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SOMMAIRE **INHOUD**

Annales de l'Association belge de Radioprotection, Vol. 41, n° 2, 2016
Annalen van de Belgische Vereniging voor Stralingsbescherming, Vol. 41, nr 2, 2016

A NEW WAVE IN RADIOLOGICAL RISK COMMUNICATION RESEARCH AND PRACTICE

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Abstract

What happens when institutional stakeholders concerned with radiological protection or nuclear safety get together with media professionals and representatives of informed civil society to talk about public communication on ionizing radiation risks? Do they have common views of the related challenges and the ways to meet these? This article debates on these questions by summarising the main findings from three European FP7 projects: EAGLE, PREPARE and OPERRA and the discussions about these findings with a broad spectrum of stakeholders at the international conference RICOMET 2015[1]. These projects aim, among other, at investigating how communication about ionising radiation in different fields could be improved and harmonised, how radiological risks are perceived, how to encourage ethical considerations in all fields of nuclear applications and what the needs are for trans-disciplinary research aimed at improving public communication about radiological risks. The projects attend to several domains; the first relates to education, training and communication, the second to nuclear emergency preparedness and response, and the third to research and development in the radiation protection field.

1 First International Conference on Risk Perception, Communication and Ethics of Exposures to Ionising Radiation (RICOMET 2015, Brdo Castle, Slovenia, 15-17 June 2015)

Introduction

Risk communication in the radiological field has been improved in recent decades by a growing focus on socio-centric communication based on public participation. Stakeholder engagement has been proven effective in bridging the gaps between stakeholders. Through stakeholder involvement, public concerns can be addressed in an open and transparent way and trust can be built between the different parties. Furthermore, stakeholders contribute to better processes and better outcomes, developing during the process a certain ownership of the solutions to be implemented. The local partnership approach MONA and STORA for siting the low and intermediate level radioactive waste disposal in Belgium is an example of successful stakeholder engagement.

However, both practice and research show that in several fields, communication on ionising radiation is often narrowed down to a form of technical communication and education whereby the public is only informed about radiological risk estimates. Risk communication which is seen as a marketing practice with the aim to persuade people to adopt a certain message can still be found in the field. For instance, in the medical field, patients' exposure to ionising radiation from medical examinations is increasingly the subject of controversy. Research showed that patients are insufficiently informed about the radiological risks of medical diagnostics or imaging and are insufficiently involved in decisions related to their application (Nickoloff and Alderson 2001; Lee, Haims et al. 2004).

Discrepancies between the recommendations on communication and public involvement in radiation protection and the real practical implementation were recognised by different research and coordination projects, for instance **EAGLE** (Enhancing Education, Training And Communication Processes For Informed Behaviours And Decision-Making Related To Ionizing Radiation Risks), **OPERRA** (Open Project for the European Radiation Research Area) and **PREPARE** (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe).

Results show large discrepancies between the public appraisal of communication about ionising radiation (Turcanu, Perko et al. 2014; Železnik, Constantin et al. 2015) and the intentions of those who provide the information on ionising radiation (IR) risks (Železnik, Constantin et al. 2015). On the one hand, communication about ionising radiation is still treated too much as a one directional transfer of information from a source to a receiver (Železnik, Marega et al. 2014). Those using IR and those in positions of authority seem mainly inspired by the idea that the general public should be 'educated' by 'explaining the facts'. Communication materials and practices mainly aim at assisting adults to obtain a better understanding of nuclear technology (Istenic and Kralj 2014). In only very few situations citizens are considered competent stakeholders, whose own questions and needs could guide the approach to communication (Železnik, Marega et al. 2014).

Differences between individuals, groups and authorities in their motivation, values, goals, knowledge, interests, as well as their perceptions, beliefs about the objectivity and efficacy are often taken as an excuse for avoiding involving stakeholders in the decision making process. Arguments over the objectivity, validity, credibility and relevance of scientific findings are also common in debates related to health effects of radiation, especially related to scientific uncertainty and effects of low doses. These differences should be seen as a drawing factor for stakeholder involvement and not as caveats. Sound communication and participation should lead to effective, democratic, ethical and transparent decisions important for radiological risk governance.

Communication campaigns for increasing public knowledge

Although increasing public's knowledge is often set as a primary objective of risk communication efforts, the public lacks knowledge related to the nuclear field and has only rarely (acknowledged) experiences with radioactivity (Kuklinski, Metlay et al. 1982; Miller 1998; Van Aeken, Turcanu et al. 2007; Perko, Turcanu et al. 2010). In Belgium for instance, knowledge related to ionising radiation is rather low, even though several information campaigns took place in recent years: an intense nuclear emergency communication campaign organised by authorities; an information campaign organised by the nuclear industry; and a campaign launched by the Health Department of the Belgian Government in 2013 to increase the lay public's awareness of medical imaging techniques and the potential risks involved (www.zuinigmetstraling.be).

Table 1: Knowledge about the nuclear domain in Belgian population (data from Perko. T, Turcanu. C et al. 2010; Turcanu, Perko et al. 2011; Turcanu

and Perko 2014; Turcanu, Perko et al. 2016) summarises the answers on several knowledge questions given by representative samples of the Belgian population in the years 2009, 2011, 2013 and 2015. Although the level of knowledge has improved in 2015, one in two respondents thinks that natural radioactivity is never dangerous and one in four thinks that every radioactive substance becomes with time more and more radioactive (Turcanu, Perko et al. 2016).

Research about how people understand ionizing radiation, what associations they make and how do they think about ionising radiation (mental models) in selected European countries showed, "*that collectively, members of the lay public (independently of their education or background) possess a non-negligible amount of knowledge on the topic of ionizing radiation and its risks, and they hold strong views on related concepts. However, formal, organized knowledge about ionizing radiation is rather low*" (Železnik, Constantin et al. 2015).

Although the level of knowledge is important for processing risk information, many risk communicators mistakenly measure the success of risk communication by what the population knows about the risk, and whether it believes it knows enough to make a decision. Knowledge may not always play a role in determining people's behaviour. Knowledge about radon, for example, is uncorrelated with actually doing a home radon test (Sandman and Eblen 1994). People who take risks are not necessarily less knowledgeable than those who do not take risks (Sjöberg and Drottz-Sjöberg 1991).

