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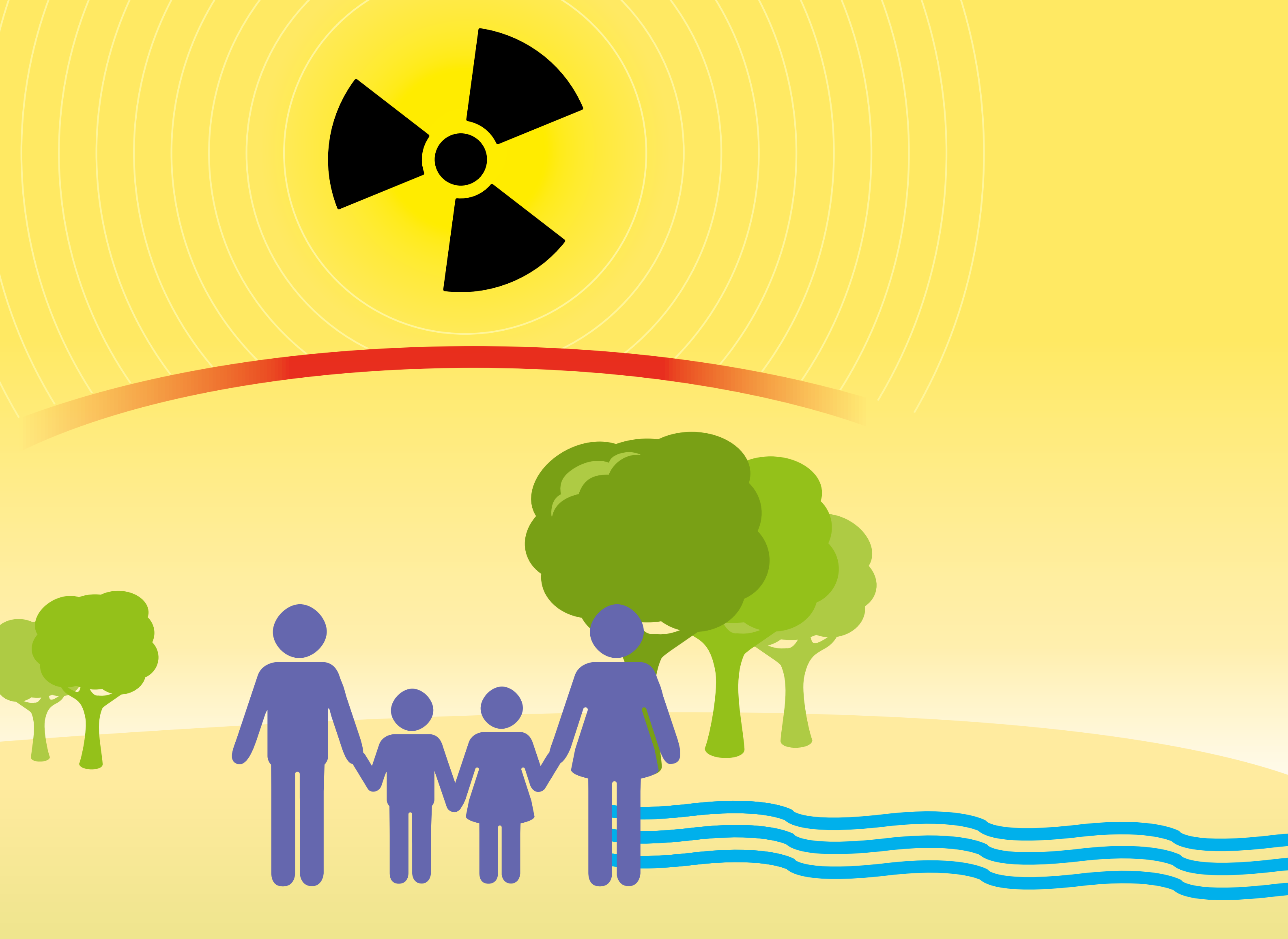

Radiation Protection

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"Risk Communication"

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EU Scientific Seminar 2015

"Risk Communication"

Proceedings of a scientific seminar held in Luxembourg on 18 November 2015

Working Party on Research Implications on Health and Safety Standards of the Article 31 Group of Experts

Directorate-General for Energy
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Unit D3 — Radiation Protection and Nuclear Safety
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FOREWORD

Luxembourg, June 2016

The European Commission organises every year, in cooperation with the Group of Experts referred to in Article 31 of the Euratom Treaty, a Scientific Seminar on emerging issues in Radiation Protection – generally addressing new research findings with potential policy and/or regulatory implications. Leading scientists are invited to present the status of scientific knowledge in the selected topic. Based on the outcome of the Scientific Seminar, the Group of Experts referred to in Article 31 of the Euratom Treaty may recommend research, regulatory or legislative initiatives. The European Commission takes into account the conclusions of the Experts when setting up its radiation protection programme. The Experts' conclusions are valuable input to the process of reviewing and potentially revising European radiation protection legislation.

In 2015, the EU Scientific Seminar covered the issue *Risk Communication*. Internationally renowned scientists presented latest developments in risk communication:

- Differences in expert and lay judgements of radiological risk
- Risk communication to radiation workers
- Risk communication in radiological terrorism
- Science on the front line – seeing science in the news as an opportunity rather than a threat
- Stakeholder involvement in risk communication

The presentations were followed by a round table discussion, in which the speakers and additional invited experts discussed potential *policy implications and research needs*.

The Group of Experts discussed this information and drew conclusions that are relevant for consideration by the European Commission and other international bodies.

I. Alehno
Head of Unit Radiation Protection and Nuclear Safety

CONTENTS

1 DIFFERENCES IN EXPERT AND LAY JUDGMENTS OF RADIOLOGICAL RISK

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Abstract

Empirical research as well as FP7 EAGLE coordination project's results shows that experts and the public frequently disagree when it comes to risk assessment. Several studies related to these differences demonstrated that experts have in general lower perception of risks than the general public. Moreover, a few existing studies from the radiological field show drastic differences in the perception of radiation risks. In the present study we examined lay people's (N=1020) and experts' (N=332) perception of five different radiological risks: nuclear waste, medical x-rays, natural radiation, an accident at a nuclear installation in general, and the Fukushima accident in particular[(1)]. The results showed that experts perceive radiological risks differently from the general public. Experts' perception of medical x-rays is significantly higher than in general population, while for nuclear waste and an accident at a nuclear installation expert have lower risk perception than the general population. In-depth research is conducted for a group of workers that received an effective dose higher than 0.5 mSv in the year before the study (n=49); for this group we identify predictors of risk perception. The empirical findings are explained in the light of the FP7 project EAGLE results. With this study we proved that: i) Experts and the public frequently disagree when it comes to radiological risk assessment, ii) Experts differ in their perceptions as well and iii) Gaps between perceptions can be bridged by socio-centric communication based on a participatory approach.

1.1 Introduction

Different studies, including the FP7 projects conference RICOMET (http://ricomet2015.sckcen) have demonstrated that lay people are able to reason about complex technical matters. Usually, they include a wider range of considerations in their reasoning processes than the experts; including values, trust, experiences… To identify how an individual understands the terms "radiation" and "radioactivity" is far more complicated than to measure the basic knowledge about ionizing radiation a member of a lay public holds. It is proven that the level of knowledge has only a limited effect on risk communication affect [(2)]. However, knowledge has been recognized as a mediator between a person and the effect of communication. Tichenor et al. [(3)] 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.[(4)], Kahlor et al.[(5)] and Huurne et al.[(6)]. Specific knowledge is the most powerful predictor for attentiveness to the radiological risk information. People with a higher specific knowledge remember and recall more information [(7)]. In other words, people who are well informed about an issue are more exposed to information, comprehend more of the information provided and remember it and recall it more than people who are less knowledgeable. Although increasing public's knowledge often is set as a primary objective of risk communication efforts, it is in the nuclear field known that the public lacks knowledge and has only rarely (acknowledged) experiences with radioactivity [8-11]. Although the level of knowledge is important for risk information, 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 [12]. People who take risks are not necessarily less knowledgeable than those who do not take risks [13]. The research about how people understand ionizing radiation, what associations they have and how do they think about ionizing 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*" [14].

In general, public understanding of nuclear risk-related information is hindered by the complexity of the risk. This concept includes not only the probability and consequences of a nuclear event, but also the specific risk characteristics, past hazard experiences, 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, trust in information sources and communication partners, and more broadly, confidence in the governance of ionizing radiation risks. Since human behaviour is primarily driven by perception and not by facts [15], risk perception is a concept of great importance when developing sound and successful risk communication. Different approaches on risk perception have been developed over time [16, 17, 15, 18]. Jaeger [15, p. 106] listed the four characteristics of the psychometric paradigm:

1. *Establish risk as a subjective concept, not an objective entity;*
2. *Include technical, physical and social, psychological aspects in assessing risks;*
3. *Accept opinions of "the public" as a matter of academic and practical interest; and*
4. *Analyse the cognitive structure of risk judgment, usually employing multivariate statistical procedures such as factor analysis, multidimensional scaling or multiple regression.*

Risk characteristics measured by the psychometric approach go beyond the classic components of risk being harm and probability of occurrence. Hence it expands the realm of subjective judgment about the nature and magnitude of risk. With the increasing complexity of technological innovations, people often rely upon their judgments about whom to trust (Gaskell et al., 2004). The meaning of trust in the field of risk perception and communication was examined in many studies on food-related risks (e.g. Frewer et al. (1996)), on opposition to a high-level radioactive-waste repository (e.g. Flynn et al. (1992)), study related to a nuclear power plant by Lofsted (1996), (Costa-Font, Rudisill, & Mossialos, 2008) and studies related to nuclear accidents (Greenberg & Truelove, 2011). These studies found that the perception of trust and credibility of a communicator is dependent on the perceptions of his/her knowledge and expertise, honesty and care (Peters, Covello, & McCallum, 1997). It was proven that effective communication requires respected and trustworthy sources (Fischhoff, 1991; Morgan, Fischhoff, Bostrom, Lave, & Atman, 1992). Conversely, not knowing whom or what to believe can make risk decisions intractable, and lack of credibility and trust can erode relations between experts (the communicator) and the public. In general, people will be more accepting of risks that are perceived to be generated by a trusted source, compared to a questionable one (Fischhoff, 1991). However, trust is not created by knowledge in itself. Rather, trusted sources are seemingly characterized by multiple positive attributes, since sources with moderate accountability are seen as the most trusted ones (Frewer et al., 1996). In the late 1990s, concerns were expressed about the quality of risk-related public discourse and communication that took place with regard to complex and controversial technologies. The question was raised whether society or individuals might be harmed by contentious, overly adversarial public debate about new technologies, including nuclear technologies. Some scholars, for instance Fischoff (1995), discussed the obligations of citizens and societal institutions to facilitate a well-reasoned discourse that is respectful of the opinions of others. Trust plays an important role in bridging the gap between experts and public and making risk communication effective. It is a moral emotion that requires trustworthiness and ethically responsible risk communication (care, empathy and respect) (Nihlén Fahlquista & Roesera, 2014). Through stakeholder involvement, public concerns can be addressed in an open and transparent manner and trust can be built between the different parties. Furthermore, stakeholders may end up developing a kind of ownership of the solutions to be implemented.

The FP7 European project EAGLE (http://eagle.sckcen) confirmed that the conflict between stakeholders is common when considering radiological risks. Arguments over the objectivity, validity, credibility and relevance of scientific findings are common in debates related to health effects of radiation, especially related to scientific uncertainty and effects of low doses. Such conflicts are often driven by differences in how activities' benefits and risks are distributed, valued and perceived. This may reflect differences between individuals, experts and authorities in their motivation, values, goals, level of knowledge, interests, and their risk perceptions.

In order to identify differences in risk perception, our study investigated the perception of radiation risks among professionally exposed employees at Belgian nuclear research installation (n=332) among which, employees that received a dose higher than 0.5 mSv in the year before the empirical study (n>40). This was compared to the risk perception of the general population in Belgium (n=1020). We compared the perception of the following risks: an accident at a nuclear installation (including the Fukushima accident), natural radiation, medical X-rays and nuclear waste [(1)]. Determining the differences in the perception of radiological risks between experts who are regularly exposed to radiation, and lay people provides important insights into how potential hazards may be effectively communicated during stakeholder engagement processes related to a radiological risk for instance communication about nuclear waste, nuclear accident, natural radiation or medical application of ionizing radiation. The communication aspects and different risk perceptions including views and values were discussed at the FP7 EAGLE, OPERRA and PREPARE projects conference RICOMET: *Risk perception, communication and ethics of exposures to ionising radiations*.

1.2 Method

In the present study we examined risk perception of a general population (N=1020) and employees in a nuclear research centre (N=332). We investigated a perception of five different radiological risks. Respondents were asked to "*evaluate the risks for an ordinary citizen of Belgium"* for the following radiation risks: *nuclear waste, an accident at a nuclear installation, natural radiation (e.g. cosmic radiation or radon) and medical x-rays*. Answering categories ranged from "*very low*" (1) to "*very high*" (5). In a later section of the survey, the respondents were asked to state their level of agreement with the following statements: "*What happened in Japan (the Fukushima accident) makes me more worried about the dangers from Belgian nuclear installations",* "*There is sufficient control by authorities on the safety in nuclear installations in Belgium*" and "*I feel well protected against risks from nuclear installations"*. The answering categories for these items ranged from "*strongly disagree*" (1) to "*strongly agree*" (5).

The results for the **general population** are based on a large scale public opinion survey in the Belgian population. The data collection method employed was *"Computer Assisted Personal Interviewing"*, consisting of personal interviews of about 45 minutes carried out at the home of the respondents in the period between 25 May 2011 and 24 June 2011. The field work was performed by a market research company with professional interviewers.

The survey (19) included, among others, questions related to risk perception and the relevance of the accident in Fukushima for Belgium. The population sample consists of 1020 respondents and is representative for the Belgian adult population (18+) with respect to sex, age, region, province, habitat and social class.

The data collected for the **professionally exposed population (experts)** are based on an opinion survey conducted in the Belgian Nuclear Research Centre SCK•CEN. The selected respondents were all employees who enter controlled areas (research reactors, plutonium laboratory, irradiation facility …) and are registered as such for monitoring. They all wear dose-meters, measuring possible radiation doses received, are regularly checked for possible internal contamination and have all received a special radiation-protection training. These people are all regularly professionally exposed to radiological risks. The other employees of the research centre were not invited to participate in the survey.

