents also greatly overestimated the magnitude of the potential risk. Our study results showed that IARC needs to improve their scientific communications. Bioelectromagnetics. © 2014 Wiley Periodicals, Inc.

Key words: risk assessment; mobile phones; risk communication; IARC; health risk

"Mobile phones may cause cancer, warn world health chiefs: After years of contradictory claims, an authoritative verdict." This and similar news headlines were published in May 2011 after the International Agency for Research on Cancer (IARC) issued their official report, concluding that cell phone usage was "possibly carcinogenic to humans" [Baan et al., 2011]. Given that there are over 6 billion cell phone subscriptions [ITU, 2011], IARC's scientific report and press release have been analyzed and reanalyzed as people tried to understand what "possibly carcinogenic" means and whether they should really be worried about using their cell phones [IARC, 2011]. While IARC carefully assessed the available scientific evidence on radio-frequency (RF) fields, there are doubts that non-experts, and even experts, fully understood what IARC's categorization actually meant, as "possibly carcinogenic" can be interpreted in many ways [IARC, 2013]. Also, in many languages, the difference between "possibly carcinogenic" (2B) and "probably carcinogenic" (2A) either does not exist or is difficult to explain.

IARC is an international agency for cancer research, not a public health agency. Therefore, the categorizations made regarding human carcinogens were not supposed to be interpreted as public health messages, as they have been used recently. IARC classifies the strength of scientific evidence about the carcinogenicity of an agent [IARC, 2006]. IARC's classification was originally meant to be part of a post-market surveillance of agents to determine whether there was enough evidence to conclude that the agents are carcinogens or whether more research was needed to assess their carcinogenicity. In the health risk assessment process, IARC conducts the first step, hazard identification, and provides information towards a full assessment of health risks by national

Grant sponsor: 7th framework program for research of the European Union and the German Telekom.

Conflicts of interest: The Science Forum EMF, founded by Peter Wiedemann, is a project of the Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT), a member of the Helmholtz Association of German Research Centres.

*Correspondence to: Franziska U. Boerner, Karlsruhe Institute of Technology (KIT), Institute for Technology Assessment and Systems Analysis (ITAS), Science Forum EMF, Anna-Louisa-Karsch-Str. 2, 10178 Berlin, Germany.
E-mail: franziska.boerner@kit.edu

Received for review 10 July 2013; Accepted 4 February 2014

DOI: 10.1002/bem.21851
Published online XX Month Year in Wiley Online Library (wileyonlinelibrary.com).

authorities or the World Health Organization's [WHO] International EMF Project for electromagnetic fields.

IARC's Group 1 is the category for agents assessed to be "carcinogenic to humans." For Group 1 carcinogens, there must be sufficient scientific evidence of carcinogenicity in humans (epidemiology studies) or less than sufficient evidence in humans, but sufficient evidence in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity. Agents categorized in Group 2 are at two extremes. If the degree of evidence is judged as "almost sufficient in humans (limited evidence) and sufficient in animals," agents are categorized as Group 2A or "probably carcinogenic to humans." If the scientific evidence is of lesser strength than required for 2A, then agents can be categorized as Group 2B, "possibly carcinogenic to humans." Thus, 2B is used when there is limited evidence in humans and less than sufficient evidence in animals. The main point is that IARC uses qualitative terms to categorize the degree of evidence available, but when used without a clear definition, the meaning of these terms can be lost or misunderstood.

Many health and science literacy studies indicate that non-experts have difficulty understanding and interpreting qualitative, non-numeric probability statements such as "possibly," "probably," or "likely" [Bergenstrom and Sherr, 2003; Berry et al., 2003]. In an earlier study, it was suggested that qualitative expressions of uncertainty elicit high individual estimates of uncertainty [Lichtenstein and Newman, 1967]. Other studies concluded that qualitative probability expressions are characteristically vague, with high between-subject and within-subject variability [Beyth-Marom, 1982; Budescu and Wallsten, 1985; Hamm, 1991]. Similarly, there are difficulties in the interpretation of percentages and reference terms for risk and hazard information (i.e., 20% higher risk). Studies suggest that people generally have low numeric capabilities. Such a lack in skill may lead to gross misinterpretations of numeric and probabilistic risk expressions [Gigerenzer et al., 2005; Gigerenzer et al., 2007; Visschers et al., 2009; Fraukje et al., 2010]. These findings motivated us to conduct a study focussing on how non-experts understand the information given in the IARC press release issued in June 2011.