Knowledge has also been recognized as a mediator between a person and the effect of communication. Tichenor et al. (1970) proved that that level of knowledge is relevant for an individual's communication skills. Those with a better reading ability, for example, should be able to comprehend information more easily. In addition, a positive direct relationship between knowledge and the perceived information-gathering capacity was evidenced by Griffin et al.(2008), Kahlor et al. (2006) and Huurne et al. (2009). Specific knowledge is the most powerful predictor for the attentiveness to radiological risk information. People with a higher specific knowledge remember and recall more information (Perko, Thijssen et al. 2014). In other words, people who are well informed about an issue are more exposed to information, comprehend more of the information provided and remember or recall it more than people who are less knowledgeable.

Table 1: Knowledge about the nuclear domain in Belgian population (data from Perko. T, Turcanu. C et al. 2010; Turcanu, Perko et al. 2011; Turcanu and Perko 2014; Turcanu, Perko et al. 2016)

Knowledge questions	**Answering categories**	**Year 2015 % correct answers**	**Year 2013 % correct answers**	**Year 2011 % Correct answers**	**Year 2009 % correct answers**
What do you think about the following issues:					
Will exposure to radiation always lead to radioactive contamination?	• Yes • No • Don't know / no answer	33% (No)	26%	31%	26%
Is radioactive waste produced only by nuclear power plants?		69% (No)	65%	61%	NA
Radioactive waste is collected and treated	• Separately from other wastes • Together with the other waste • Don't know/no answer	82% («Separately from other waste»)	87%	87%	NA
The measurement unit for radioactivity is:	• Becquerel • Hertz • Metres/second • I don't know/ no answer	56% (Bq)	52%	53%	NA
Vegetables grown near a nuclear power plant are not good for consumption because of radioactivity	• Yes • No • Don't know/ no answer	37% (No)	33%	NA	NA
Natural radioactivity is never dangerous because we are used and adapted to it		56% (No)	51%	NA	NA
The human body is naturally radioactive		39% (Yes)	37%	NA	NA
With time, every radioactive substance becomes more and more radioactive		50% (No)	47%	NA	NA

Stakeholder engagement processes related to exposures to ionising radiation should focus on the full complexity related to ionising radiation, e.g. the specific risk characteristics, intuition, emotions, personal interest, involvement in the topic, existing widespread images related to risk, interpretations, (mis)understanding of scientific facts, educational background, access to and understanding of information, credibility of information and communication processes. Such processes may increase mutual trust between stakeholders, and raise public confidence in the governance of ionizing radiation risks or past hazard experiences, for instance experiencing a nuclear emergency event.

In a recent study we investigated how is a nuclear accident perceived by the Belgium population and, in particular, if there are differences in the perception of an accident at a nuclear installation between the general population in Belgium (N=1035) and the population that was exposed to a nuclear incident (INES level 3) in 2008 in Fleurus, Belgium (N= 104). Figure 1 shows that a nuclear accident is perceived as a strongly feared event with fatal consequences, delayed effects, and being the result of humans tampering with nature. An accident is also perceived as rather unknown to science and to the exposed people. Interesting, we did not observe any strongly significant differences in risk perception of an accident between a general population and affected population, except for the catastrophic potential factor, where affected population perceived a nuclear accident as less catastrophic than general population and for unknown to science factor, where affected population perceived a nuclear accident as more unknown than general population.

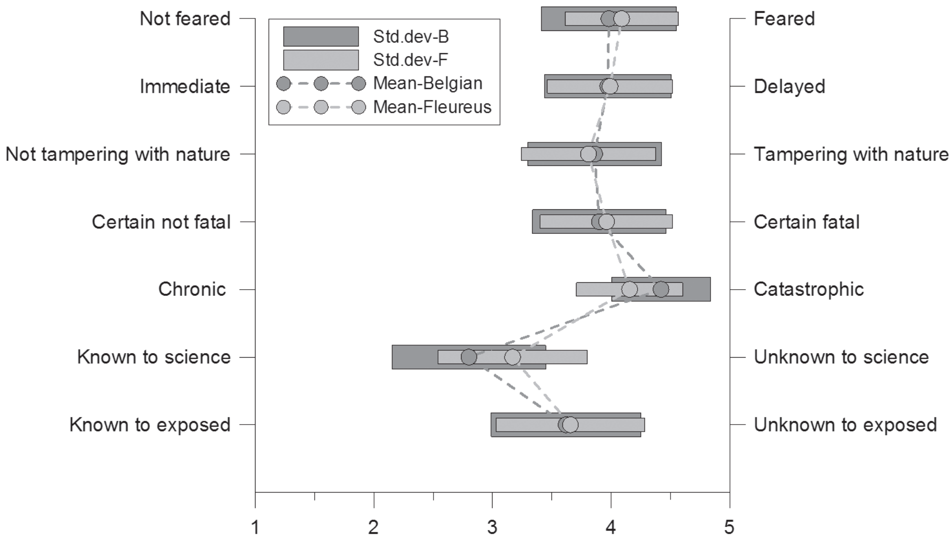

Figure 1: Risk perception of an accident at a nuclear installation in Belgium; Differences between the general population (N=1035) and the affected population (N=104)

New and traditional mass media in nuclear or radiological emergency communication

Mass media communication offers great opportunities for emergency management since it is by definition capable of reaching a large number of people simultaneously (Wimmer and Dominick 2006). In the early phase of an emergency, mass media can help increasing the awareness and understanding of protective actions and improve the response of affected populations. In the medium and long term, media can facilitate the remediation process and the return to normal life. Effective media communication can support implementation of protective measures, reduce public fears, and thus minimize the chance of negative psychological effects and help sustain public confidence in the organizations responsible for emergency management (Perko 2012). Moreover, emerging and evolving communication technologies, such as social media, offer the possibility of improved nuclear emergency communication, as these technologies have the potential for increased information capacity, dependability, and interactivity (Jaeger, Shneiderman et al. 2007).