The data collection method employed was *"Computer Assisted Interviewing"*, which consisted of internet interviews of about 20 minutes carried out at the working place of the respondent, conducted in the period between 23 May 2012 and 11 June 2012. The respondents were encouraged to participate by a personal letter ensuring anonymity. The data base consists of 332 experts, among which, employees that received a dose higher than 0.5 mSv in the year before the empirical study (n=49). The employees varied in age from 19-63 years, most of them were in 36-45 age category (33%). The education level of the respondents reflects the nature of the research centre – 70% of them had higher non-university or university degree. The employees in the expert group had on average 15 years of working experience in nuclear applications, including education (most of them having between 10 -20 years of experience). For the most part they were occupationally exposed to radiation several times per month (31%) or almost every day (17%). They performed diverse tasks in the controlled area: from laboratory work (16%), manipulation of sources (13%), maintenance of equipment (13%), to inspection and supervision (14%). Thus, taking into account these characteristics of the employees, they can be recognized as topical experts in the field of ionizing radiation.

The questions measuring risk perception and the perception of the Fukushima accident, in the survey carried out in the nuclear research centre were the same as the questions asked to the general public. As regards background variables, additional items were introduced for the expert population; these measured personal experiences, exposure to and familiarity with radiological risks.

These empirical data are combined with the FP7 EAGLE project findings in order to make conclusions important for an improved radiological risk communication.

1.3 Results

A statistically significant difference between the radiological risk perceptions of the lay public and the expert population was confirmed. T-test revealed statistically reliable differences between the risk perceptions for the following items: nuclear waste, an accident in a nuclear installation, natural radiation, medical x-rays and the Fukushima nuclear accident.

Significance was for all risk perceptions bellow a level of 0.05. In addition, we identified, with Levene's test for homogeneity, that variances in the groups of the general population and the experts are different for all investigated radiological risk perceptions (sig=0.001), with the exception of natural radiation (sig=0.53).

The general population had a higher risk perception for nuclear waste and natural radiation than the experts. Moreover, the general population perceived a nuclear accident in a nuclear installation as a higher than did the experts from the nuclear research centre; they were also more concerned about Belgian nuclear installations after the Fukushima accident. However, experts had higher perception of medical x-rays than the general population (Table 1).

Table 1: Differences in radiological risks perception

Risk	**General population** **Mean,** (Std. Deviation) **n =1020**	**Professionally exposed** **Mean, (Std. Deviation)** **n = 332**
Medical X-rays	2.60 (1,04)	2.83 (0,97)
Nuclear waste	3.11 (1,13)	1.74 (0,93)
Natural radioactivity	2.54 (1,02)	2.27 (1,03)
Nuclear accident	2.98 (1,19)	2.02 (1,13)
The Fukushima	3.28 (1,22)	2.29 (0,99)

Proved statistically significant differences in risk perception: The independent group t-test, Sig. (2-tailed) α = .05; Scale: 1= Very low; 5 = Very high

From the distribution of answers on the question related to risk of an accident in a nuclear *installation* and from the distribution of answers related to *the Fukushima nuclear accident* we can see, that the expert population is much more homogeneous than the general public (Figure 1 and 2).

Figure 1: Risk perception of an accident in a nuclear installation; general public vs. experts

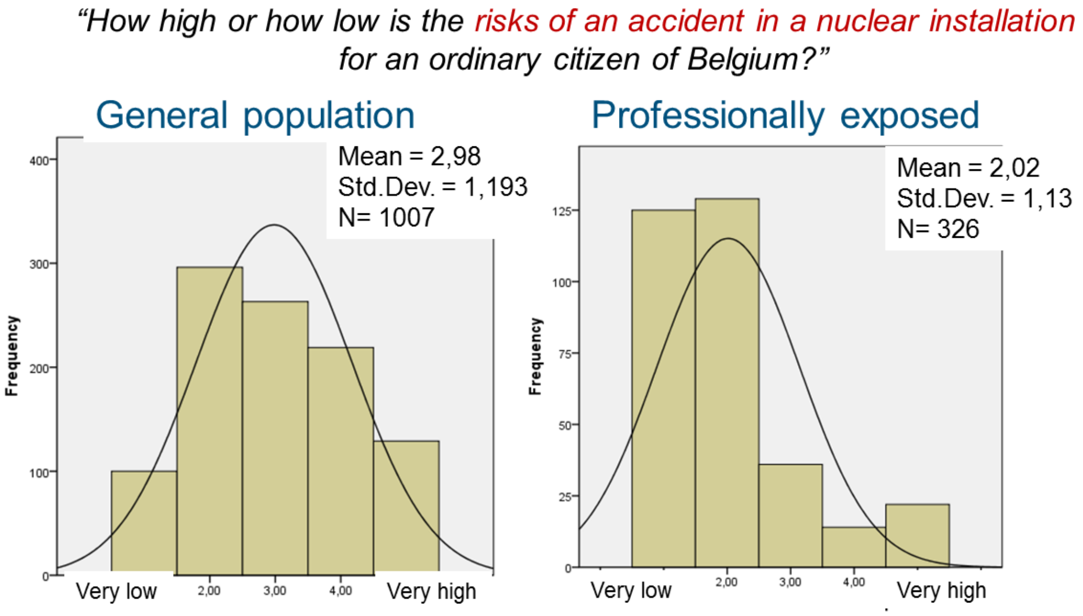
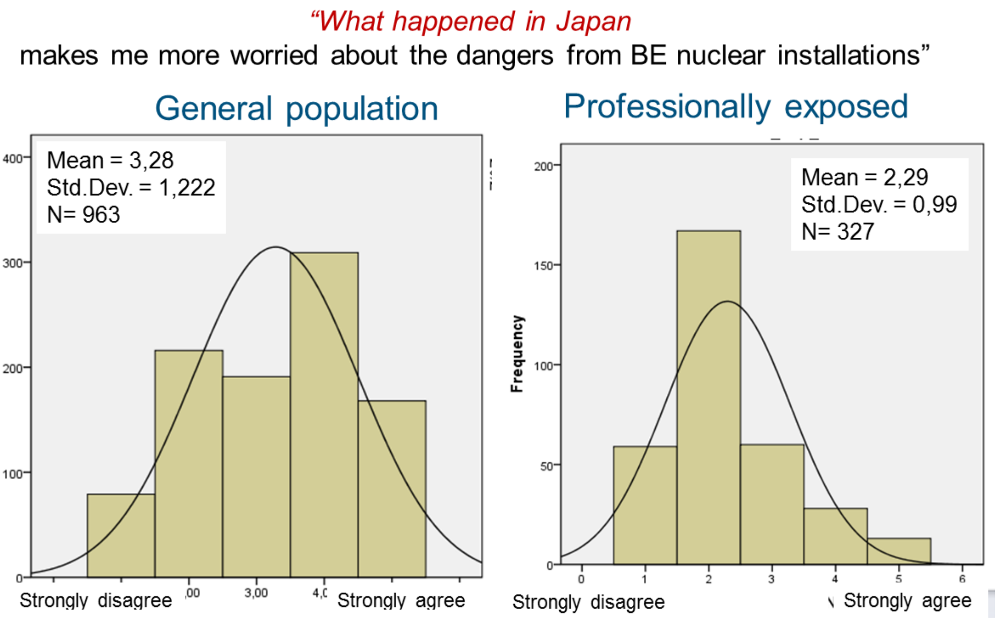


Figure 2: Risk perception of the Fukushima nuclear accident; general public vs. experts



In order to show that also the experts population is not as homogeneous in risk perception as is often presented, we analysed the hypothetical differences in radiological risk perceptions between the experts in the nuclear research centre that received a dose higher than 0.5 mSv due to professional exposure in the year before the empirical study and those that received doses lower than 0.5 mSv. A statistically significant difference in the radiological risk perceptions between the two groups was confirmed for the following items: nuclear waste, accident in a nuclear installation and the perception of the Fukushima nuclear accident. For these risk perceptions, the significance value of the t-test was $p<0.05$. (Table 2)

Table 2: Differences between radiological risk perceptions of the experts that received a dose higher than 0.5 mSv and experts that received lower doses

Risk	Expert group received doses due to professional exposure < 0.5mSv **Mean,** (Std. Deviation) n = 270	Expert group received doses due to professional exposure >0.5mSv **Mean,** (Std. Deviation) n = 49
Medical X-rays	2,81 (0,99)	2,94 (0,92)
Nuclear waste	1,79 (0,96)	1,47 (0,93)
Natural radioactivity	2,24 (1,02)	2,43 (1,10)
Nuclear accident	2,06 (1,17)	1,76 (0,78)
The Fukushima	2,33 (1,01)	2,06 (0,85)

Experts of the nuclear research centre that received a dose of more than 0.5 mSv in the year before this study due to their professional exposure, perceived the risk of nuclear waste significantly lower than their work colleagues. Similarly to this, the perception of an accident in a nuclear installation was also perceived much lower among the employees that received a dose of more than 0.5 mSv. Moreover, these employees were less concerned about the dangers from Belgian nuclear installations due to the events in Japan. Attention-grabbing is the level of risk perception of natural radiation and medical use of radiation: the experts receiving a dose higher than 0.5 mSv had significantly higher perception of these risks (see Table 2).

With Levene's test for homogeneity we tested if the variances in the two groups of employees were the same. The test revealed that group variances are different for the risk perception of radioactive waste (0.04,) risk perception of an accident in a nuclear installation (sig=0.03), and the perception of the Fukushima nuclear accident (sig=0.04). Yet, the variances were similar for the risk perception of natural radiation (sig=0.41) and the medical x-rays (sig=0.12).

Next, we analysed the factor constructed by risk perception of nuclear waste and an accident in a nuclear installation (Cronbach's $\alpha = 0.80$) in order to identify potential explanatory variables for the perception of the related radiation risks. We tested if the perception of nuclear waste and the perception of an accident are influenced by the following hypothetical predictors: i) number of years of experience, ii) the average frequency of the professional exposure to radiation, iii) the feeling of protection against risks from nuclear installations, iv) the level of perceived control by authorities on the safety in nuclear installations assessed by the employee.

With a linear regression model we can confirm that the larger is the professional experience of the employee, the lower is his/her radiological risk perception ($\beta=-0.13$, sig.=0.03). The feeling of being protected against risks from nuclear installations was revealed as the most important influencing factor for the radiological risk perception among people professionally exposed to radiological risks. Professionals that do not feel well protected had higher radiological risk perceptions (β=-0.24, sig.=0.00). Furthermore, a higher perceived control by the authorities on the safety in nuclear installations leads to lower perception of radiological risks (nuclear waste and accident in a nuclear installation) (β=-0.14, sig.=0.01). Interestingly, the predictor "*how often is an employee in average professionally exposed to radiation*" was revealed as not influencing the radiological risk perception. The results confirmed the hypothesis four: a lower perception of radiological risks among employees at a nuclear installation is influenced by the following hypothetical predictors: i) higher personal experiences in a nuclear application, ii) strong feeling of being protected from risk, and iii) higher perceived control by authorities on the safety in nuclear installations. Contradictory to our expectations, higher familiarity with the radiation, expressed with a regular professional exposure to radiological risks did not revealed as statistically influential for the perception of radiological risks (nuclear waste and accident at a nuclear installation).

1.4 Discussion and Conclusions

The results showed that experts perceive radiological risks differently from the general public. Experts' perception of medical x-rays is significantly higher than in general population, while for nuclear waste and an accident at a nuclear installation expert have lower risk perception than the general population. Moreover, also experts don't speak with one voice. We confirmed that within the group of experts, employees have different radiological risk perceptions and, although they are experts, they have different feelings related to radiological risks. We identified at least two groups in the research centre: the group of workers that received an effective dose higher than 0.5 mSv in the year before the study, having in general lower perception of waste and accidents and a higher risk perception of x-rays and natural radiation, and the group of their colleagues that received less than 0.5 mSv effective dose due to occupational exposure. The in-depth analysis of the group of experts allowed to identify predictors of radiological risk perception and confirmed again the influence of psychometric risk characteristics [(17)] suggesting that familiarity with hazard, knowledge, personal control and voluntariness decrease risk perception [(20, 15)].

- the larger is the professional experience of the employee (voluntariness and knowledge), the lower is his/her radiological risk perception,
- the feeling of being protected against risks from nuclear installations (personal control) leads to lower perception of radiological risks,
- a higher perceived control by the authorities on the safety in nuclear installations (institutional control) leads to lower perception of radiological risks.

Remarkable, within the experts, higher familiarity with radiation, measured by the number of entries in the controlled area, did not reveal as influential for the perception of radiological risks.

Judgement of radiological risks includes a wider range of considerations in lay population reasoning processes as well as in an expert population. The judgment includes values, trust, experiences, familiarity with a risk … and not only scientific and factual knowledge about ionizing radiation. Therefore, risk communication should not be seen as a form of a technical communication and education whereby the public should be informed about risk estimates, it should be not seen as a marketing practice with the aim to persuade people to adopt a certain message. In nowadays societies, risk communication should be seen as a socio-centric communication based on public participation with which the gaps between stakeholders can be bridged [(21)]. A stakeholder engagement process should provide a safe space for discussion about arguments over the objectivity, validity, credibility and relevance of scientific findings related to health effects of radiation, scientific uncertainty and effects of low doses. The related values and prioritization of these values should be discussed, since conflicts between lay public and experts are often driven by differences in how activities' benefits and risks are distributed, valued and perceived. The participative process, the one that stresses dialogue and two-way communication rather than a simple provision of information should lead to converging values and differences between general public and experts (including between different experts views) to effective, democratic, ethical and transparent decisions. The socio-centric risk communication is the win-win approach where gaps related to the perception of ionizing radiation can be bridged.

Acknowledgement

The field work for data collection was funded through the R&D collaboration agreement between SCK-CEN and GDF-SUEZ. The stakeholder engagement views used in this study were collected as part of the European Commission project EAGLE (grant agreement n°604521) under the Seventh EURATOM Research and Training Programme (FP7) on Nuclear Energy.