Using Survey Monkey (Palo Alto, CA), an online survey consisting of 13 questions was conducted in April 2012. Information about this on-going survey and the opportunity to participate was made available to all 27,000 students of the University of Innsbruck in Austria. A total of 2,013 students with a mean age of 24.5 years participated, with 66% of the respondents being female and 34% male. The students were from a wide variety of academic disciplines, and participation was anonymous and voluntary. The survey used parts of the original IARC [2011] press release as stimulus material. Participants were instructed to read the text from the original IARC press release: "The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as *possibly carcinogenic to humans (Group 2B)*, based on an increased risk for *glioma*, a malignant type of brain cancer associated with wireless phone use. The IARC [2011] did not quantitate the risk; however, one study of past cell phone use (up to the year 2004), showed a 40% increased risk for gliomas in the highest category of heavy users (using their phones for 30 min per day over a 10-year period)."

They were then asked to express their own opinion about the risk of getting brain cancer from cell phones using the 5-point Likert-scale. Finally, they answered 13 short questions requiring, on average, about 5 min to answer.

We were especially interested in two questions: How do respondents interpret the expression "possibly carcinogenic" and how do they understand what is meant by a 40% increase in risk? The first question was evaluated by asking the respondents to express their degree of confidence that a carcinogenic effect would actually occur from cell phone use. Participants then had to identify the meaning of the "40% risk increase" by choosing one of five options. Finally, respondents answered questions about the reference group from which the risk increase among heavy users was calculated.

The readability of the IARC text passage received good marks. On average, our respondents perceived the text as clear, simple, and understandable. Figure 1a shows how respondents interpreted the qualitative probability expression "possibly carcinogenic." Judgments on confidence about the risk and the possible occurrence of a carcinogenic effect from cell phones were gathered using a Likert-scale ranging from 0 to 100 (0 = no confidence; 100 = 100% confident). Figure 1a shows that the expression "possibly carcinogenic" has a variety of meanings among participants. Within the 90% confidence interval, 50% of the numerical interpretations of "possibly carcinogenic" are within the box where the median numerical interpretation is 30.

Figure 1b suggests that at least some of the interpretations of the qualitative probability expression can be explained by pre-existing risk perceptions since, the higher the risk perception, and the higher the degree of confidence that a carcinogenic effect occurs. A between-groups ANOVA indicates that the differ-

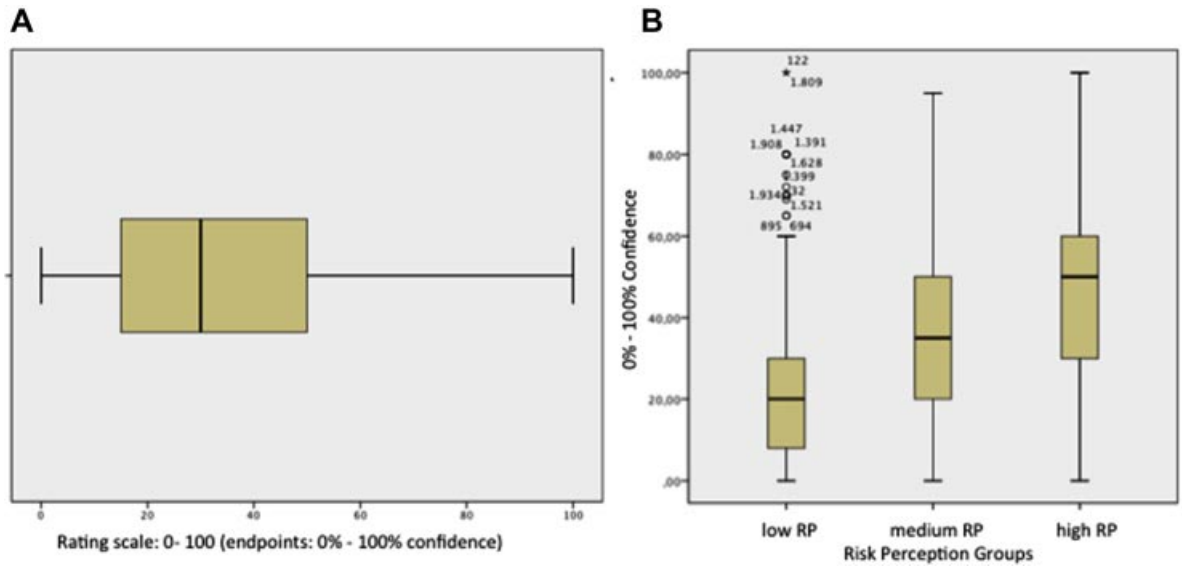

Fig. 1. Numerical interpretation of "possibly carcinogenic" on 100-point Likert-scale. **A**: Median numerical interpretation. **B**: Median numerical interpretation three risk perception groups.

ences between the confidence judgments in the three risk perception groups are significant ($F = 151, 47$, $P < .001$, $\text{Eta}^2 = 0.142$). Post hoc t-tests also revealed significant differences between all three groups ($P < .001$).