At the same time, mass media communication is a challenge for emergency management since communication has evolved into a multiple-way process where information is disseminated at an, often, uncoordinated incredibly rapid pace, and is able to easily reach all kinds of audiences: affected, indirectly affected, and not affected by radiological risks. Social media have given to all users a virtual platform to express themselves and to share information. An overload of (miss)information coming from all kinds of sources (e.g. government, expert organisations, traditional media, individuals, inhabitants, NGOs etc.) can make it difficult for people to differentiate which information is correct. Moreover, the rise of social media has enabled users to demand more transparent, high-speed communication and accountability from governments, public institutions and emergency managers. Besides their obvious advantages, social media can potentially become a tool for misinformation and manipulation, as well as spread anxiety. It is therefore of importance that nuclear emergency communicators keep track of all parties that might be interested in the nuclear emergency, correct any incorrect information or add to information that is incomplete. These actions cause high time pressure and additional personnel burden for emergency managers (Perko, Mays et al. 2015): they require skills, training and resources.

The importance of media communication has been highlighted during all the historical nuclear emergencies (Perko 2011). The recent disaster at the Fukushima nuclear power plants has shown that there are still gaps to be filled in nuclear and radiological preparedness communication (Utz, Schultz et al. 2013). All people, even those who are not directly affected, have the right to receive accurate information so they can make informed decisions. There has been an increase in efforts to identify and formulate emergency management protocols for improving media communication (e.g. IAEA 2012) and to integrate social media into existing emergency response systems (e.g. Wendling. Cécile, Radisch. Jack et al. 2013), alongside the scientific attempts to understand the effects of emergency social media use (e.g Bunce, Partridge et al. 2012). Since the utility of social media relative to nuclear emergencies is intuitively appealing, different reports show that in general many social media ‘applications remain speculative, while others remain in their infancy’(Lindsay 2011).

Today mass media can intensify or downplay a nuclear risk (Kasperson 2005), they allow rapid dialogue among users (Utz, Schultz et al. 2013) and public engagement (Ng and Lean 2012). Therefore, implementation of media communication in the emergency management plan requires clear recommendations, practical advice as well as an experienced and dedicated team to be successful.

Research supporting new way of risk communication and stakeholder engagement

The RICOMET 2015 conference stressed many areas where improvements could be made and where additional research and/or coordination would be beneficial, among which the link and/or communication between natural and social sciences. The participatory activities organised during RICOMET 2015 (dialogues, round table discussions, focus groups) clearly showed the need for social science research, in particular on risk perception and risk communication, and the need for trans-disciplinary approaches in the field of radiation protection. The conference conclusions resulted in the RICOMET conference declaration: *Appeal to implement Responsible Research and Innovation in Euratom nuclear research, development and activities (Perko, Jourdain et al. 2015).* The appeal aims at a deeper integration of social sciences and humanities in nuclear R&D, which resonates with the spirit of the European Research Area and aligns with call for Responsible Research and Innovation (RRI). The RICOMET conference affirmed that Social Sciences and Humanities can facilitate RRI in a timely and supportive manner.

RICOMET helped identifying several areas needing improvement in the field of communication about ionising radiation. Among others, the following points should be addressed:

- Public opinion research is mainly focused on EU citizens' attitudes towards nuclear energy, and omits other IR applications or challenges. It was suggested to identify the impacts of IR risks in everyday life and to focus on issues that are meaningful for the public.
- Communication about IR risks has become more complex, extensive and multi-directional. More attention has to be given

to joint learning and participative problem-solving should be done. The final aim, shared by professionals in institutions and by scientific journalists, is to help developing a *risk culture*: awareness of the dangers and potential consequences of IR risks, but also of protective actions that can be taken by the authorities or by the citizens themselves.

- The new media speeds up, decentralises and diversifies information provision, while offering platforms for direct citizen participation, expression and feedback. The need was identified for institutions to adapt with new personnel, new practices and new policies related to communication and public involvement.
- The ideal of communication about radiological risks is to support the stakeholders to make informed decisions, to establish a two-way communication and joint problem solving. In order to take informed decisions, people need a certain level of understanding of the issue. From this point of view, teachers in schools and other people involved in education programs hold an important role in risk communication and public understanding.

The activities implied by these focus points tend explicitly towards a) increasing reflexivity and transparency of education, training and education in the nuclear domain; b) better European dissemination of materials and methods developed and tested at national level; c) better integration of diverse stakeholders' characteristics and needs; d) contribution to better accident preparedness for nuclear host communities, as well as for European Member States overall, through the creation of new types of relationships among the actors involved in communication.

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COMMUNICATING IONISING RADIATION RISKS: REFLECTION ON THE DEVELOPMENTAL STAGES IN RISK COMMUNICATION

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Abstract
In his 1995 work on "Risk perception and Communication Unplugged: Twenty years of process", Baruch Fischhoff reviews the developmental stages in risk perception and risk communication. He asks whether in terms of risk communication "ontogeny repeats phylogeny" or we can learn instead from the known pitfalls, and apply best practices in risk communication and stakeholder engagement. In this paper we reflect on the seven developmental stages outlined by Fischhoff and the meaning of these stages for radiological risk governance.

INTRODUCTION

In his 1995 work on "Risk perception and Communication Unplugged: Twenty years of process", Baruch Fischhoff (Fischhoff, 1995) identified a set of developmental stages in risk communication and management:

- *All we have to do is get the numbers right*
- *All we have to do is tell them the numbers*
- *All we have to do is explain what we mean by the numbers*
- *All we have to do is show them that they've accepted similar risks*
- *All we have to do is show them that it's a good deal for them*

- *All we have to do is treat them nice*
- *All we have to do is make them partners*
- *All of the above*

Fischhoff argues that “each stage builds on its predecessors but it does not replace them” and that progressing through these stages involves consolidating the required skills and, conversely, acknowledging the limitations of each stage. At the same time, Fischhoff reflects on whether instead of repeating this developmental process we can learn from the best available practice and theory in science communication in order to design effective risk communication and avoid falling into the inherent pitfalls of separating science from risk management policy.

As pointed out by various scholars (e.g. Hellström and Jacob 2001, pp. 9) this approach to communication based on risk psychology illustrates the “increasing understanding of how people respond to risk”; however, by this separation between real and perceived risk, it does not elucidate “how risk itself is socially constructed” (pp. 9).