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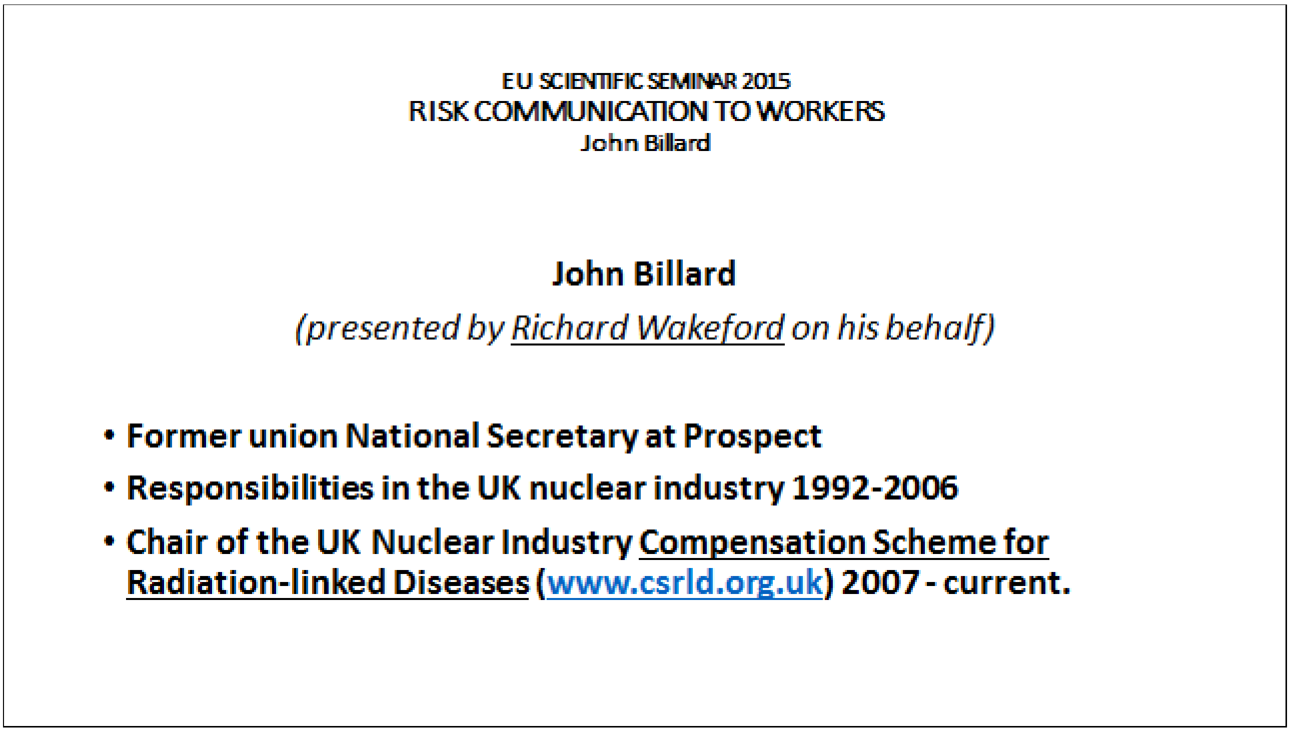
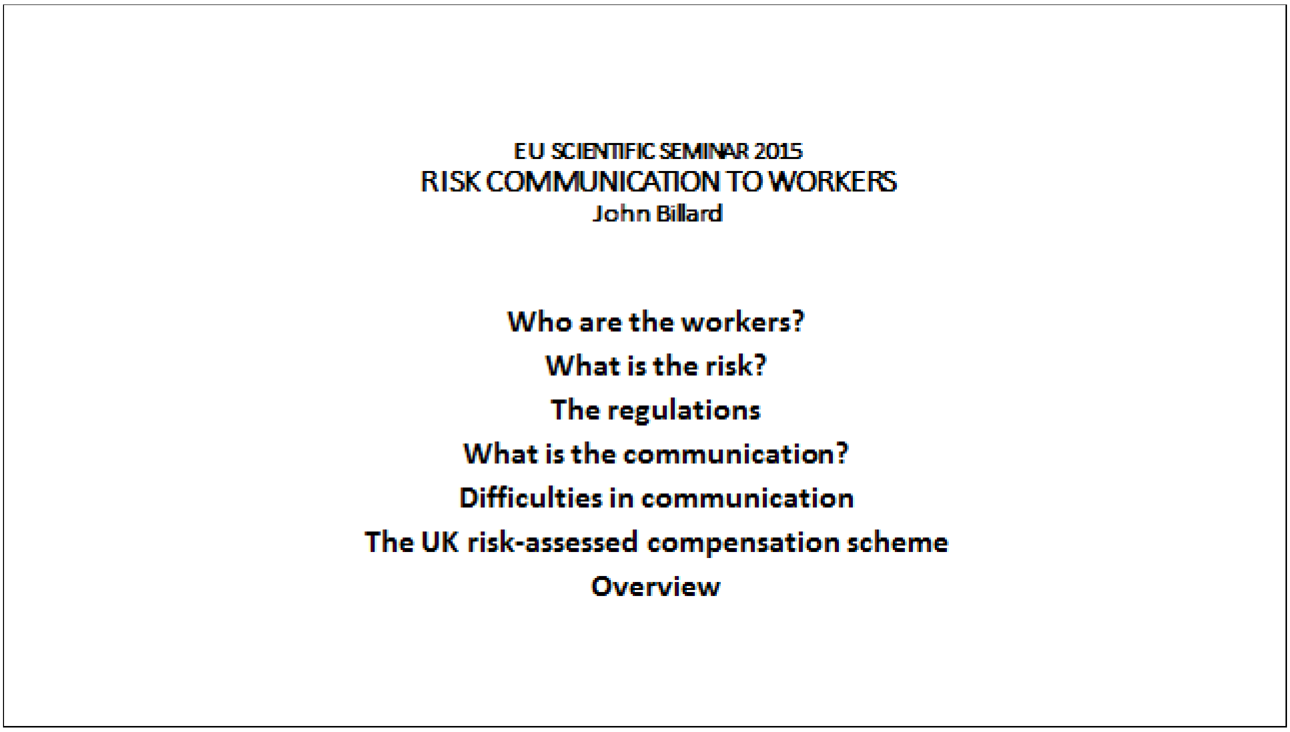
2 RISK COMMUNICATION TO WORKERS

John Billard



2.1 Introduction



2.2 Who are the workers?

UK National Registration of Radiation Workers in the UK nuclear industry (NRRW) lists 175,000 persons up to 2001.

A very recent cohort study INWORKS published by the British Medical Journal (BMJ 2015; 351) lists 308,297 classified radiation workers from the last 70 years in the nuclear industry from France, the United Kingdom and the United States (results suggest/confirm a linear increase in the rate of cancer with increasing radiation exposure – the Linear No Threshold Model (LNT)).

Exposed workers with an annual dose including others are

Above ground (Radon)	4.8 mSv
Aircrew	2.7 mSv
Nuclear cycle including mining	1.8 mSv
Industrial radiologists	0.5 mSv
Medical workers	0.3 mSv

(Source UNSCEAR)

EU SCIENTIFIC SEMINAR 2015

RISK COMMUNICATION TO WORKERS

John Billard

Exposed workers with an annual dose

Above ground (radon)	4.8 mSv
Aircrew	2.7 mSv
Nuclear cycle including mining	1.8 mSv
Industrial radiologists	0.5 mSv
Medical workers	0.3 mSv

Source UNSCEAR

UK NRRW includes 175,000 radiation workers in the UK up to 2001

Recent epidemiological studies of workers indicate a radiation-related risk of cancer, but also a "healthy worker effect".

KM Lim reported (2001) that there was an increased risk of cancer among aircrew after 20 years of flying although this was slight < 5 in 1000. (by comparison the US population cancer risk is 220 in 1000)

Guidance exists from the UK Civil Aviation Authority regarding control of exposure and monitoring on aircraft. It includes assessment of individual doses and the use of computer calculation of dose and ICRP recognises that such dose is occupational exposure.

The risk to aircrew is not severe or unreported. They do not reach the legal threshold of 3/10 of the national radiation limit of 20 mSv so they are not required to be individually monitored. But their low doses still put them at the head of average doses from various occupations. I will return to the example of aircrew later.

2.3 What is the risk?

The risk is the probability, not the certainty, that there will be some health effect from low level exposure to radiation. This is an increased risk of cancer.

Estimates based on very large epidemiological studies carried out on radiation workers who have incurred very low doses over many years e.g. the NRRW study and more recently the INWORKS study (2015) have been distilled into one risk factor covering all cancers 5 in 100 people per sievert (a very large dose) or 5 in 100,000 people per millisievert (mSv). The latest study confirms a linear increase in cancer risk with dose.

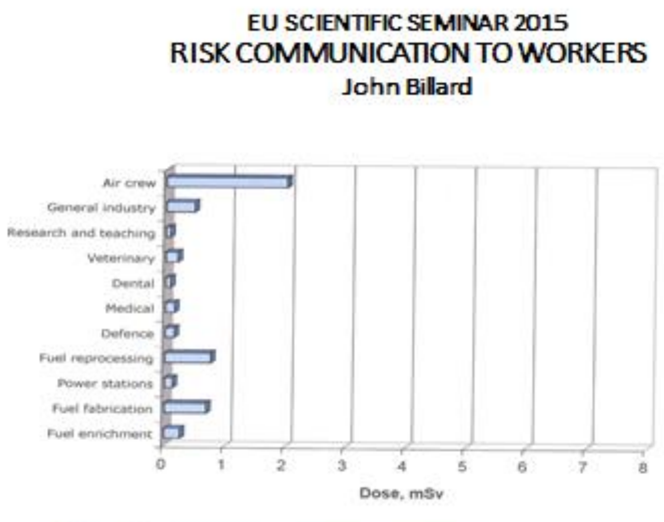


Figure 15 Average doses from various occupations

To compare with doses to the general population

Chest x-ray	0.02 mSv
Transatlantic flight	0.07 mSv
CT scan of head	1.4 mSv
UK population background average	2.7 mSv*
CT scan of chest	6.6 mSv
Radon dose in Cornwall	7.8 mSv

Whole body CT	10.0 mSv
(UK worker legal limit	20.0 mSv)

(Source AWE)

*not required to be taken into account when calculating occupational radiation exposure.

In fact, the total morbidity in the UK nuclear industry is less than the population as a whole – the Healthy Worker Effect i.e. better education, reasonable employment conditions and worker benefits, increased health monitoring etc.

While not directly relevant to this study radon is responsible for 1,100 UK deaths a year from lung cancer but smoking causes 28,000 similar deaths. (Source UK PHE)

There are some interesting comparisons where death from a nuclear power accident is classed with that by a lightning strike or by New Variant CJD (Creutzfeldt-Jakob disease) - at 1 in 10,000,000. (Death to all causes to age 40 is put at 1 in 500) (Source UK Royal College of Anaesthetists).

2.4 The Regulations

In the UK we have the Ionising Radiation Regulations 1999 (IRR99). On introduction this reduced worker exposure limits, down from 50 mSv/a to 20 mSv/a.

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IRR99 Regulation 14 requires that all employers should ensure that radiation workers: -

have appropriate training and to know the risks to health,

the precautions that should be taken and the importance of compliance with the law,

adequate information is given to persons directly concerned with this work,

and that female employees are made aware of the possible risk to the foetus and a nursing infant.

IRR99 Regulation 15 requires that separate employers on a common nuclear site should cooperate and share information with each other.

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- and that female employees are made aware of the possible risk to the foetus and a nursing infant.

Regulation 15 requires that separate employers on a common nuclear site should cooperate and share information with each other.

2.5 What is the communication?

It is essential that it is communicated that cancer is the consequence of radiation exposure; that there is a close linear relationship with dose which is likely nevertheless to be at low levels and long term i.e. the greater the dose over time the greater the risk. It must be explained that this risk is real but remains very small e.g. a risk factor covering all cancers is at 5 in 100,000 people per millisievert (mSv) or 0.005 percent causation probability per mSv. (INWORKS 2015)

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Low doses of radiation are considered acceptable in the work place and in the environment because they present similar risks to those we accept as part of living in an industrial society. Additionally, such cancer risk should be seen alongside the risk in society i.e. about 1 in 3 of the general population incurs cancer from any cause and 1 in 4 dies from it.

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Such risk communication is dependent on cooperation between the regulators, employers and workers. They should be seen as part of the same team. Otherwise there may be impediments that prevent an optimum solution. Cooperation with the workers always provides a better outcome then the alternative. There is a joint interest to protect the worker and the employer in the conduct of its business.

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Trust is needed between the parties to provide the best communication. Fortunately, the UK nuclear industry has a tradition of effective worker representation and trade union membership remains at a comparatively high level.

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Risk communication at a UK nuclear licensed site (Site A)

- Induction training for all people on the site
- Specific training for radiation workers and including for example emergency response teams
- Radiation Protection Supervisor training looking at risk factors and biological harm
- Documentation reviewing risks, radiological assessments and safety cases
- Briefs to workers starting a task
- Learning from experience

Typically, a UK nuclear employer of a nuclear licenced site (Site A) reports that they have

- Induction training for all people on the site

- Specific training for radiation workers and including for example emergency response teams
- Radiation Protection Supervisor training looking at risk factors and biological harm
- Documentation reviewing risks, radiological risk assessments and safety cases
- Briefs to workers starting a task
- Learning from experience.

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>
> However according to another large UK nuclear site employer (Site B)
>
> *"There appears to be no company strategy/policy that covers the communication of risk. Rather it is addressed in a piecemeal way depending on the target audience e g reference is made in induction training to radiation workers, in local liaison with the public and, rarely, by counselling of workers.*
>
> *This has been arrived at due to the low doses that are now recorded and therefore a general lack of interest in the workforce. In practice real interest is only expressed post-incident where additional dosimetry (e.g. faecal sampling) is provided. In these cases it is treated very much on an individual basis".*
>
> Following this up with the appropriate Site B local trade union representative no concern was expressed at the level of training and it was thought that IRR 99 was being complied with at the site. However, it may be significant that the union appeared to have no role or control in the matter.

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Following this up with the appropriate Site B local trade union representative no concern was expressed at the level of training and it was thought that IRR 99 was being complied with at the site. However, it may be significant that the union appeared to have role or control in the matter.

By contrast at a further large nuclear licensed site (Site C) it is reported that the management recognises that they have a duty of care to regularly consult with the trade unions and considerable union health and safety training is paid for and there is regular dialogue on safety and radiological issues to the benefit of both sides. On that basis assurances that risk communication based on IRR 99 at that site is handled effectively is that much more likely to be accurate.

2.6 Difficulties in risk communication

In order to communicate risk, the risk has to be understood.