Our second topic refers to the interpretation of the term "40% risk increase" in brain cancer. We asked, "What does a 40% risk increase mean?" and "How many additional cases will suffer from cancer?" Respondents could choose between five answers (1) 1 in 4, (2) 4 in 10, (3) 4 in 100, (4) 1 in 40, and (5) a number >0. As shown in Figure 2, the majority of respondents interpreted a 40% risk increase as 4 in 10. The correct answer depends on the baseline, that is, the normal brain cancer incidence in the population studied. Since IARC does not present any baseline information, a number >0, is the only meaningful answer to the information provided from Text 1. Figure 2 shows that only about 10% of the respondents picked the correct category ($N > 0$).

Finally, in order to quantify the risk, we asked the subjects about the reference group to which the group of heavy cell phone users was compared. They could make a choice between three groups: non-users, infrequent users, and the general population. Only a small minority of the survey participants (13%) answered correctly, selecting "non-users." When it came to the extrapolation of findings, the majority of respondents (64%) believed that the 40% risk increase refers to each heavy user of cell phones and not just to the average person in the heavy user group, which would have been the correct interpretation.

Even as our results are based on a non-randomized online survey using a student population, our survey data indicate that both the characterization of the probability of carcinogenicity and description of the risk increase given in the IARC press release are likely to be misunderstood by educated non-experts (university students with a social and natural science background). Taking these results into account, it is reasonable to assume it may be even more difficult for the general public to understand IARC information. However, we cannot exclude the occurrence of a

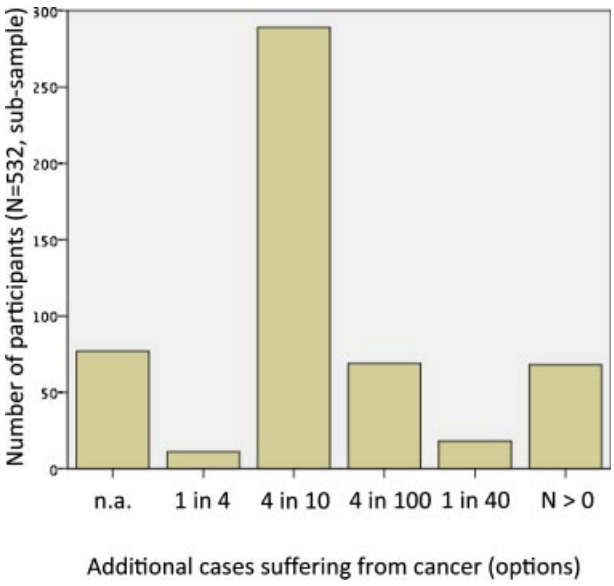

Fig. 2. Interpretation of the statement "40% risk increase."

sampling bias because we have no information about the non-responders in our survey. In addition, we have to be cautious about extrapolating the findings from the student population to the general public without additional evidence from a representative sample.

In sum, (1) the study indicates that the numerical values assigned to the qualitative probability term "possibly carcinogenic to humans" varied widely across our participant sample. (2) In line with available evidence [Gigerenzer et al., 2007], our results show that the provision of relative risks leads to a higher risk perception. Thus, both key messages of the IARC press release trigger biased estimations and misunderstandings about the RF risk potential.

Taking into account IARC's mission of "producing evidence-based science for global cancer control policies," using terms that lead to misinterpretation and misunderstanding does not assist in conveying their policy. Both good science and scientific communication are essential to fulfil its mission. This leads to the question of how to improve the communication of IARC's core messages on its carcinogenicity assessments to non-experts. As stated above, a crucial issue is to understand the qualitative probability terms used by IARC in a way that clearly describes IARC's conclusions about the strength of the scientific evidence on whether or not an agent is carcinogenic. Furthermore, the statement "40% risk increase" should be made clearer, with the need for a baseline to properly describe the actual increase in risk of cancer from an agent. The latter task can be solved easily by providing baseline information. The relative risk statement should be strengthened by information on the incidence rate expressed as the number of new cases per unit of population per year. Given that the incidence of adult glioma is approximately 4.7 per 100,000 persons a year, a 40% increase in risk would mean an additional 1.9 cases of glioma per 100,000 people each year.