In the remainder of this paper we reflect on the developmental stages outlined by Fischhoff and the meaning of these stages for the governance of radiological risk.

Reflection on the developmental stages of risk communication

Get the numbers right

Governance of radiological risk is a complex policy issue, due to both epistemic complexity, as well as moral pluralism (Turcanu el al, 2015). The first relates to the inherent limits of scientific knowledge, and deriving from this the disagreements between experts. The latter means that even “*even if all actors agreed on the knowledge base for the evaluation of radiological risk, their opinions on its acceptability could, and probably would, still be different*” (Turcanu el al, 2015, pp. 90).

Fischhoff (1995, pp. 138) draws attention that working within a discipline often leads to scientists getting accustomed to its limitations and “*learning to live with the reality of critical unsolved problems, e.g. how to model operator behavior, how to extrapolate from animal data*” .

“Getting the numbers right” implies developing state of the art research in radiation protection domains such as radiobiology, radioecology, dosimetry, emergency planning and response. But can science answer all the questions, for instance related to the uncertainties in the estimation of effects of low doses of ionising radiation?

Moreover, radiation protection is informed by science, but driven by personal and social values. As an example, the decision on reference levels in the aftermath of a nuclear accident is not only a science-based, but also a socio-political decision, often driven by economic aspects.

Tell them the numbers

Renn (2008) argues that risk governance structures should reflect criteria such as transparency, accountability, equity and fairness. Slovic (2013, pp. 45, quoting Fessenden-Raden *et al,* 1987) reminds that "*if trust is lacking no form or process of communication will be satisfactory*".

Perceived competence and truthfulness are two important trust dimensions, alongside objectivity, fairness, consistency, faith and empathy (Renn and Levine 1991, Covello 1992). Taking these two dimensions together, independent scientists and family doctors are generally perceived as the most trusted sources of information among the actors in the nuclear field**,** whereas the politicians and the journalists are among the least trusted sources of information (Eurobarometer 324, Turcanu and Perko 2014a, Turcanu *et al* 2011, El Jammal *et al* 2013). Studies on public perception in Belgium and France showed that the nuclear industry scores relatively high on competence, but lacks in trustworthiness. In addition, trustworthiness is generally perceived as lower than the technical competence for most of the actors in the nuclear field, with the exception of family doctors, environmental organisations and journalists in Belgium (Turcanu and Perko 2014a, Turcanu *et al* 2011) and the consumers' associations and the journalists in France (El-Jammal *el al* 2013).

Explain what we mean by the numbers

Knowledge in the lay public concerning ionising radiation risks is rather low (Turcanu et al, 2016). However, increasing knowledge does not lead to higher acceptance of nuclear technology (Turcanu, Perko, Kermisch, 2013) or protective actions in case of a nuclear emergency (Perko, Thijssen et al, 2014). Moreover, human behaviour is "*primarily driven by perception and not by facts, or by what is understood as facts by risk analysts and scientists*" (Renn, 2008, pp. 93).

In case of an accidental exposure to ionising radiation, one of the main concerns of the population is to know what level of radiation is safe and whether they can continue living their lives in the affected territory. Stakeholder panel discussions organised in European countries in the framework of the FP7 project PREPARE highlighted several challenges connected to this (Charron et al, 2016). Deciding what is safe (or "how safe is safe enough", see e.g. Fischhoff et al, 1978) is not only a scientific matter. How to explain for instance that for two houses in the same street one needs to be evacuated and one not? Also, what do Maximal Permitted Levels of radioactivity in food mean? Is any value below these levels safe, while values above render food products not safe? Besides the numbers themselves, there is a need for explaining the hypotheses underlying such values.

Show them that they've accepted similar risks

A first difficulty in making risk comparisons is the gap between lay public and experts' perception of radiations risks (Perko 2014; Stiévenart and Turcanu 2013; Slovic 1996). Risk perception is strongly influenced by contextual variables (see Renn, 2008 for a synthesis), such as risk-related characteristics (e.g. dread, familiarity), situation-related characteristics (personal control, voluntariness, distribution of risks and benefits, etc), as well as other factors among which trust in risk management institutions and media coverage.

However, making risk comparisons is considered to be a valuable approach to risk communication, because it constitutes an effective way to address public questions and concerns about risks during and after an emergency. Fischhoff (2007) mentions two main reasons for providing risk comparisons. The first is to give the recipients "an intuitive feeling" about how large a risk in comparison with "another, otherwise similar, risk that recipients understand". A second purpose is to "facilitate making consistent decisions regarding different risks".

Abstract and unfeeling language, for example reporting quantitative radiation units, often offends and confuses people (Covello 2011), therefore the use of comparisons of risks is advised also by IAEA (IAEA, 2012) in order to develop sound communication. Covello (2011, p. 517) indicates a number of comparisons that are effective in addressing public questions and concerns about risks during an emergency and in the post-emergency phase, arguing these "have some claim to relevance and legitimacy":

- the same risk at two different times;
- comparisons with a regulatory standard (such as a public health or food safety standard);
- the risk of doing something vs. not doing something;
- alternative solutions to the same problem
- the same risk as experienced in other places.

Studies of media reporting in European countries after the Fukushima nuclear accident (Perko, Tomkiv et al, 2015; Turcanu, Perko, Geenen et al 2013) showed that units related to radiation exposure were seldom used by the media, whereas risk comparisons with legal norms, natural background or historical accidents (Chernobyl) were more frequently encountered in newspaper articles reporting on the accident.

Show them that it's a good deal for them

Justification is a basic principle in radiation protection, but the grounds of justification strongly depend on the application context. As explained in the previous section, the characteristics of risk (voluntariness, distribution of risks and benefits, etc) make for instance that risks from medical exposures pose less concern and are perceived differently than risks from exposure to radiation after a nuclear accident (Perko, Adam et al. 2015).

A study on the acceptance of residual contamination in food after an accidental contamination (Turcanu and Perko, 2014) showed that justification is also central to understanding planned consumer's behaviour. This study showed that the most influential predictors for the acceptance of products with residual radioactivity were the attitude towards the product (anxiety, justification and health concerns), subjective norms (perceived support from their close environment) and trust in legal norms.