Globally there is a wide discrepancy – a good example is aircrew again. The EU is ahead of everyone else with occupational health legislation. ICRP decided in 1990 that jet aircrew doses were occupational and this was accepted by the EU in 1996 and incorporated into mandatory basic safety standards. In the US precautions are taken in that it is recommended that aircrews are educated into the enhanced risk of radiation exposure but this is only advisory on employers. For the rest of the world (Canada, Australia and NZ being exceptions) exposure to cosmic rays remains a little known, low priority occupational and safety issue. On the above basis risk communication to workers follows accordingly.

In this respect the issue raised by Site B may be relevant i.e. low doses and therefore the perceived risk leading to general disinterest.

The break-up of large organisations and the introduction of contracts and subcontracts provides a disincentive. Pressure of increased commercialisation and introduction of further management interfaces and interests that may conflict. (Despite this IRR 99 Regulation 15 requires employers sharing a nuclear site to cooperate with each other). This can lead to the increased chance that an absence of interaction between employers, regulators and workers which can lead to actions being taken that are poorly understood and therefore poorly implemented. Also senior executives do not expect to receive a radiation dose in their offices and if that office is on another continent understanding and communication lines may be stretched accordingly.

It can still be difficult to convince workers to protect themselves against a hazard they can neither feel nor see, and which may have consequences up to five decades ahead. The worker must be encouraged to contribute and understand the need for radiation protection. Therefore, the worker must be brought into the picture. Pressure of work can lead to operatives ignoring safety equipment because it hinders what they see as their speed of operation. Radiation protection instruction is essential so that the worker can understand the risks, whatever the outside pressure or financial penalty.

The linear no-threshold model (LNT) is used in radiation protection to quantify radiation exposure and sets regulatory limits. It assumes that the, long term, cancer risk caused by ionising radiation is directly proportional to the accumulated dose. Radiation is always considered harmful with no safety threshold, and the sum of several very small exposures is considered to have the same effect as one larger exposure (response linearity).

The communication of this risk is always a problem. Most industries prefer to have a threshold of safety because it is easier to manage and provides reassurance. It can be difficult to get across that there is a finite risk to the smallest dose via the LNT theory.

Plus, that increase in risk is accompanied by the impossibility of distinguishing between radiogenic cancers and naturally occurring cancers leading to an assumption by the worker that the cause of the disease “must be my radiation exposure”.

It is also necessary to distinguish between acute risk and chronic risk. The latter is the risk from radiation exposure i.e. the increased risk of cancer. Perhaps the nuclear company managements and unions don’t want the C word mentioned – they prefer to compare risks with, say, a brick dropping on your head. The problem in terms of life lost is that a brick may drop on your head and remove half your life whereas cancer is a disease of old age and an increased incidence may only remove a few years of life. This is an important issue when communicating cancer risk which should be explained in a comparable way rather than a head strike.

As the nuclear industry has matured workers are now required to keep to just a fraction of the legal authorised limit and while higher doses can be managed by careful rotation of workers the continuing trend for lower doses may lead to complacency in the workforce.

There are hazards in decommissioning experimental plant where, after a long period of operation, records or the memory of operators may be incomplete or the knowledge may no longer be available. If the risk is unknown, it cannot be communicated.

2.7 The UK risk assessed compensation scheme

ILO (International Labour Organisation) Convention 121 requires that those workers who have developed cancer as a result of occupational exposure to radiation should be compensated.

The UK has a well-established joint trade union/employer “no fault” compensation scheme which is based on the calculated risk to the individual radiation worker who has a diagnosed radiation linked disease. This is informed by the best international scientific and medical knowledge. It considers the worker’s lifetime dose record, diagnosis date and the type of cancer (or cataract in this case). The outcome is recorded as a calculated percentage causation probability (CP) and payment is proportional provided the CP is 20 percent or over with a full payment made over 50 percent, where a legal claim would have been successful.

This provides a quicker, cheaper, and more certain response to the alternative which is a legal personal injury claim. It is supported by practically the whole of the UK nuclear employers and their trade unions. Today about 1 in 11 of claimants receives a payment.

By 2014 the UK scheme had dealt with 1,496 cases of which 156 had received payments totalling £8.09m.

In compliance with Convention 121 a number of countries offer compensation for injury to radiation workers but the methodology varies and not all are directly causal e.g. a cancer diagnosis and service at a nuclear plant is considered sufficient to award payment in some circumstances.

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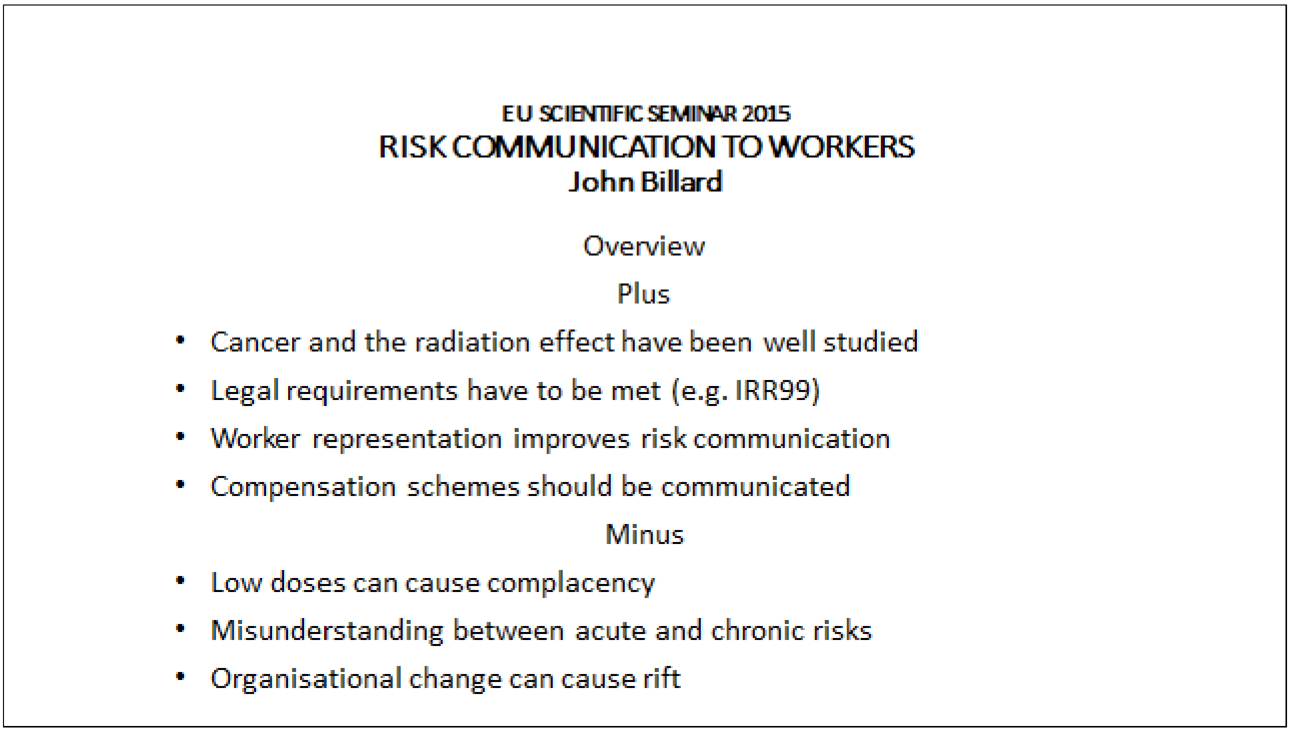
INTERNATIONAL LABOUR ORGANIATION

Convention 21

Requires that those workers who have developed cancer as a result of occupational exposure to radiation should be compensated.

Risk communication should include the availability and access to such schemes in the event that a radiation linked disease is incurred by the worker.

2.8 Overview



We have the advantage that both the subject of cancer and the effect of radiation on the person have been well studied over many years. Consequently, there is a large body of knowledge to inform the radiation worker of the risk incurred by exposure.

Such information may be a legal requirement as in the UK IRR99 but in any case there remains a moral duty on the employer to protect and brief its workforce of the incurred risk.

It has been shown that good worker participation increases the likelihood of effective risk communication. Confounders may be complacency caused by low dose rates, misunderstanding of the difference between acute and chronic risk and the break-up of large organisations leading to multifaceted interfaces between managers and the radiation worker.

Compensation schemes exist and where they do they should be part of the communication provided to the radiation worker.

3 RISK COMMUNICATION IN RADIOLOGICAL TERRORISM

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3.1 Overview

Effective risk communication and the provision of information are vital components in preparedness for radiological and nuclear terrorism. This paper focuses on the use of risk communication to mitigate the physical, psychological, social and economic impacts of radiological terrorism. Radiological terrorism scenarios that would result in relatively low numbers of casualties are of particular interest from a risk communication perspective. This is due to the potential for attacks involving radiation to cause fear and fatalism amongst the general public that may result in more widespread impacts than those caused by the device itself. The importance of effective risk communication is established with respect to its influence on risk perceptions and behavioural responses that determine the overall impacts of a radiological terrorist attack. The findings of a three stage study that explored public information needs and intended responses to a hypothetical radiological terrorist attack in the UK and Germany are presented and implications for improving risk communication are discussed.

3.2 Radiological vs nuclear terrorism

Radiological terrorism is of particular interest from a risk communication perspective due to the fact that radiological incidents tend to score highly on psychometric measures of fear and dread (Becker, 2004; Rogers, Amlôt and Rubin 2013) and even incidents that result in limited or no actual exposure have the potential to cause widespread anxiety and behaviour change (Bromet, 2011; Pearce et al., 2013a). Radiological terrorism scenarios, such as the use of a 'dirty bomb' are generally considered more likely than nuclear terrorism due to high levels of security surrounding nuclear weapons materials (Becker, 2004). Despite the fact that this type of incident would be unlikely to produce large numbers of causalities, the public tend to associate radiological terrorism with nuclear and biological weapons which "have the potential to 'kill hundreds if not thousands'" (Acton, Rogers and Zimmerman, 2007 p152). This expectation can lead to anxiety and fatalism amongst the public that may inhibit their ability to understand information that is provided after an incident (Keselman, Slaughter and Patel, 2005). It may also lead to mass flight or overwhelming demands on health services (Rogers, Amlôt and Rubin 2013). In contrast, the detonation of an improvised nuclear device would most likely result in far greater numbers of casualties and highly radioactive fallout (Dodgen et al., 2011). Whilst there tends to be a greater focus on prevention rather than mitigation in the context of nuclear terrorism, successful pre-event communication to inform the public about the benefits of sheltering in place for 12-24 hours after a detonation rather than fleeing has the potential to save many lives in the event of a nuclear terrorist attack (Acton, Rogers and Zimmerman, 2007; Pandza, 2011).

3.3 Why public risk perceptions matter

Public reactions are likely to play a major role in determining the overall economic, social, physical and psychological impacts following a radiological terrorist attack (Becker, 2004: Pearce et al. 2013a; Rogers and Pearce, 2013). Negative economic impacts associated with heightened risk perceptions range from an increased burden on healthcare services as a consequence of low risk patients seeking care, to stigmatisation of products from areas perceived to be contaminated (Rubin and Dickmann, 2010; Rogers et al. 2007; Rogers and Pearce, 2013). For example, following Sarin attacks in the Tokyo subway in 1995, over five thousand of those who reported to hospital emergency departments with physical symptoms had not in fact been directly exposed to the nerve agent (Lemyre et al. 2005). Social impacts include unwillingness to return to previously contaminated areas and stigmatisation of communities. For example, following the 1987 radioactive accident in Goiania, Brazil, events in the city were cancelled and there was a significant reduction in visitors to the city (Becker, 2004). Furthermore, Goiania residents were refused service by some airlines as well as hotels in other parts of Brazil (Kasperson and Kasperson, 1996). Physical impacts (i.e. morbidity and mortality rates) will be influenced by whether individuals in the immediate area take appropriate actions in the aftermath of an attack, such as sheltering in place rather than spontaneous evacuation (Acton, Rogers and Zimmerman, 2007). Psychological impacts include the extent to which high levels of distress persist amongst those not exposed to radiation as well as the directly affected (Pandza, 2011). By influencing risk perceptions, effective communication can improve outcomes following a radiological terrorist attack by reducing unnecessary care-seeking by unthreatened populations, enhancing the likelihood that those at risk will take protection actions, by reducing rumours and fear and by maintaining public trust and confidence in those tasked with responding to the incident (Becker, 2004; Acton, Rogers & Zimmerman, 2007; Rogers and Pearce, 2013; Pearce et al. 2013a).

3.4 Factors that influence risk perceptions

There is a substantial literature regarding factors that are likely to influence public perceptions of risk (Rogers et al. 2007). Choice, familiarity, control, fairness and whether a threat is natural or technological have all been demonstrated to influence risk perceptions (Slovic, Fischhoff and Lichtenstein 1981; Slovic, 1987; Slovic, 1991; Beck, 1999; Eiser, 2004). As radiological terrorism is unfamiliar, technological, beyond the control of the public, involuntary and likely to be perceived as unfair it falls on the ‘heightened risk perception’ end of the scale for all of these factors. Furthermore, there is also a large body of research which demonstrates that radiation is viewed as one of the most dreaded hazards (Slovic, 1996; Becker, 2004; Becker, 2007; Dodgen et al., 2011). Dread risks are low probability, high impact events that are perceived to have catastrophic potential and these types of hazard are also associated with particularly high levels of concern (Slovic, Fischhoff and Lichtenstein 1981; Gigerenzer, 2006; Rogers and Pearce, 2013).

Other factors that influence public risk perceptions include lack of information about the relative likelihood of different types of hazard. For example, the relatively higher probability of dying in a car accident when driving a short distance to an airport in comparison with the likelihood of dying in a plane crash during a direct short haul flight (Gigerenzer, 2006). It is also important that those tasked with communicating risk take into consideration differences between expert and public understandings of risk (Tanaka, 1998; Pidgeon, Kasperson and Slovic, 2003; Rogers et al. 2007; Rogers and Pearce, 2013). Experts tend to discuss risk in terms of probability and quantifiable measures of harm whereas the public may be more influenced by the emotional significance of events (Rogers et al. 2007). The extent to which there is expert agreement on an issue will also influence public perceptions and this is of particular concern in the context of radiological terrorism due to the likelihood of uncertainty following this type of attack (Fullerton et. al. 2003).