The issue of communicating the IARC category "possibly carcinogenic for humans" is not as easily resolved. The first step towards better communication could be to provide quantitative information, for example, by giving a number or range of percentages to these verbal probability phrases, as the International Panel on Climate Change (IPPC) has done for risks of climate change [IPCC, 2005]. Adding numerical values can help overcome the vagueness of qualitative terms [Budescu et al., 2009], at least to some degree. Additional information is required to help people interpret the probability expressions ("possibly" or "probably"). This could be done by offering comparisons with other substances in the same category or by explaining the classification system and noting that 2B is located between "probably carcinogenic" and "not classifiable as to its carcinogenicity to humans." Thus, IARC's "possibly carcinogenic to humans" can be characterized as the weakest classification category still indicating that a carcinogenic effect is possible.

From a communication perspective, it can be argued that people understand the world in a narrative framework [Akerlof and Shiller, 2009; Wilson, 2011; Bruine de Bruin and Bostrom, 2013]. Therefore, it might be useful to construct a narrative that supports the understanding of the 2B category. A good 2B narrative should address the issues of who, why and what follows from the 2B classification. The "who" refers to the need to characterize the authors of the classification. The key issue here is that the credibility of the classification of RF fields depends on trust in the process and in the people who conducted the classification. There should be some concern that there are working group members who are the very researchers assessing the quality of their own studies. This would be a reason for people to question the credibility of the classification. A solution to this credibility issue for IARC could be to more thoroughly determine and account for the various potential conflicts of interest and to search for potential working group members without such conflicts. An example could be to select working group members who are not involved in the EMF field to conduct a truly independent review.

The "why" refers to the main arguments on which the 2B-classification is based. IARC's 2B classification is primarily based on two epidemiology studies indicating an increased risk of glioma [Hardell et al., 2009; Interphone Study Group, 2010]. The Interphone Study noted that: "Overall, no increase in risk of glioma or meningioma was observed with use of mobile phones. There were suggestions of an increased risk of glioma at the highest exposure levels, but biases and error prevent a causal interpretation." IARC claims this is a positive study according to their definition when the study authors do not. This is a credibility issue. This existing ambiguity in the 2B-evidence base opens IARC's classification to contrasting interpretations and opinions. From a communications standpoint, it is necessary to clearly and transparently inform about the pro and contra arguments for the classification based on the selected evidence. The other positive study [Hardell et al., 2009] was clearly demonstrated [Ahlbom et al., 2009] to be an outlier compared with the majority of other epidemiological studies. While IARC's definition of 2B was technically complied with, because two epidemiology studies showed positive results, there is considerable doubt about the interpretation of what is a positive effect.

The "what follows" is especially relevant. People like to know whether actions should be taken or not, and if so, which ones. Thus, it is incumbent upon IARC to state clearly whether there is any need for concern besides the recommendation for more research to clarify the carcinogenic status of RF. While IARC is not an agency that provides recommendations about health risk, the agency should merely indicate the type of research still needed to make more definitive conclusions about the strength of the scientific evidence. A more radical way to improve IARC's communication would be a new approach to the classification of the evidence of indicating different levels of carcinogenicity. For instance, Leitgeb [2012] described a more elaborated classification approach developed by the German Commission of Radiation Protection. It can certainly be argued that the German approach is a step forward to overcome existing weaknesses in classifying evidence for carcinogenicity. Nevertheless, even this approach does not automatically lead to better communication with the general public.

The central message of the present study is that IARC needs to improve their current scientific communications, and in doing so, keep within its mandate vis-à-vis its parent WHO. We believe that focusing, for example, on adding a quantitative explanation to verbal probability expressions or using comparisons and narratives could help to ensure that everyone understands the state of the scientific findings and their underlying uncertainty. This may also enable all parties to draw the necessary conclusions for future health policy activities.

ACKNOWLEDGMENTS

The Science Forum EMF is supported by third-party funds. At present, funds are provided by the 7th framework program for research of the European Union and the German Telekom. The present study was not funded by the mobile communication industry.

REFERENCES

Ahlbom A, Feychting M, Green A, Kheifets L, Savitz D, Swerdlow A. 2009. Epidemiologic evidence on mobile phones and tumor risk: A review. Epidemiology 20:1–14.