Treat them nice

There are many divergent views, as well as mutual misunderstandings and misconceptions related to radiological risks between professionals and the public. Research related to attitudes towards radiological risks shows that these are mainly influenced by perception of risks due to different activities or technologies, trust, involvement of people in the process and opportunities for participation in decision making, rather than by how much people know about ionising radiation (e.g. Locke 2011; Skarlatidou, Cheng et al. 2012; Slovic 2012). Mutual understanding and respect of these different views and attitudes is a precondition of successful communication (Tateno and Yokoyama 2013).

All we have to do is make them partners

Communication about ionising radiation risks is not only a prerequisite of nowadays democratic society, but also a tool enabling public participation in the context of nuclear activities (Gadbois et al 2007, OECD 2004). With the increased public concern about technological risks, there has been a gradual "*shift in the public expectations from one-way communication to participation and dialogue between a plurality of stakeholders*" in the context of nuclear activities (Gadbois et al 2007).

As pointed out in recent dialogues carried out in the FP7 projects OPERRA and EAGLE (Perko, Lazaro et al. 2015), there is a need for mutual recognition of values and concerns between experts and publics. Experts have to finally understand the need to go beyond the public knowledge deficit model and the focus on educating the lay public, towards two way communication and real stakeholder engagement. What citizens need is the recognition of plurality of values and empathy from the radiation protection experts.

As outlined in the Lessons learned from the Fukushima nuclear accident, (http://fukushimalessons.jp/assets/content/doc/Fukushima10Lessons_ENG.pdf), "when creating these [legal] systems [of protection], it is absolutely essential that the affected communities and individuals themselves can be at the center of the process".

CONCLUSION: *All of the above*

If radiation protection is informed by science, but driven by personal and social values, then, in turn, communicating is not just about providing scientific knowledge, but also about tackling ethical issues, lay beliefs and concerns. Risk communication in the modern society should be seen as an opportunity for stakeholder involvement, and be enacted through dialogue and two-way communication, rather than the simple provision of information. Early engagement of relevant stakeholders in decisions related to radiological risks should be a formal part of radiation protection policies. Mutual learning and transparency among all stakeholders, including scientists and lay people, is essential. The technocratic approach, where '*experts know best and can decide for the people who do not understand the technical issues*' should be replaced by socio-centric communication based on public participation. Citizen initiatives and engagement opportunities should be created at a large scale, including local communities, teachers, students, mothers, volunteers.

Finally, trans-disciplinary approaches are needed to develop appropriate, responsible and value based risk communication. This would imply, among others, the identification of converging as well as diverging values among the different groups of stakeholders, and the recognition of local knowledge, practices and needs. We argue that communication about radiological risks requires a legitimate procedure for discussing the values and emotions associated with these risks, an ethical justification through deliberation about the values and emotions involved in the different risk communication messages, and that the effects of communication are adequately addressed.

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IMPORTANCE OF ENGAGING IN DIALOGUE WITH THE AFFECTED POPULATION AFTER THE ACUTE PHASE OF AN ACCIDENT

Change the state of mind of the affected people from victims to survivors

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Abstract

Human behavior is primarily driven by perceptions and this is particularly important in the aftermath of a nuclear accident. One of the main lessons we can draw from the Chernobyl and Fukushima accidents is that once the acute phase of the accident is over, it is important to engage in dialogue with the affected population. Science-based government measures, imposed from above and expressed in μSv/h, mSv/year, Bq/kg or kBq/m² give rise to much opposition, to fruitless discussion and to conflicts of principle. Some examples to illustrate my point of view: The first example concerns the aversion to live in a contaminated environment even if the additional radiation is only a fraction of the natural background radiation. The next example looks at the reluctance of consumers to buy slightly contaminated food. This behavior has led to frequent changes of the maximum food contamination levels after the Fukushima accident. The last example addresses the fact that most of the evacuated people do not want to return to their old homes in spite of the efforts to clean up the radioactive contamination. On top of that comes the ongoing scientific controversy about low-dose health effects, which is not very helpful in communicating with the public. In order to overcome these problems it is important to empower the affected population in a way that they feel they have some kind of control over the situation. Local participation improves when it is organized in

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a structured way by establishing a formal consultation structure after the acute phase. A kind of partnership funded by the authorities but operated by the local community. Such a participatory approach is very demanding for the authorities, but is likely to change the state of mind of the affected people from victims to survivors.

KEYWORDS: Nuclear accident; stakeholder engagement; Chernobyl; Fukushima.

1 INTRODUCTION

The Chernobyl accident thirty years ago and the Fukushima accident five years ago are good illustrations of the inability of society and the authorities in particular to effectively deal with the disruptive impact of the countermeasures on the well-being of the affected population. And in particular to deal with the concern and anxiety of the evacuated people close to the accident site, most of whom have still not returned home, and the people further away who first had to stay inside their homes for a period of time and now have to live their lives in a contaminated environment. A lot of these people have difficulties to resume to a normal life as they still define themselves as victims of the accident, even if from a scientific point of view their risks from the exposure at the time of the accident, or from the remaining environmental contamination are small compared to the risks of everyday life. The controversy in the scientific community on the significance and magnitude of the health effects of low doses of ionizing radiation, where on the one hand some are convinced of supra-linear detrimental effects, while others claim that doses just above the natural background are beneficial, isn't helpful and confuses the affected populations still struggling with the considerable impact of the accident on their daily life. A difference in mindset between the techno-scientific community and the affected population is at the base of this lack of understanding. While experts tend to focus on the facts, the population is mainly driven by their perception of the risk, which is subjective in nature and closely related to how they think and feel about nuclear energy and radiation risks in general. This attitude is not something specific for nuclear accidents but of a general nature as expressed by Renn in 2008 [1] «Human behavior is primarily driven by perceptions and not by facts». Hence, a successful communication has to address the patterns and rationale of risk perception in general and the perception of ionizing radiation in particular. The way the affected population perceives the risk is influenced by a lot of factors, like the involuntary nature of the exposure, the involvement of women and children, the unfamiliarity with the risk… Radiation risk perception is a well-studied subject. More information on the consistent patterns and rationale of risk perception can be found at [2-5].