3.5 How will the public respond?

Despite evidence that terrorists are interested in acquiring radiological weapons, there have not been any successful detonations of 'dirty bombs' to date. Consequently, research which focuses on risk communication and radiological terrorism tends to employ hypothetical scenarios to explore behavioural intentions (e.g. Becker 2004; Pearce et al. 2013a; Rogers, Amlôt and Rubin 2013). Prior to presenting one such study, this paper briefly considers two contrasting examples of genuine radiological incidents; one of which is often used to demonstrate the widespread fear that radiation incidents may provoke, the second of which demonstrates that such reactions are not inevitable.

The first case study, a radioactive contamination incident which took place in Goiania, Brazil in 1987 is often cited in the risk communication literature as it was a relatively small-scale incident which had large-scale impacts as a consequence of public behavioural responses linked to heightened risk perceptions (Becker, 2004; Acton, Bell and Rogers, 2007; Rogers et al. 2007; Dodgen et al, 2011; Pandza 2011; Rogers and Pearce, 2013). This incident occurred when scavengers discovered a small source of caesium-137 in an abandoned teletherapy unit and without understanding that the material was dangerous were attracted by its blue glow and distributed it amongst family and friends. Ultimately this incident results in 4 deaths and 249 contaminations, but despite the relatively low numbers of fatalities and injuries more than 112,000 individuals sought monitoring to confirm that they were not contaminated (IAEA, 1988). These high levels of unnecessary care-seeking have been attributed to poor risk communication in the immediate aftermath of the incident (Pandza, 2011).

In contrast, there was a relatively muted response from the public following the poisoning of Alexander Litvinenko with polonium-210 in central London in 2006 (Rubin et al. 2007). Even amongst those with most cause for concern – i.e. members of the public who had visited sites that were confirmed to have been contaminated – there has been little evidence for persistent anxiety (Acton, Bell and Rogers, 2007). This has been attributed to the perception that this was a targeted attack rather than terrorism, as well as the fact that the incident coincided with a widespread advertising campaign for a new James Bond spy movie (Rubin et al., 2007) – a factor that was exploited by the restaurant chain Itsu, who directly referenced the film on hoardings outside the branch where Alexander Litvinenko ate prior to being admitted to hospital with radiation poisoning. It has also been attributed to an effective communication strategy employed by the UK Health Protection Agency which successfully conveyed that the risk to public health was geographically restricted (Rubin et al. 2007; Pandza 2011). Whilst the peculiarities of this case limit its use as an example of what might happen in a radiological terrorist attack, it does demonstrate that heightened risk perceptions are not inevitable and that effective risk communication can help manage public responses.

3.6 Public responses to a hypothetical radiological attack

The PIRATE project (Public Information Responses After Terrorist Events) was a two year EU funded project led by Public Health England (formerly the Health Protection Agency) with King's College London and DIALOGIK (University of Stuttgart) which assessed public intentions and information needs following biological and radiological terrorism scenarios in the UK and Germany. The radiological scenario involved a covert attack using a gamma-emitting source strapped underneath a table in a train carriage. This scenario was designed to allow comparison with a previous study that involved a covert radiological dispersal device (as described in Rogers, Amlôt and Rubin, 2013). We expected that a covert radiological attack would potentially result in higher levels of anxiety in the public as the onset of this type of attack would not necessarily be noticed and it could therefore be hours or days before the authorities would become aware that an attack had taken place, giving the contamination time to spread. This type of scenario would also have the potential for greater numbers of casualties than a more contained 'dirty bomb' scenario (Acton, Rogers and Zimmerman, 2007).

This research had three stages. At the first stage, focus groups were conducted with members of the public to identify their information needs and behavioural intentions in response to a hypothetical scenario involving a radiological exposure device (RED). The outcomes of these focus groups were used to inform national telephone surveys, which quantified intended behaviours and assessed what perceptions were correlated with these behaviours. Phase 1 focus groups and survey results were used to develop video and leaflet communication interventions that were then evaluated in a second round of focus groups. This paper presents the findings of Phase 1 and Phase 2 focus groups. The survey results were consistent with Phase 1 focus group findings. Pearce et al (2013a) provides a fuller description of the methods and findings for all three stages of this study.

The RED scenario was presented to participants with four media injects. The first was a mock newspaper story which described the discovery of radiological material during a police raid. This was designed to 'set the scene' for participants and elicit information about their baseline understanding /expectations regarding the use of radiological material in a terrorist attack. The other injects consisted of mock television news footage, the first of which concerned the recent discovery of a suspicious package on a commuter train. This inject confirmed that radiation experts were present, but that no explosives had been found. It also informed participants that the train station had been evacuated. The next inject, which was presented as a news item that appeared later the same day, focused on the official confirmation that the package was a RED and confirmed that it had been present on the train for several days. A medical expert described the symptoms of acute radiation sickness and asked anyone experiencing symptoms or who was on the train over the past few days to contact a telephone helpline or visit a monitoring centre to check for exposure. The final mock TV news inject was presented as appearing three weeks later. This item described the reopening of the train station and focused on the claims of one 'independent scientist' who challenged official statements about the numbers of people who had been exposed.

Key issues that were identified in the Phase 1 focus groups included low levels of knowledge about different types of radiation and that radiological terrorism was primarily associated with nuclear bombs and disasters (e.g. Hiroshima and Chernobyl). Participants were not aware that radiological material could be distributed using a covert device and during the early stages of the scenario they therefore assumed that the device had failed to 'go off' as there was no explosion. Consequently initial risk perceptions were lower than we had expected, although participants did indicate concern regarding the potential severity, contagion and pervasiveness of a radiological attack. For example, many expressed surprise that the cordoned area was not larger. The majority of participants indicated that they would intend to continue with their daily routine in the days and weeks following an attack of this type, but a sizeable minority indicated that they would unnecessarily attend a monitoring centre (i.e. they would attend if they had been outside of the immediate impact zone to obtain reassurance that they had not been affected). Primary information needs identified during Phase 1 focus groups included the desire for more information about health and security. Where comments resonated with existing concerns participants responded positively to the 'independent scientist' who questioned the official version of events during the last stage of the scenario.

Responses to the second round of focus groups indicated that the additional information that had been provided had successfully countered a number of challenges identified in the first round of focus groups. Additional information about the way that the device worked reduced concern about cordon size, incident severity and the lack of quarantine. There was reduced intention to unnecessarily attend monitoring centres and importantly this was based on increased understanding regarding the likelihood of personal impact. Furthermore there was increased scepticism in relation to the 'independent scientist' that was also based on the additional information that was provided. Participants therefore attributed their intentions to follow official advice and their lack of willingness to listen to rumour and misinformation to the risk communication material that was presented. They were also particularly positive about the credibility of information provided in the form of leaflets, an important point to note in the context of increasing reliance on social media to communicate messages during and after emergencies. Leaflets were seen to be credible due to the fact that the information that they provide cannot be easily changed and due to the costs involved in producing them. However, some participants expressed concern that the use of this type of leaflet – particularly if it were to be distributed in advance of an event – might cause alarm. A further caveat is that these leaflets were presented in a context in which our participants were engaged with the scenario and keen for additional information. This is unlikely to be the case if leaflets are used for pre-event communication.

3.7 Conclusions for improving risk communication in the context of radiological terrorism

Effective communication is an essential part of preparing for and responding to radiological terrorism. In order to improve communication it is important to recognise that increased information seeking and anxiety is a likely – and indeed reasonable – response to this type of event. Rather than characterising those seeking reassurance as 'the worried well' it should be recognised that the degree of uncertainty that is likely in the immediate aftermath of a radiological terrorist attack means that provision needs to be made for 'low risk patients' seeking information and/or reassurance (Stone, 2007; Rubin and Dickmann, 2010). Effective communication should be targeted at encouraging specific behaviours and should take into account public risk perceptions, their perceptions regarding the efficacy of recommended behaviours and the ease of carrying out these instructions. The emotional costs of carrying out recommended behaviours also need to be considered. For example, instructions to shelter in place may not be followed if this prevents parents from collecting their children from school (Pearce et al. 2013b). Furthermore, it is also important to consider perceptions about those who are tasked with communicating the response. The success or failure of risk communication is strongly and consistently mediated by levels of trust in the communicators of the message (Glass and Schoch-Spana, 2002; Earle 2004; Kasperson and Palmlund, 2005; Pearce et al. 2013b). It is therefore important that messengers and the organisations that they represent are considered by the public to be credible sources of information. Scientific experts who are perceived to be independent of political influence are likely to be trusted sources of information, however for their messages to be effective it is also important that they can be successfully conveyed via the mass media (Stone, 2007). Understanding the differences in expert and public understandings of risk described in this paper and ensuring that explanations/recommendations are provided in language that is understood by and resonates with the public is an important element of effective risk communication. However, when using the media to convey these messages the success of this communication will also rely on the use of engaging communicators. For example, the way that participants responded to the messages that were presented in the PIRATE project media injects was influenced by the communication style and physical appearance of the experts who presented this information. Finally it is important to recognise that generic principles of risk communication may need adaptation for different audiences and in different national and cultural contexts.

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4 SCIENCE ON THE FRONT LINE – SEEING SCIENCE IN THE NEWS AS AN OPPORTUNITY RATHER THAN A THREAT

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4.1 Introduction

There are many and varied ways that the scientific community can attempt to improve the public understanding of radiation issues. Public engagement activities and campaigns, working with schools on education programmes, and using the internet and social media to speak directly to the public are all important ways for scientific experts to inform the discussion of radiation issues. Scientists who care about improving the quality of public debate and correcting misinformation should exploit all these opportunities to get the very best information to the wider public.

But the scientific community should not ignore the national and international news media. Many scientists working on radiation issues view the global media with caution, seeing it as a threat rather than an opportunity. Radiation experts express frustration that the news media is prone to sensationalising and misrepresenting the risks of radiation, giving too much space to anti-nuclear campaigners who play fast and loose with the facts. After nuclear accidents like Chernobyl and Fukushima scientists accused the media of wilfully scaring the wider public by exaggerating the deaths and injuries caused by radiation.

But the Science Media Centre believes that the scientific community ignores the news media at their peril. Despite the explosion of wonderful new ways to get our voices heard it remains the case that the vast majority of ordinary people still formulate their views on issues like radiation from consuming the mass media. Whether they are watching news on a television or reading it on iPhones and tablets, opinion polls continue to suggest that most people to some extent absorb news from mass media outlets from the BBC to Reuters to new outlets like Buzzfeed in the UK. Politicians and policy makers too are heavily influenced by national and global news headlines. Whatever their scientific advisers are telling them behind closed doors the reality is that if the front pages and editorials of the national media are calling for an end to nuclear power because of the risks, politicians must take notice.

4.2 What is the Science Media Centre

The Science Media Centre was set up in 2002 to encourage more of the very best scientists to engage more often and more pro-actively in the big controversial science stories hitting the headlines. We were established by a scientific community who had stood by in dismay as they watched the UK public and policy makers turn against GM crops in 1999 and 2000 after a yearlong ill-informed media frenzy on the risks of GM during which very few scientists spoke out in the media. The SMC supports and champions the many and varied public engagement activities of the scientific community, but we believe that these activities must be accompanied by a willingness on behalf of our best radiation experts to engage in the topical controversies when they hit the headlines and when the wider public are arguably most engaged and concerned. We see radiation in the headlines as a wonderful opportunity for the best scientists to communicate accurate and measured information about radiation to an engaged audience. The SMC seeks to persuade more experts that they should seize these opportunities rather than avoiding them, and engage directly and positively with the concerns of the public and journalists at times of heightened media interest. The alternative is to leaving a vacuum in the media for pundits with less respect for truth and accuracy.

The SMC is a small team of 8 staff but we have pioneered a number of activities that seek to adapt the very best science to the needs and demands of a hungry 24 hour news media. By being extremely responsive, fast and useful to busy news journalists we can seize opportunities to ensure that a larger percentage of those speaking about radiation in the news are the best experts and therefore have the opportunity of a more measured and accurate public debate on issues such as nuclear power.

The SMC model in the UK has now been emulated in several other countries including Australia, New Zealand, Canada, and Germany. The SMC is a charity funded by over 80 science based organisations. The Centres are all independent of their funders and in the case of the UK SMC there is an upper limit on donations of 5% of the SMC's running costs to ensure maximum independence.

4.3 Adapting the best science to the needs of the media - SMC Services to journalists

Rapid Reactions to breaking news

When a story breaks the SMC springs into action – persuading leading scientific experts to drop what they're doing to engage with the story and then contacting journalists at all the major news outlets to offer those experts for interviews or immediate comment. Our Rapid Reaction service is a real example of a win-win scenario for science and the media: the eager news journalists are delighted to get credible experts to talk to, and the SMC ensures that the public is hearing the best science from the people who are leading the field. Examples of Rapid Reactions include stories like Fukushima when the SMC made it easy for the UK news media to access the UK's best nuclear experts by pro-actively issuing written comments and fact sheets as well as making many top scientists available for interview on every aspect of the unfolding drama. One leading politician said publicly that she had learned more about the real risks of radiation from watching so many great scientists on the BBC and Sky news during Fukushima than she had ever learned at school.

Roundups of third party opinion on the significance, strengths and weaknesses of new research

This service is totally unique to the SMC and has become a key tool for us and for journalists. We issue media friendly critiques of new research from leading scientists in the field, providing journalists with insights which help them to assess the news-worthiness of a new study. Journalists use the roundup of third party experts to rate the accuracy of the press release for the research and to gauge how significant the new study is. Journalists often use the quotes in their articles to ensure that their reporting is measured and accurate. Statements from independent scientists can help reporters identify the strengths and weaknesses of a new study and put it into the context of wider scientific knowledge. These comments can indicate how surprising or important the findings are and describe any implications. Print and broadcast journalists can lift quotes for their reports and follow-up for further interviews with the experts. Radiation experts can become part of this service and help journalists to navigate which new studies on radiation risks are scientifically significant and deserve a prominent place in the news headlines, and which may be more preliminary and suggestive and would need to be replicated in larger trials to be of wider public and media concern.

Press Briefings – where scientists seize the media agenda and answer questions from journalists

The Science Media Centre runs regular press briefings for UK news journalists. News briefings give scientists the opportunity to explain complex news findings directly to an audience of journalists. Background briefings address a wide range of topical issues where experts feel that accurate, evidence-based information has been missing from the media and public debate. Our briefings have proved to be instrumental in ensuring scientifically-accurate media coverage of certain issues. We have run many briefings on radiation issues including briefings around cracks in nuclear power stations, the risk of deep geological disposal of waste, the public health risks from the poisoning of Alexander Litvinenko, the risk of internal radiation in hospital contexts and many more.