Akerlof GA, Shiller RJ. 2009. Animal spirits: How human psychology drives the economy, and why it matters for global capitalism. Princeton, NJ: Princeton University Press.

Baan R, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, Guha N, Islami F, Galichet L, Straif K, WHO International Agency for Research on Cancer Monograph Working Group. 2011. Carcinogenicity of radiofrequency electromagnetic fields. Lancet Oncol 12:624–626.

Bergenstrom A, Sherr L. 2003. The effect of order of presentation of verbal probability expressions on numerical estimates in a medical context. Psychol Health Med 8:391–398.

Berry DC, Raynor DK, Knapp P, Bersellini E. 2003. Patients' understanding of risk associated with medication use: Impact of European Commission guidelines and other risk scales. Drug Safety 26:1–11.

Beyth-Marom R. 1982. How probable is probable? A numerical translation of verbal probability expression. J Forecast 1:257–269.

Bruine de Bruin W, Bostrom A. 2013. Assessing what to address in science communication. Proc Natl Acad Sci USA 110:14033–14039.

Budescu DV, Broomell S, Por HH. 2009. Improving communication of uncertainty in the reports of the intergovernmental panel on climate change. Psychol Sci 20:299–308.

Budescu DV, Wallsten TS. 1985. Consistency in interpretation of probabilistic phrases. Organ Behav Hum Decis Process 36:391–405.

Fraukje EF, Mevissen RM, Meertens RA, Ruiter RA, Schaalma HP. 2010. Testing implicit assumptions and explicit recommendations: The effects of probability information on risk perception. J Health Commun 15:578–589.

Gigerenzer G, Gaissmaier W, Kurz-Milcke E, Schwartz LM, Woloshin S. 2007. Helping doctors and patients to make sense of health statistics. Psychol Sci Public Interest 8:53–96.

Gigerenzer G, Hertwig R, Van Den Broek E, Fasolo B, Katsikopoulos KV. 2005. A 30% chance of rain tomorrow": How does the public understand probabilistic weather forecasts? Risk Anal 25:623–629.

Hamm RM. 1991. Selection of verbal probabilities: A solution for some problems of verbal probability expression. Organ Behav Hum Decis Process 45:1–18.

Hardell L, Carlberg M, Hansson Mild K. 2009. Epidemiological evidence for an association between use of wireless phones and tumor diseases. Pathophysiology 16:113–122.

Intergovernmental Panel on Climate Change. 2005. Guidance notes for lead authors of the IPCC fourth assessment report on addressing uncertainties [Internet]. Geneva, Switzerland: Intergovernmental Panel on Climate Change. Available from: https://www.ipcc-wg1.unibe.ch/.../uncertainty-guidance-note.pdf. Accessed October 17, 2013.

International Agency for Research on Cancer. 2006. IARC Monographs on the evaluation of carcinogenic risks in humans [Internet]. Lyon, France: International Agency for Research on Cancer. Available from: http://monographs.iarc.fr/ENG/Preamble/CurrentPreamble.pdf. Accessed October 16, 2013.

International Agency for Research on Cancer. 2011. IARC classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans [press release]. Lyon, France: International Agency for Research on Cancer. Available from: http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf. Accessed October 20, 2013.

International Agency for Research on Cancer. 2013. Non-ionizing radiation, Part 2: Radiofrequency electromagnetic fields [Internet]. Lyon, France: International Agency for Research on Cancer. Available from: http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf. Accessed October 14, 2013.

The International Telecommunication Union (ITU). 2011. Measuring the information society 2012. Geneva, Switzerland:

International Communication Union. Available from: http://www.itc.int/ict/publications/idi/index.html. Accessed December 12, 2013.

INTERPHONE Study Group. 2010. Brain tumour risk in relation to mobile telephone use: Results of the INTERPHONE international case-control study. Int J Epidemiol 39:675–694.

Leitgeb N. 2012. Improved classification of evidence for EMF health risks. Health Phys 103:195–199.

Lichtenstein S, Newman JR. 1967. Empirical scaling of common verbal phrases associated with numerical probabilities. Psychon Sci 9:563–564.

Visschers VH, Meertens RM, Passchier WW, de Vries NN. 2009. Probability information in risk communication: A review of the research literature. Risk Anal 29:267–287.

Wilson TD. 2011. Redirect: The surprising new science of psychological change. New York, NY: Little, Brown and Company.