2 EXAMPLES OF HEIGHTENED SOCIETAL CONCERN

If we accept that human behavior is primarily driven by perceptions and not by facts then the central question is how to change the negative perception of the affected population after a nuclear accident into a more positive perception, or in other words how to change their state of mind from victims to survivors? A few examples from the Chernobyl and Fukushima accidents to illustrate the problems of our current approach:

2.1 A strong aversion to live in a contaminated territory

Large areas in Ukraine, Belarus and Russia suffered high levels of radioactive contamination due to the Chernobyl accident. Cesium-137 is the most important radionuclide in the long term. In total, an area of about 150,000 km² (5 times the surface area of Belgium) was contaminated with more than 37 kBq/m² cesium-137 and 3,100 km², mainly in Belarus, with more than 1,480 kBq/m² (Table 1) [6]. The contamination of the soil is not homogeneous at all, as can be seen in Fig. 1, due to the variable weather conditions (wind direction, precipitation...) during the atmospheric releases.

For comparison, the soil contamination in Belgium with cesium-137 was a few kBq/m² at the time of the Chernobyl accident, in about equal measure from Chernobyl fallout and from atmospheric nuclear weapons testing in the late 50s and early 60s.

Table 1: Surface area contaminated with cesium-137 in the three most affected republics of the former Soviet Union [6].

Country	37 - 185 kBq/m²	185 - 555 kBq/m²	555 - 1480 kBq/m²	> 1480 kBq/m²	Total
Belarus (km²)	30,000	10,000	4,200	2,200	46,400
Russia (km²)	50,000	5,500	2,100	300	57,900
Ukraine (km²)	37,000	3,200	900	600	41,700
Total (km²)	117,000	18,700	7,200	3,100	146,000

UNSCEAR's estimation of the total effective dose accumulated during the first 10 years by the 5 million people living in the most contaminated areas is not so high, despite the high contamination level of the soil:

- 0 - 5 mSv: 59 % (less than the annual average exposure in Belgium: 4.6 mSv [7-8])
- 5 - 10 mSv: 20 % (about one CT-scan)
- 10 - 20 mSv: 13 %
- 20 - 50 mSv: 6.9 % (more than the annual limit for radiation workers: 20 mSv)
- 50 -100 mSv: 0.9 %
- 100 - 200 mSv: 0.02 %
- > 200 mSv: 0.002%

These values do not take the thyroid doses from the short lived iodine isotopes into account, which dominated the exposure during the first few months.

The additional exposure due to the Chernobyl accident of the people living in the most contaminated areas is in the range of exposures from natural radiation sources. For example, the natural exposure in the Ardennes region in southern Belgium is on average 2 mSv/year higher than in the Campine region in northern Belgium where SCK•CEN is located. The difference is due to the higher radon concentration and higher external exposure in the Ardennes. So the exposure to natural radiation sources in the Ardennes is over a period of 10 years about 20 mSv higher than in the Campine region, which is more than the average additional exposure received by the people living in the most contaminated areas around Chernobyl.

Figure 1: The radioactive contamination of the soil with cesium-137 after the Chernobyl accident in 1986. Kiev is located 110 km south of Chernobyl [6].

2.2 Reluctance of consumers to buy slightly contaminated food

Consumers have a strong aversion to buy food that could contain traces of contamination. This attitude has led to a decrease of the maximum food contamination levels in Europe and Japan in the aftermath of the Fukushima accident as shown in Table 2.

Table 2: Frequent changes of the European Union maximum food contamination levels for the sum of Cs-137 and Cs-134 after the Fukushima accident and the very low levels currently applicable in Japan.

	Infants foods Bq/kg	Milk Bq/kg	Other foodstuffs Bq/kg
After Chernobyl	370	370	600
After Fukushima (pre-established levels)	400	1000	1250
Since 13 April 2011 (old Japanese levels)	200	200	500
New levels in Japan since 1 April 2012	*50*	*50*	*100*

In the European Union, the maximum level for radioactive cesium in milk (sum of Cs-137 and Cs-134) was first increased on 15 March 2011 from the post Chernobyl level of 370 Bq/l to the pre-established level of 1000 Bq/l and was decreased one month later, on 13 April 2011, by a factor of five to the Japanese level of 200 Bq/l. Complains from citizens about these changes resulted in an inquiry by the European Ombudsman [9]. On top of that, a year later, on 1 April 2012, Japan lowered its level by a factor of four to 50 Bq/l. Although this level is now comparable to the concentration of natural K-40 in milk of 45 Bq/l, the consumers in Japan continue to be extremely reluctant to buy local food.

2.3 Most evacuees do not want to return to their old homes

In 1986, 115,000 people were forced to leave their house in the 30 km exclusion zone after the Chernobyl accident. Thirty years later, only 400 elderly people, mostly poor farmers and former plant workers, have resettled inside the exclusion zone. At the same time, almost 7,000 people still work at the Chernobyl power plant to decommission the site. Half of them live inside the exclusion zone for up to 14 days, while the others live on the borders of the exclusion zone and commute in. In recent years, tourist interest to visit the accident site has increased to approximately 10,000 tourists a year. The most popular site to visit is the ghost town of Pripyat once home of 49,000 people, located just 3 km away from the reactor. Pripyat was built primarily to house workers from the Chernobyl nuclear power plant.

The government of Japan is determined not to get into the same situation and has engaged in a more than $10 billion effort to clean up the environmental contamination from the Fukushima accident. The intention is to reopen 70% of the evacuation zone to human habitation by 2017. Only the most contaminated areas near to the accident site would remain closed indefinitely.

The Japanese government lifted evacuation orders in two smaller areas previous to September 5, 2015, when the 7,400 residents of the town of Nahara, one of municipalities within the 20 km radius that were evacuated in March 2011, were allowed to return home permanently. While some evacuees were determined to go back, many more did not want to return for various reasons. One of the main reasons is the fear of radiation, fueled by the fact that it is not possible to clear away all the environmental contamination. There will always be some cesium-137 contamination remaining because of its long half-life of 30 years. In order to become more familiar with the risk, the government supplied radiation monitors and personal dosimeters to the residents to perform their own contamination measurements and to check their radiation levels.