4.4 Case study – Fukushima – A Reuters Journalist and a leading nuclear scientist describe their experience of working with the Science Media Centre

On March 11, 2011 at 14:46 local time in the NW Pacific Ocean there was an undersea earthquake of magnitude 9. Its epicentre was approximately 70 km east of the Oshika Peninsula of Tohoku, Japan. It lasted about six minutes. The nearest big city, Sendai, was on the coast some 130 km from the epicentre. The up thrust of the ocean floor caused a 5- 8 metre tsunami that did immense damage and cost many lives along the Pacific coastline of the northern islands of Japan.

Following any large earthquake you can expect comment from earth scientists. There are discussions of the fault line responsible for the movement, of the mechanisms involved, and likelihood of aftershocks. On this occasion, though, experts from a different scientific discipline were in demand. So too were engineers. The earthquake and the tsunami that followed it had wrecked a coastal power station. A nuclear power station.

On the Saturday morning that the news of the first explosion in the Fukushima plant hit the media headlines the small team at the Science Media Centre dropped everything to zoom into action. We went to our database of 3000 top quality scientific experts and engineers and searched for all the experts with relevant key words. These top experts are fully aware of why they are on the SMC's database. They know we will be in touch when their area of expertise hits the headlines and they have already bought into the SMC philosophy that the media coverage of these crises will be better if we make it easy for the news media to access the very best scientists. As such the SMC was able to send quotes, facts and reliable accurate information about the Fukushima story to the media within the time frame needed to make a difference and influence the media reporting. Comments from scientists sourced for our database were all over the news within hours and reminded there for the next 3 weeks. Weeks when the story remained headline news on a daily basis and the public and policy makers aware more interested in and concerned about the risk of radiation than for many years. Rather than avoiding the media feeding frenzy and leaving a vacuum for campaigners with an ideological agenda, great scientists with formidable knowledge and expertise about the risks of radiation and about other similar accidents gave up their valuable time to engaging with the media and addressing public concerns.

Prof Paddy Regan, professor of nuclear physics at the University of Surrey, was one of the experts called to explain what had happened and, more chillingly, what might happen.

Reuters' health and science reporter Kate Kelland was among the journalists reporting regularly on the events happening on the far side of the world. Both found themselves grateful to the SMC.

Professor Paddy Regan

Like many others, the first I heard of the Japanese earthquake of March 11, 2011 was on BBC Radio.

My initial thoughts were of the risk to people. I immediately emailed academic colleagues and friends in the country to find out whether they were safe and what was happening. One friend, a professor of nuclear physics at the University of Tokyo, replied to thank me. “We are fine,” he wrote. “But many people cannot go home because transportation in Tokyo is still stopped. The earthquake is the biggest I have ever seen. I even fear a building in the university is collapsing. I really hope everything is fixed soon.”

The story, at this early stage, was still of the earthquake and the devastation caused by the subsequent tsunami which had hit the eastern coast of Japan, ultimately taking the lives of more than 15,000 people. But within 24 hours this changed. The world's focus had shifted to the stricken nuclear reactors at the Fukushima Daiichi plant. Although the nuclear reactors had, as designed, shutdown automatically following the earthquake, the flooding caused by the tsunami had knocked out the power supply required to keep water circulating through the cooling system of the reactor cores. This was serious. Unless this cooling could be restored there was the likelihood of a dreaded meltdown in the reactor cores.

By virtue of the job I have at the University of Surrey, and because I also run an MSc course on radiation protection, I was contacted by the Science Media Centre to comment on the quickly evolving situation at Fukushima Daiichi.

I had worked with the SMC before on radiation related issues and was happy to do so. I knew I could trust them in their handling of any comments I made, and I was aware of their role as a focal point for the media. What I did not anticipate at the start of this process was just how big the Fukushima story would become, and how it would dominate the pages of the national papers for so many weeks.

The fascination, I suppose, grew out of established fears of radiation, and also had a direct link to the ongoing debate about the place of nuclear power in future energy policy of the UK and elsewhere. Following a couple of days of interviews with an array of media outlets including ITN, Sky News, the BBC, RTE, Radio New Zealand, US National Public Radio, CNN, Al-Jazeera and the Australian Broadcasting Corporation it had become abundantly clear that this was a science story on a global scale.

The period I spent dealing with the press on Fukushima and radiation-related issues, courtesy of the SMC, was rewarding on a personal level. The SMC had brought together experts in other areas of nuclear and radiation science, and I enjoyed the scientific interaction and discussion I had through working with them. One highlight was sharing a BBC Breakfast sofa with biologist Professor Gerry Thomas of Imperial College London.

Besides being well versed in her own subject (the biological effects of radiation following Chernobyl) she was calmness and charm personified. The experience of discussing nuclear physics under these circumstances was surreal.

I also enjoyed taking part in one of the SMC's press briefings before a room of TV, radio and newspaper journalists at the SMC's old offices in Albemarle Street. Experiencing something like this, together with experts from applied nuclear science (Laurence Williams, Malcolm Sperrin and Francois Perchet), epidemiology (Richard Wakeford) and volcanism (David Rothery) was a privilege.

I was also impressed by the journalists who interviewed us and asked insightful questions as they got to grips with the science involved. It brought home the importance - indeed, to my mind, the duty – of scientists and engineers with some knowledge of esoteric topics to provide analysis and comment as events of this kind occur.

The SMC did its usual workmanlike job of co-ordinating comments, not making judgements themselves, but simply and effectively acting as a conduit between the media and the experts during this fast developing news story. The SMC is a great asset to this country. I cannot praise their professionalism enough.

"The SMC's staff was outstanding in their coordination of the expert commentary as the Fukushima nuclear accident developed in 2011. Their insight into the areas of public concern, links with nuclear experts, and proactive approach to working with the media ensured factual and scientific reporting." ***Professor Andrew Sherry, Director, Dalton Nuclear Institute, University of Manchester***.

Kate Kelland

Japan's Tohoku earthquake and the devastating tsunami that followed it were shocking in their scale and impact. Yet almost as shocking was the speed with which the global media shifted their focus away from these human tragedies to concentrate so intently on a possible nuclear meltdown.

Within a day or two of the tsunami, which killed thousands of people and swept away whole towns, stories about this death and destruction were rapidly eclipsed by reports of looming nuclear crisis at Fukushima. Rumours about global radiation risks spread, a European Commissioner predicted an "apocalypse", and several countries said they were delaying or cancelling their nuclear power programmes.

To me this shift was disconcerting. But given human nature - and more particularly the nature of newsrooms - it also made some sense: there are few things more newsworthy than a potential nuclear disaster. Because the radiation risks were largely unknown in the early stages of the event, and the fear of radiation is heightened by its invisibility, anyone with a nose for news was keen to learn more.

Reuters' bureaux in Asia were staffed around the clock, pumping out hundreds of stories a week about the earthquake, the tsunami, and the developing Fukushima crisis. With a lack of Japanese experts available or willing to talk about the nuclear consequences, it fell to our team of health, science, environment and energy reporters in Europe and the United States to step in.

It became a daily event for me to call round British and European expert scientists, or meet them at the Science Media Centre's briefing room, to talk through what was happening then and what might happen next. The SMC's factsheets and background briefings became invaluable. The likes of Jim Smith of the University of Portsmouth (who was often speaking on a mobile from Chernobyl when I called), Paddy Regan at Surrey University, and Malcolm Sperrin at the Royal Berkshire Hospital quickly became people I felt able to call again and again with more and more questions.

I'm not ashamed - though maybe I should be - to say I was pretty much in the dark to begin with. I'd been on the health and science beat at Reuters for just over a year, and was beginning to get to grips with the complexities of cancer drugs, swine flu vaccines and malaria. But nuclear crises are (thankfully) few and far between, so this was the first time I'd had to use the words “millisievert” or “radioisotope” in any copy.

I knew, however, that what we needed was to be able to put scores of sometimes simple, sometimes tricky questions to experts who could give us honest answers about the potential risks. We also needed to be able to quiz those experts about their credentials.

Who were they working for? What was their experience of nuclear disasters? Did they have any connections with the nuclear industry? Where were they getting their information from?

I remember some guffaws and throwing up of hands in despair when one scientist at an SMC Fukushima briefing answered this last question with breath-taking honesty. He said that for the moment at least, Sky News was one of his main sources.

This answer underscored some important points about Fukushima. Data from the plant itself, as well as from the Japanese government, were scarce, patchy and sometimes from sources whose reliability was uncertain. Scientists as well as journalists were desperate to get more, and more accurate, information. The best that reporters stuck here could do was ensure that the scientists we talked to were the best kind of experts giving their best judgment on the best levels of information they could get hold of.

The SMC made that happen. We could not have done it without them. Yes, we could have gone through the same motions, and certainly we could have made the same number of phone calls and asked the same questions every day. But I have no doubt that the people we would have talked to would have had less credibility and fewer answers. Our sources would have been less intelligent, less scrutinised, and less newsworthy.

One afterthought: I do hope the European Commissioner read the report of the World Health Organisation's investigation in May. It found that no-one has died from radiation since the Fukushima crisis, and that spikes in radiation caused by the Fukushima nuclear disaster were below cancer-causing levels in almost all of Japan.

4.5 Case Study on nuclear waste

For several years government funded scientists and communications officers engaged with the Science Media Centre about the possibility of pro-active media relations work on the safety issues around the burying of nuclear waste. Since the strategy in the UK is to seek applications from communities to host the waste repositories the scientists and communications officers were keenly aware that misinformation and poor public understanding of the level of risk were a very real threat to their agreed strategy. Yet for several years the SMC was unable to persuade the experts to adopt a more pro-active media strategy. As is far too common, the experts involved were paralysed by fear of the risks of open communication. Instead of looking at the real and present risks of not engaging with public concern and media scrutiny, the experts focussed only on the things that could go wrong.

It was therefore a huge ‘proof of principle’ case study for us when we finally persuaded the experts to come into the SMC and speak to journalists about the weight of evidence on burying nuclear waste. Despite the years of avoiding it, the press briefing was a success. Interested and engaged science and environment reporters' from the national news media attended and asked the experts intelligent and tough questions. However there was nothing the experts on the panel could not answer with huge expertise, honesty and evidence.

The SMC will continue to use this example and the many others we have gathered to persuade radiation experts that they must engage positively and pro-actively with the media on these issues. Failing to do so only leaves a vacuum for campaigners and politicians with less respect for evidence. We cannot despair at public and media ignorance about radiation if we in the scientific community have ducked our responsibility to inform the public debate through the mass media and other channels. As the SMC philosophy states, 'The media will 'do' science better when scientists 'do' the media better'.

4.6 More courage in standing up to Government

One of the issues raised in discussion at the Luxembourg seminar was the fact that many of the best experts on radiation work for government agencies or UN agencies and are restricted from speaking openly to the media. This is the case in the UK where many of the best experts work for the Centre for Radiation, Chemicals and Environmental Hazards (CRCE) which is owned by PHE, an agency of government. Scientists at CRCE do occasionally speak to journalists but only under strict control and restriction from corporate communications officers. The SMC does not have access to these wonderful experts and most journalists covering radiation crises will probably never have used them. The SMC is campaigning hard to release these great experts from the restrictions and make it easier for the news media and Science Media Centre to access their expertise during time of crisis. We hope to find allies in this struggle amongst leading scientists who share our view that the media and public need to hear from these experts. Of course there are risks to engaging the media during times of crisis as during Fukushima or the Litvinenko crisis. However it is also at such times when misinformation is rife and we need to hear from the best scientists. We believe that the risks of not engaging with the media during times of heightened public interest and politicisation are far outweighed by the benefits of journalists, the public and policy makes being exposed to experts who respect the evidence and have no axe to grind.

4.7 Conclusion

The SMC has pioneered a new approach to engaging with public concern and misinformation about the risks of radiation. It relies on treating radiation stories in the news, even negative ones, as an opportunity to be embraced rather than a threat to be avoided. By persuading and supporting more radiation experts who share this approach we have been able to make it easier for the UK national news media to access the best science when it most matters - when radiation is in the headlines and the public are paying attention. We call on all those attending the seminar and reading this essay to sign up for the SMC UK or your national SMC and to help us to make sure that the public have access to the best science on radiation. There are risks engaging the national news media but the imagined fears are usually much worse than the reality and the benefits far outweigh the risks. If you have considerable expertise on nuclear or radiation issues and want to join our database please contact Fiona Fox at the SMC at www.sciencemediacentre.org.

5 STAKEHOLDER INVOLVEMENT IN RISK COMMUNICATION

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5.1 Introduction

This paper takes different perspectives of experts and other stakeholders to the concept of risk as a point of departure, and in relation to this the idea of rationality is discussed. Section 2 also refers to a series of books from the US National Academy of Sciences as an illustration to the development leading to the modern approach to risk communication with stakeholder involvement. Societal decisions are always related to risks and benefits and they include factual and value-laden elements of both. Section 3 starts with a description of possible damaging consequences of a scenario in which risk assessment and risk communication are too narrowly framed from the beginning of a decision making process. The conclusion is that the social and societal issues need to be addressed by stakeholder involvement. Different approaches to this are explored in section 4 including letting the stakeholders have real decision making power and a "safe space" approach designed to increase awareness and clarity about all relevant issues. The section also describes a number of principles for mapping stakeholder involvement processes. Then section 5 gives advices to actors planning to launch a stakeholder involvement process for risk communication and special focus is given to the early signals sent to potential participants. Finally, section 6 gives some concluding remarks in the form of "bullet points".

5.2 Rationality and the concept of risk

Risk can be defined as a mathematical construct, the product of probability and the consequence of an undesired event (often also called "scenario"). Typically, there are many possible undesired events that can take place in, for example, a nuclear reactor. The total risk is then the sum of all products of probability and consequences of these events. Risk is also closely associated with uncertainty. For example there is a completeness problem in risk assessment since the risk analyst may not be capable of identifying all possible undesired events. There is also uncertainty about how well the analyst can assign the probability of events and describe their consequences. There are thus subjective elements in how the experts conduct their risk assessments, especially how uncertainties are handled.

In spite of the limitations in completeness, ability to assign probabilities and consequence analysis, the quantitative risk assessment (QRA) has enjoyed great success in nuclear safety.

QRA is best suited to large technical systems where the failure probabilities of the components in the system can be estimated with relatively large certainty. QRA can then be used ***for risk-informed decision-making***

However QRA cannot be the only source of information for decisions on a political level, e.g. concerning the use of nuclear power as opposed to other energy sources, or the siting of reactor power plants. Other dimensions in a more comprehensive risk assessment which takes into account social and societal factors then appear on the scene. This leads us to the idea of rationality.

Rationality is a word with positive associations. Among experts and many others there is a tendency to accept only factual issues as relevant in decision-making. In the risk area it means assessments only including the mathematical construct of risk – values and ethical issues are seen as irrational and are therefore to be discounted.

The German sociologist Max Weber [1] distinguished between “value rationality” and “instrumental rationality” where value rationality is behaviour consistent with a particular value position and instrumental or scientific rationality looks at the consequences of various actions and carries out cost-benefit type of assessments. A rational decision-making process obviously must include both these types of rationality. Furthermore, a prerequisite for rational decision-making is awareness of all the relevant aspects, which includes not only the factual but also the value-laden issues.

Although there are established methods of assessing risk for example in the nuclear area, risk is a complex mixture of values and perceptions incapable of reduction to a simple mathematical formulae, perceived differently from individual to individual. Both society and affected communities should be empowered to develop their own understanding of risk and from there be competent actors in risk management taking into consideration issues such as the social and economic benefits or costs for alternative developments.

In this context it is interesting to consider the evolving concepts in risk assessment and risk management evident in three major risk studies published by the U.S. National Academy of Sciences. In 1983, the *Red Book* [2] was published after a study that sought “institutional mechanisms that best foster a constructive partnership between science and government”. The study made the important distinction between risk assessment and risk management and raised the issue of how to best keep the two functions separate but coordinated. Research would lead to risk assessment, which would then lead to risk management. In 1989, in *Improving Risk Communication* [3] the Academy stressed the need for a two-way dialogue between the government and the public. Although this report still relied on traditional risk analysis, it went beyond the usual framework by identifying the need for early and sustained dialogue. The report recognized that disputes are often not about facts but about values, and that a good two-way dialogue might not lead to consensus, since improving understanding might solidify opposing views. In 1996, *Understanding Risk* [4], the third risk study by the Academy, gave little space to traditional analysis, but concentrated on working with interested and affected parties to decide what should be examined, how it should be examined, and how decisions should be made. This report stressed the need to bring in value issues from the beginning and to iterate them throughout the decision-making process.

In summary, the three US reports represent three steps in the understanding on how risks should be managed in society: first acknowledgement of subjectivity in risk assessment, then emphasis on dialogue instead of one-way information, and finally the conclusion that one should first address the concerns of laypeople. Expressed in other words, they showed the way to the modern approach to risk communication with stakeholder involvement.

5.3 Risk communication as part of decision making processes

Decision making processes in many areas with risk assessment elements such as nuclear programmes are often long term processes that go on for a large number of years, sometimes for several political election periods. In areas such as the introduction of genetically modified crops in Europe and the siting of nuclear waste repositories, we have seen scenarios developed of time which cannot be said to be optimal or rational from a societal point of view. In the early stage there is enthusiasm for a new promising technology among the experts and a wider technical community which disseminates among the public at large as there is little evident opposition. What this means in reality is that the consequences of the new technology becomes framed narrowly by the technical community without much analysis of social consequences or even technical uncertainties. Such concerns appear later when large investments have already been done resulting in negative events, media debates, conflicting interests and frustration which means that the early framing is found irrelevant.

These issues often have a complicated nature with many relevant technical, social and societal issues. This makes it possible for various interest groups, both in favour and against the technology, to bring up only certain factors in favour of their interests to public debate which thus gets fragmented. The combination of early too narrow framing, the consequential unawareness of the uncertainties and possible negative consequences, and the following fragmentation by interest groups makes the policy making environment controversial and difficult to handle. The decision making system may become paralyzed and the whole issue postponed to an uncertain future. This is a scenario we don't want and hopefully it can be avoided by proper risk communication with stakeholder involvement already from an early phase. Fragmentation can be made more difficult by early and proactive awareness building by stakeholder participation processes.

Societal decisions are always related to risks and benefits and they include factual and value-laden elements of both. In all decisions, positive and negative factors have to be taken into account and be weighed against each other. The more aware the decision-makers and the public are about both, the better the decisions. There is a need for insight and transparency as a first prerequisite of high quality decisions that take social values into account. The challenge is thus to make risk assessment more transparent and to make it more accessible to the general public. Risk communication needs to incorporate citizens' values and concerns and the experts need to engage themselves in the dialogue.

There are methodologies like strategic risk assessment, multi-attribute decision analysis, cost benefit analysis and cost effectiveness analysis for giving risk related decision problems a wider frame to include value-laden factors, see e.g. [5] and [6]. These are quantitative decision analysis methods that arrive at a preferred decision among a number of alternatives based on the importance and values of different factors, including value-laden ones. The weighting of the attributes can be done by a combination of expert and non-expert panels. Typically they are implemented by including public values in risk assessment by transforming them into quantitative elements that fit into a technical framework used by experts. The risk with this type of methods is that they can be used by expert groups to apparently include public and stakeholder values while still retaining expert control of the process. At the same time, the technical risk assessment also needs to keep its identity as a scientific and engineering enterprise. Engaging in public dialogue must not dilute the science and steer experts away too much from their core activity.

5.4 Approaches to stakeholder involvement

To conclude that stakeholder involvement in risk communication is needed for high quality decision making processes is not enough as then comes the question how to do it. Let us first conclude that only information in more traditional ways is far away from enough. To rely on information only has been called the Decide, Announce and Defend (DAD) approach as it builds on the idea that "we know best – you only need to be informed". Especially in information society it cannot work. People have infinite access to information, but there are many information senders and the individual has limited attention span. You are only one of many informers and other stakeholders frame and fragment the issues to the benefit of their goals. The individual either does not know who to trust or he chooses to trust someone having similar values as him.

There are many processes and tools that can be used for stakeholder involvement in risk assessment as well as for other areas; Citizen Advisory Group, Citizens' Jury, Citizens' Panels, Consensus Conference, Delphi Survey, Focus Groups, Partnership, Mediation forum, Opinion Polls, Public Hearings, Safe space (RISCOM Process), Roundtables, Scenario Workshop, Seminar, Surveys, and more. They are summarized in [7]. In a specific situation an actor who wants to initiate stakeholder involvement will chose between them, find another one or develop a new one for the purpose. In this situation it may be useful to take part of efforts which have been made to map, or even evaluate, the processes.

A variety of schemes for evaluation have been proposed. For example, Gene Rowe and Lynn Frewer at the Institute of Food Research present nine criteria for the evaluation of processes: representativeness (participants should comprise a representative sample of the population), independence, early involvement, influence, transparency, resource accessibility (participants should have adequate resources for their participation), task definition (a clearly defined process), structured decision making and cost effectiveness [8].

In a study for Resources for the Future, Thomas C. Beierle and Jerry Cayford [9] made an extensive review of public participation processes in the Unites States. They used five "social goals" in their review: incorporating public values into decisions, improving the substantive quality of decisions, resolving conflict among competing interests, building trust in institutions and educating and informing the public. This report concludes that processes with more intensive mechanisms than for example traditional hearings, and processes where agencies are responsive to stakeholders, are more likely to be successful than others.

Rowe and Frewer have not only developed their own criteria but also reviewed the entire field of public participation exercises [10]. They collected 34 studies world-wide on public participation evaluation. The evaluation criteria vary broadly between research groups, but some of the most common ones are representativeness, deliberation, fairness, competence, impact and influence, effectiveness (for example in decreased time to develop regulations), early input, responsiveness to results and consensus. Rowe and Frewer conclude that research in this area has been disorganized and sporadic and they suggest a more systematic research agenda. In spite of much progress in the area the latest decade, it seems like this lack of organization and systematics still prevails.

In the IPPA Knowledge Base [11] reports thirteen properties were used to characterize public participation processes, divided into three groups: instrumental (for enhancing the quality of decision-making), procedural (e.g. if the process is conducted with transparency and legitimacy) and constitutive (benefits for participants). A pragmatic guide into stakeholder involvement processes is found on-line as the IPPA "tool box" (http://toolbox.ippaproject.eu/index) where we find search criteria like the type of stakeholders involved, the number of stakeholders and frequency of meetings, in addition to some of the search criteria given above. These criteria can easily be specified and inserted into a search system, and potential "customers" of the knowledge base may find them useful.

The IPPA mapping used a scheme which can be said to have its origin in the "Arnstein participation ladder", originally presented in 1969 [12] which is a classical schema for evaluating public participation. It defines different levels of participation in terms of how much and how citizens are involved. The lowest, non-interactive level is information to the public in order to assist them in understanding the problem, alternatives, opportunities and/or solutions under consideration. The information sender decides what information is provided. Then there are levels of listening, consultation, collaboration all the way up to joint decision-making where the public is empowered to take part in the final decision-making and the decision-making responsibility is therefore shared. It has often been supposed that the higher up on the ladder, the better and the more democratic the process is. Clearly being higher up on the ladder gives more influence but also more shared responsibility. It can mean that fewer can take part, for example a regulator needs to be independent from implementers of proposed actions. Thus, the idea that the public and stakeholders should take part in the decision processes as much as possible has its limitations and drawbacks.

Another approach is to use involvement methods that can support the normal (political, court, administrative, etc.) decision making processes and democratic institutions (representative assemblies, referenda, etc.) by vitalizing them and increasing the awareness and clarity about alternative ways of action. The ***safe space process*** (based on the RISCOM model) is designed for enhancing awareness and clarity in active dialogue between different stakeholders, see e.g. [13]. The stakeholders together form the process on the basis of agreed principles. Arenas are formed for clarification of issues and for enhancing the understanding between stakeholders about their arguments and positions, while safeguarding their integrity, thus maintaining their independence in the legal and political decision making processes. The approach has been implemented in different sectors and in different countries (Sweden [14], Czech Republic [13] and Poland [15]).

Independent of the approach and method selected, stakeholder involvement in risk communication will meet obstacles and challenges. It is supposed that citizens think that involvement is worthwhile but there are practical limitations since the individual may not have enough time and attention span left for participation which could mean that participation exercises become dominated by "professional" stakeholders (NGOs). Another problem is the long-time spans in many projects from plans to operation meaning that stakeholder involvement also needs to prevail for long times, in many cases over several election periods for political decision makers which normally are about four years. These are challenging factors which need to be taken into account already from the beginning.

5.5 Guidelines for stakeholder involvement processes

Those who intend to initiate a process for stakeholder involvement in risk communication may be government agencies, regulators, regional and local communities and implementing organizations. In an EU governance project in nuclear waste management area, ARGONA, recommendations were given for how a process should be set up and organized [16].

When setting up a dialogue process it will be beneficial to make use of different kinds of resources that are available to help guiding the process in the intended direction to achieve the goals. In this context it was highlighted in the ARGONA report that existing EU Directives, international conventions and national legislation should be seen as resources. For example, the Aarhus convention [17] is a resource for e.g. communities and NGOs that can be referred to when requiring access to information and participation.

The report also addressed the role of "mediators" of participation processes. Rather than simply wishing to educate the public about environmental dangers, the mediators are committed to involving publics and assisting them to recognize their own stakes in environmental problems. Mediators thus do not only assist in defining the context of public policies. They may also be crucial for how concerned parties or publics are constituted, and what role they are assumed to play in discussions over policy. Successful mediators define new arenas of risk governance, they draw people and things closer together, intensify interactions between them, and allow productive new combinations and alignments of people and things to emerge. A stakeholder wishing to start a dialogue process should, however, be aware that also mediators are actors on “the market of mediation”, and therefore the stakeholder should make him/herself aware of different approaches and define his/her own purpose with the mediation in order to be able to choose the best approach.

ARGONA emphasized that early stakeholder involvement brings big benefits. First it is a matter of fairness as it makes possible for all stakeholders to influence the process and to contribute with their perspectives at a stage when they still can be incorporated. Secondly, it provides not only an early warning system for potential conflict situations but also a chance to solve problems early. Thirdly it can prevent, or at least decrease the likelihood of, narrow early framing which later shows up to be insufficient. In that way early involvement provides perspectives that could make the entire process more effective saving financial resources and time.

In the PIPNA report [18] produced for the European Commission, the following basic principles are given for good practices on the participation of civil society, referring to European experiences:

- Provide a safe space for discussion;
- Give access of civil society to expertise to favour their engagement into the process while developing their own understanding of the issues at stake and preserving their autonomy;
- Have flexibility in the design of the dialogue process in order to give opportunity to the stakeholders to adapt the dialogue process to their needs and constraints;
- Organize the power sharing within the dialogue process;
- Develop the inclusiveness of the process to encourage the participation of all stakeholders who have an interest in or who would be affected by decisions;
- Ensure the independence of the dialogue process;
- Ensure the responsiveness of decision-makers engaged in the process;
- Develop a collective learning process in which every engaged person and/or organization should learn from other participants;
- Allow the participants to reframe the issues at stake;
- Ensure the accountability of the initiator of the process;
- Ensure the availability of adequate resources for supporting stakeholder engagement;
- Enable the participants to exert some reflexivity over the process itself, by assessing its quality on the course of the process in order to adapt it to emerging needs.

The most important phase of a stakeholder involvement process is the very beginning, even before the process has been formally started. The first signals the initiator sends to potentially participating stakeholders are critical for their decision to participate or not. First, who you are, for example an industrial developer or a safety authority, determines what you can do, what objectives and approaches are feasible, who can participate, etc. Secondly, the aim of the process must be properly communicated – to promise more than you keep for example about stakeholders influence on the decision making process will be counterproductive. The funding of the process must be transparent and acceptable for all participating stakeholders. Finally it must be realized that the process stands and falls with trust in the process itself. Various formal and informal signals are important for the trust, such as chairpersons´ and secretariats´ autonomy, neutral venues, etc.