Other reasons than fear of radiation why most of the evacuees do not want to go back:

- Most of the families with children have restarted lives elsewhere over the past few years.
- A lot of the younger evacuees have found a job elsewhere.
- Quite a few of the evacuees, particularly older people who have failed to find new livelihoods since the accident, are afraid to lose the compensation payments they need so badly.
- Farmers returning will probably not be allowed to grow the food crops they were familiar with for many years to come, due to the remaining ^{137}Cs contamination.
- Lack of infrastructure and damage to houses in the towns abandoned since many years (almost no shops, doctors, schools, public transport available).

In the meantime many thousands of evacuees have joined lawsuits to demand more compensation so that they can choose for themselves whether to return, or to build new lives elsewhere.

3 UNHELPFUL SCIENTIFIC CONTROVERSY ABOUT LOW-DOSE RISKS

From the above examples it is clear that a primarily scientifically driven approach with government measures expressed in µSv/h, mSv/year, Bq/kg or kBq/m² is not well accepted as it is not in line with the way the public perceives the risks from a nuclear accident. A government issuing this kind of radiation protection measures will be faced with much opposition, fruitless discussions and conflicts of principle. On top of that comes the continuing controversy within the scientific community on the health implications of low doses of ionizing radiation, which results in conflicting messages to the population. On the one end of the scale, an alarming message based on the use of collective dose as an indicator of health risk and on the other end of the scale a reassuring message based on epidemiological considerations of no discernable increase in risk to be expected.

3.1 Unhelpful approaches of dealing with low-dose risks

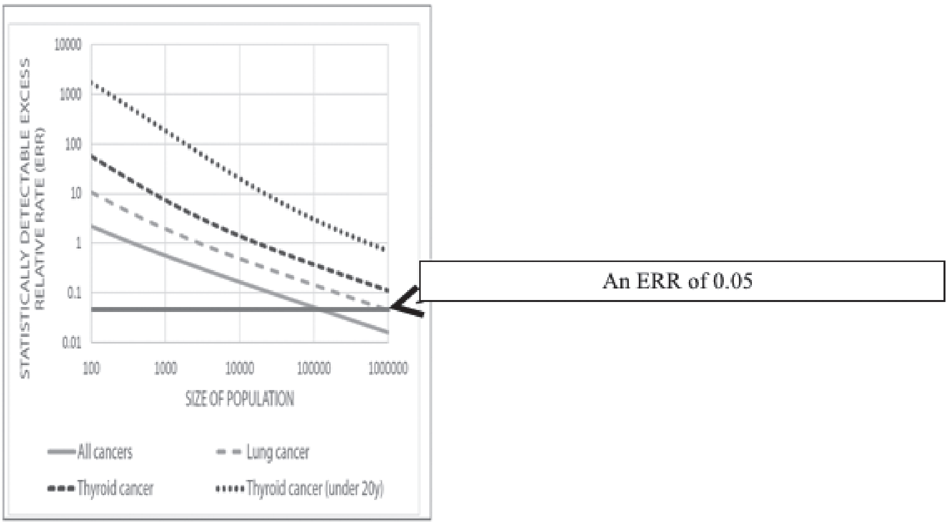
The use of collective dose as an indicator of health risk at low individual doses sends an alarming message to the public. The concept is based on the translation of an individual risk with a low individual probability, to a collective risk with a theoretical number of victims. It fails to take into account our limited knowledge of the health risks at low doses of ionizing radiation and the fact that the ICRP system for operational radiation protection is based on practical but unproven assumptions, like the use of dose as a surrogate of risk and the linear no-threshold (LNT) hypothesis. Hence, the use of collective dose as a health risk indicator at low individual doses results in a simplistic and alarming message to the public.

Another approach at the other end of the scale is sending the misleading message from epidemiological studies of "no discernable increase in risk to be expected", because it is based on the intrinsic limitations of epidemiological studies and not on scientific evidence of absence of health effects at low doses. Radiation epidemiology is at best a blunt instrument to determine health risks at low doses. Even the billion dollar study of the atomic bomb survivors is not statistically significant below 150 mSv.

3.2 Epidemiological studies are not sensitive enough at low doses

The scientific community has relied heavily on the results of epidemiological investigations to quantify the increased frequency of occurrence of cancer in an exposed population. Figure A-IV of the UNSCEAR report of 2012 on "Attributing health effects to ionizing exposure and inferring risks" [10] shows the cancer mortality for different organs from the Hiroshima Nagasaki study. The Excess Relative Rate (ERR) per unit dose for all cancers combined is 0.5 per Gy (or 0.5 per Sv as the dose was mainly due to gamma radiation). Fig. 2 is adapted from figure A-II of the same UNSCEAR report [10] and illustrates the minimum detectable ERR for ideal cohort studies.

Figure 2: Size of cohort study needed to detect an excess relative rate [10].



The figure shows that for all cancers combined and an ERR of 0.05, which corresponds in the Hiroshima Nagasaki study to an exposure of 100 mSv, two perfectly matched populations of 100,000 people are needed. For specific cancers, like lung cancer or thyroid cancer, even much larger cohorts are needed. On top of that, in practice, the ERR will be higher still because of the difficulty to perfectly match the two populations and to eliminate the effects of confounding factors [10].

The average exposure in Belgium has doubled since the discovery of ionizing radiation in 1895, from approximately 2.3 mSv to 4.6 mSv in 2006 [7-8]. Of this increase 0.2 mSv comes from natural sources and 2.1 mSv from medical applications. During the same period the average life expectancy in Belgium has increased by 30 years, for men from 48 to 77 years and for women from 51 to 83 years. The combined effect of these two trends resulted in an increase of the average lifetime exposure by a factor of 3 to 4; for men from 110 mSv in 1895 to 354 mSv in 2006 and for women from 117 mSv in 1895 to 382 mSv in 2006. This high and increasing lifetime exposure effectively limits the power of low-dose epidemiological studies. There is, on top of that, a wide range of exposures. Quite a few people in the Ardennes, a radon prone area in Belgium, receive more than 10 mSv per year from natural sources (mainly from radon but also from gamma radiation) and quite a few patients receive more than 10 mSv per year from medical imaging in radiology and nuclear medicine. How would we be able to detect the health risks of a few tens of mSv with epidemiological studies if we already receive hundreds of mSv in our life from natural sources and medical imaging?

3.3 Dosimetric limitations of low-dose radiobiology research

The absorbed energy from ionizing radiation is not uniformly distributed on the very small scale of the order of a cell nucleus, typically 5 to 10 µm. It is deposited close to the tracks with a density of ionization depending on the type and energy of the particle. The tracks of alpha particles (high-LET radiation) are two orders of magnitude more dense than the tracks from photons and electrons (low-LET radiation). A dose of 10 mGy to a cell nucleus corresponds to about 10 tracks from photons or electrons and only one track in every 25 cells from alpha particles [11], BEIR VI page 51. The natural background from low-LET radiation is of the order of 1 mGy/year or on average one track per cell nucleus per year. The intestinal epithelium of the alimentary tract system is a rapidly renewing tissue. A complete cellular replacement takes four to five days, which results in only one track from low-LET background radiation in every 80 cell nuclei, so that the vast majority of the intestinal epithelial cells will never be hit during their lifetime. These microdosimetric considerations on the frequency and density of tracks from ionizing radiation put a practical limit on low-dose radiobiology studies of a few mSv to a few tens of mSv.

3.4 Radiobiology research and animal models can shed light on low-dose health effects

The difficulty to attribute specific cancer cases to low-dose exposure is mainly caused by.

- The lack of a biomarker or a characteristic specific to radiation induced cancer.
- The long latency period between radiation exposure and cancer development. For instance, 45% of the cohort of atomic bomb survivors in Japan was still alive in December 2000.
- The high spontaneous cancer incidence in the general population not related to exposure to ionizing radiation. The lifetime risk of developing cancer in a well-developed country is of the order of 35% to 40%.

For diseases other than cancer, the same difficulties exist (hereditary effects, congenital malformations, cardio-vascular diseases, cataracts…).

The animal model has an important role in understanding the effects of ionizing radiation on living organisms. Current molecular techniques are so sensitive that we can see all kinds of biological responses after very low doses of the order of a few mSv. We observe these biological effects on a daily basis in the lab (double strand breaks, activation and deactivation of gene networks…). As these effects are transient in nature, their significance for the human health in the long term is still unclear given the absence of biomarkers specific to radiation exposure and the long latency period, which is for cancer in humans typically a few years to a few decades. Hence more radiobiology research in general and animal studies in particular is needed to bridge the gap between the transient short term effects and disease.

4 HEALTH EFFECTS FROM IONIZING RADIATION VERSUS THE DISRUPTIVE IMPACT OF COUNTER-MEASURES ON THE POPULATION

The Chernobyl accident caused acute radiation sickness amongst 134 rescue workers; 28 of whom died from this sickness in the first four months after the accident. Later, 19 more people of this group died of various diseases in the period 1987-2006 [6] [12]. In contrast, no acute radiation sickness was diagnosed in rescue workers after the Fukushima accident [13].

With regard to stochastic effects from the Chernobyl accident, there is clear epidemiological evidence of an increase of thyroid cancer amongst people who as children were heavily exposed to radioactive iodine. In the period 1991-2005, more than 6,000 cases have been diagnosed and this higher risk is expected to remain for years [12]. Only a few people in whom thyroid cancer was diagnosed have passed away. Experience has shown that people suffering from this type of cancer have a very high chance of survival. It is difficult to scientifically prove other health effects. This does not mean that there are no additional cancers or hereditary defects, but that we are not able to distinguish them from the normal occurrence of these diseases. A limiting factor for epidemiological studies is the bad economic situation in which the affected regions found themselves after the collapse of the Soviet Union, with a worsening of the health care and a decrease in the average life expectancy. Despite the difficult situation, there is some epidemiological evidence of an increase of leukemia and the development of cataract among recovery workers. The Chernobyl Forum, a collaboration between 8 agencies of the United Nations and the governments of Ukraine, Belarus and Russia, has made in 2005 an estimate of the number of additional deaths in the highest exposed population groups. The total number of deaths attributable or to be expected in the future was estimated at 4,000 [14].

Latency periods of cancer range from several years to decades, so that for most of the cancer types it is still too early to develop cancer from the Fukushima accident. In addition, the cancer incidence to be expected from the doses received by the workers and the local population will probably be too low to distinguish them from the normal occurrence of these cancers [13].

In the Chernobyl and Fukushima accidents, the government had to take very disruptive measures to protect the population from high exposures to ionizing radiation. In both cases, more than hundred thousand people close the accident site were evacuated within a few days. People further away had to take shelter in their homes for a period of time and the interdiction of contaminated foods affected populations at great distances from the accident site. These countermeasures deeply disturbed the life of the local population, resulting in various stress-related health complains, including depression and post-traumatic stress disorder.

5 ENGAGE IN DIALOGUE TO CHANGE THE NEGATIVE PERCEPTION

The examples developed in point 2, namely the aversion of having to live in a contaminated territory, the reluctance to buy even slightly contaminated food and the opposition of most evacuees to return to their old homes, illustrate the great uneasiness of the affected populations with a purely technical and science-based governmental approach. Policy implementation from a top-down perspective ignoring the social dimension conflicts with the values and beliefs of the public with respect to the various consequences of a nuclear accident and its health implications.

In order to overcome these problems it is important to pursue a bottom-up approach by involving civil society and local actors. Both approaches (top-down and bottom-up) should be combined as the social and technical aspects of the decision and implementation of countermeasures in the aftermath of a nuclear accident are intertwined and subject to change over time. Engaging in direct dialogue with the affected population and granting them a say in the decision-making processes will bring the feeling of regaining some kind of control over the situation. The practical implementation requires, once the acute phase of the accident is over, the creation of a formal consultation structure; of local bodies and committees (partnership) funded by the authorities but operated by the local community. The partnership should be given sufficient financial means to consult experts on their own, to perform radiation measurements and to put radiation monitors at the disposal of the population concerned. Such a participatory approach is very demanding for the authorities, but is likely to have a positive influence on the negative perception of the affected populations and can accomplish a change of their state of mind from «victims to survivors».

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