5.6 Conclusions

Briefly, this paper leads to the following conclusions with regard to stakeholder involvement in risk communication:

- Societal decisions are always related to risks and benefits and they include factual and value-laden elements of both. A prerequisite for rational decision-making is awareness of all the relevant aspects, which includes not only the factual but also the value-laden issues.
- The combination of early too narrow framing in a decision making process, the consequential unawareness of the uncertainties and possible negative factors and fragmentation by interest groups is a risky situation for a high quality decision making process. Risk communication with stakeholder involvement can decrease the risk for this to happen.
- Quantitative decision analysis methods that include value-laden issues can be beneficial but should be used with care not to become just another form of expert dominated process.
- The idea that the public and stakeholders should take part in the decision processes as much as possible has its limitations and drawbacks as more influence also means more responsibility difficult to share between, for example, industrial developers and safety authorities.
- The safe space process designed for enhancing awareness and clarity in active dialogue between stakeholders avoids this problem as the dialogue arenas are used only for clarification of issues and enhancing the understanding between stakeholders. They maintain their independence in the legal and political decision making processes.
- Early stakeholder involvement is needed as 1) it is a matter of fairness as it makes possible for all stakeholders to influence the process; 2) it provides an early warning system for potential conflict situations; and 3) it can prevent the likelihood of harmful narrow early framing.
- Trust in the process is fundamental. Therefore, the first signals an initiator sends to potentially participating stakeholders are critical for success. His role in the decision making system determines what he can do and his objectives. The aim of the process must be properly communicated and its funding must be transparent and acceptable for all participating stakeholders.

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6 SUMMARY

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6.1 Introduction

This document provides the background, summarizes the presentations and the results of the round-table discussion, and tries to emphasize the potential implications of the Scientific Seminar on "Risk Communication", held in Luxembourg on 18 November 2015. It takes into account the discussions that took place during the seminar and during the subsequent meeting of the Article 31 Group of Experts, although it is not intended to report in an exhaustive manner all the opinions that were expressed. The document has been submitted for comments to the lecturers, as far as their contributions were concerned.

6.2 The Article 31 Group of Experts and the rationale of the RIHSS seminars

The Article 31 Group of Experts is a group of independent scientific experts referred to in Article 31 of the Euratom Treaty, which assists the European Commission in the preparation of the EU Basic Safety Standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. According to the Euratom Treaty and to their Code of Ethics, this group of experts has to give priority to the protection of health, to the safety and to the development of the best available operational radiation protection. For doing so, they have to follow carefully the scientific and technological developments and the new data coming from the world of research, particularly when these could affect the health of the exposed persons.

In this context, a Scientific Seminar is devoted every year to emerging issues in Radiation Protection – generally addressing new research findings with potential policy and/or regulatory implications. On the basis of input from the Directorate General Research of the European Commission and of information provided by individual members of the Article 31 Group of Experts, the Working Party RIHSS proposes relevant themes to the Article 31 Group that could be discussed during a subsequent seminar. After selection of the theme and approval of a draft programme by the Article 31 Group, the Working Party RIHSS deals with the preparation and the follow up of the seminar. Leading scientists are invited to present the status of scientific knowledge in the selected topic. Additional experts, identified by members of the Article 31 Group from their own country, take part in the seminars and act as peer reviewers. The Commission convenes the seminars on the day before a meeting of the Article 31 Group, in order that members of the Group can discuss the potential

1 Besides R. Huiskamp (who was acting as rapporteur for the seminar), the following members of the Working Party on Research Implications on Health and Safety Standards of the Article 31 Group of Experts contributed to the preparation of this overview: H. Janžekovič, L. Lebaron-Jacobs, F. Bochicchio, F. Hardeman, P. Krajewski, J. Pedroso de Lima, and P. Smeesters. They were assisted by S. Mundigl from the European Commission.

implications of the combined scientific results. Based on the outcome of the Scientific Seminar, the Group of Experts referred to in Article 31 of the Euratom Treaty may recommend research, regulatory or legislative initiatives. The European Commission takes into account the conclusions of the Experts when setting up its radiation protection programme. The Experts' conclusions are also valuable input to the process of reviewing and potentially revising European radiation protection legislation.

6.3 Key Highlights of Presentations at Scientific Seminar on Risk Communication

Tanja Perko – *Differences in Expert and Lay Judgements of Radiological Risk*

When communicating potential hazards to the public, it is important to understand that human behaviour is primarily driven by perception and not by facts. The expert and the general population usually disagree about the risk assessment. This is illustrated by the perceived risks related to nanotechnology where differences were observed in risk perception between the experts and the lay people[2]. Lay people's risk assessment was higher and showed less trust in authorities. However, the experts and lay people perceived similar levels of benefits.

Related to biotechnology, it was observed that experts see more benefits and less harm than lay people do. With regard to nuclear waste disposal, it was shown that there is a belief about differences in perception as part of a mental models approach. Experts believe that lay people are thought to have a high perception of danger and fear when thinking about radiation, and also for health effects caused by radiation whereas lay people believe that experts have a low perception of radiation risk that can be managed by technically feasible solutions.

However, previous research on risk perception is hampered by the fact that small groups of experts were used, often not topical experts in the field studied and the assumption that the experts know the most about the topic and that experts speak with one voice. Furthermore, no empirical studies are available related to nuclear technology and risk related to accidents.

A new study was carried out investigating the lay people's and experts perception of 5 scenarios of radiological risks: nuclear waste, medical X-rays, natural radiation, an accident at a nuclear installation in general and the Fukushima accident in particular, Over 330 professionals from Belgian nuclear research installations (only people entering the controlled area) were interviewed on risk perception and included a special group of 50 professionals occupationally exposed to >0.5 mSv/y. These results were compared with the risk perception of a representative sample of the Belgian population (n=1020). The study revealed that the experts and the general public disagree in risk perception for the 5 scenarios. The general public has a higher risk perception for all scenarios except medical X-rays exposure.

It was also noted that experts do not have a single opinion. In general, professionals exposed >0.5 mSv/y have the lowest risk perception for an accident in a nuclear installation, the Fukushima accident and nuclear waste. Radiological risk perception amongst exposed professionals is influenced by that they feel well protected, that there is sufficient control by the competent authorities on safety in nuclear installations and their number of years of experience in nuclear applications.

Risk perception was also topic of the EAGLE project, a Euratom FP7 "Coordination Action" on identification and dissemination of good practices in information and communication processes related to ionising radiation. It was shown that gaps between experts and lay

[2] In this text, "lay people" is used to group the so-called laypersons in the meaning of "a person not belonging to some particular profession"

people could be decreased by good communication and education. Lay people seem to miss being recognized as a competent stakeholder and they also miss empathy. Experts on the other hand often disagree and they can be biased due to a conflict of interest. Lay people can add important perspectives on risk perception.

With respect to risk communication the level of knowledge of the lay people seems to have a limited effect. Mutual learning about each other's mental model of ionizing radiation appears to be important. This will increase controllability and will also increase familiarity. It will develop a trust between stakeholders and will stimulate systematic information processing, all resulting in a shared problem ownership.

In the discussion following the presentation, a question was asked whether there are differences between countries in risk perception. A comparison in risk perception between Belgium and France revealed that there were no differences in risk perception or mental models. However, factors such as trust in Government or the wording of statements are influential.

John Billard presented by Richard Wakeford – *Risk Communication to Workers*

According to UNSCEAR the average annual dose to workers is: 4.8 mSv/y for workers above ground (radon), 2.7 mSv/y for aircrew, 1.8 mSv/y for workers in the nuclear fuel cycle (including mining), 0.5 mSv/y for industrial radiologists and 0.3 mSv/y for medical workers. Up to 2001 there are 175000 radiation workers in the United Kingdom (UK).

A recent epidemiological study (INWORKS) of over 300,000 workers indicates a radiation related risk of developing cancer but also a "healthy worker effect". Aircrew members have a relative high exposure to cosmic radiation but in the United Kingdom (UK) they are not considered to be radiation workers. If cancer develops in this group also their unconventional lifestyle needs to be taken into account.

In the UK, Ionising Radiation Regulations 1999 (IRR 1999) regulation 14 requires that all employers should ensure that radiation workers have appropriate training, get adequate information about the work, know the risks to health including risk to foetus and nursing child, take the appropriate precautions and comply with law.

However, in the UK the level of compliance to the IRR 1999 regulation 14 differs from one nuclear licensed site to another.

Risk communication is dependent on cooperation between regulators, employers and workers. There is joint interest to protect the worker and the employer in the conduct of its business. Trust is needed to provide the best communication. The effective worker representation in UK nuclear industry improves risk communication. Risk communication is also dependent on the understanding of the risk with respect to acute and late effects and compensation schemes should be communicated to all workers.

In this context, Convention 121 of International Labour Organization (ILO) requires that those workers who have developed cancer as a result of occupational exposure need to be compensated. Usually this compensation scheme will replace legal action. The basis of compensation is the worker's lifetime dose record, time of diagnosis and type of cancer and the fact that the effects of radiation on cancer development have been well studied.

In the discussion following the presentation, a question was asked about the number of workers that are compensated. In 2014, 1496 people applied for compensation, of which 156 received payments (in total 8.1 million pounds).

The compensation scheme is important for affected and unaffected workers. No more antagonism or conflicts. Workforce understands if there is an effect, there is an agreed compensation scheme supported by management and Union.

Regarding the criteria for compensation, the risk model of BEIR VII/UNSCEAR delivers the technical basis. On the basis hereof a calculation will be made of the percentage causation probability (CP) of the cancer by occupational radiation. Based on the CP compensation will be paid provided the CP is over 20%. When the CP is between 20-50% fractional compensation will take place and if the CP is > 50% full compensation will be made. A joint paper of ILO/WHO/IAEA on this topic will be published.

With this generous scheme there are no problems in UK with respect to compensation for occupational health effects,.

Julia Pearce – *Risk Communication in Radiological Terrorism*

When radiological and nuclear terrorism scenarios are compared, the former are generally considered to be more likely due to the high levels of security surrounding nuclear weapons. In general, Government is not eager to talk about these scenarios. The general public does not see differences between these scenarios.

Public perception of radiological terrorism is that such a scenario has the potential to kill hundreds to thousands of people. The public reaction can be a major determinant of the overall economic, social, physical and psychological impact of terrorist incident.

Factors that influence risk perception are voluntary versus involuntary, familiarity, controllability, fairness, natural versus technological, and natural versus dread risk. In addition factors like lack of information about probability of risks, heuristic risk versus risk analysis, expert agreement and proximity play a role.

By influencing risk perception, effective communication can improve post-terrorism outcomes in reducing unnecessary care seeking by unthreatened populations, enhancing the likelihood that populations at risk will take protective actions, reducing rumours and fear, and maintaining public trust and confidence. This is illustrated by two examples.

In the Goiania accident in Brazil where scavengers discovered a small Cs-137 source in an abandoned teletherapy unit, 4 people were killed and about 250 people were contaminated. Due to poor risk communication more than 110,000 people were monitored to confirm that they were not contaminated.

In contrast, the polonium poisoning of Mr. Litvinenko elicited a muted public response and was perceived as targeted attack. This was most probably due to an effective communication campaign indicating that risk to public health was geographically restricted.

The PIRATE project (Public Information Responses after Terrorist Events) is an EU-funded initiative assessing public behavioural intention and information needs following biological and radiological terrorism. Two (hypothetical) scenarios were used: a deliberate release of smallpox and the use of a radiological device hidden on a commuter train.

Using the focus group method, the information needs for and behavioural intentions to these scenarios were explored among the British and German public. Interventions like messages, leaflets intended to inform people about the risks associated with these threats and to encourage them to adopt behaviours that might be recommended by public health officials were devised and tested.

The key issues that were identified in radiological terrorism scenario focus groups were: low level of knowledge about radiation, no risk awareness, concern of the severity, contagious, pervasiveness of a radiological attack, a fairly resilient response of the participants, need for expert information and independent expert addressing existing concern.

The impact of the interventions reduced concern about cordon size, incident severity, and intention to unnecessary attend monitoring centres. In addition, it increased scepticism in relation to the independent scientist. Leaflets are considered as trustworthy but have a drawback: the public perceives that if a leaflet is printed, the situation must be really serious/severe.

Communication can be improved by recognition that information seeking and anxiety is to be expected and that provisions should be made for low risk patients seeking information and /or reassurance. Formal partnerships with media should be developed ahead of an event. The use of trusted communicators (and validators) is recommended.

In the discussion following the presentation, a question was asked about inclusion implicit information like personnel having personal protective equipment. Although the public is getting used to see this, it is an important factor.

Another question addressed the security aspects of the scenarios. In the PIRATE project a lot of concern was given to this issue and even the participants from the public were worried that exposing 'the generic public' to these scenarios might scare them.

Fiona Fox – *Risk Communication and the new Media*

The Science Media Centre (SMC) was established in 2002 after a number of public debates about controversial scientific issues, like genetically modified crops (GMC), bovine spongiform encephalopathy (BSE) and animal research. Its mission is to provide, for the benefit of the public and policymakers, accurate and evidence-based information about science and engineering through the media, particularly on controversial and headline news stories when most confusion and misinformation occurs. The philosophy behind SMC is "We'll get the media to do science better when scientist do media better". SMC is independent in governance and funding.

The SMC has about 3000 senior scientists in its database that are willing to interact with the media.

SMC philosophy is established by rapid reactions responding to breaking news using leading scientists, proving fact sheets, providing roundups which puts research into context and media briefings. These media briefings can be about giving background, emerging news, encounters with experts about a particular subject or in a case of an emergency.

The strategy has been proven to be successful in a number of cases like the Litvinenko poisoning incident, Fukushima nuclear disaster and geological disposal of radioactive waste.

During the discussion the question was raised how to encourage scientist to cooperate because they are involved in the research, can barely spare 2 weeks and are dependent on financial support. The cooperation is mainly obtained through conversation with scientists. For instance with GMC there was no cooperation until GMC was almost banned. Scientist had to engage otherwise the discussion about the subject would have terminated the research. Public engagement of scientist is nowadays often in the contract of scientists.

A lot of prominent experts are often employed in public institutions or Governmental Agencies and are restricted from speaking openly to the media.

Kjell Andersson – *Stakeholder Involvement in Risk Communication*

From a technical point of view risk can be defined as the product of probability and the consequence of an undesired event and is used in quantitative risk assessment (QRA). QRA of large technical systems is also used for risk-informed decision-making. However QRA cannot be the only source of information for decisions on a political level because it lacks social and societal factors.

Focus on QRA only in the early stage of technology development can lead to narrow framing by the technical community without much analysis of social consequences or even technical uncertainties. This can be avoided by stakeholder participation. The various issues involved could lead to fragmentation by interest groups that will complicate the decision making process. Stakeholder participation processes will help to minimize fragmentation.

Stakeholder involvement should start as early as possible in all phases of decision making to build trust and avoid narrow framing.

Organisation of stakeholder involvement can be done in different ways:

- Decide, Announce and Defend, relies only on information and trust in the information sender (which might be lacking)
- Let the stakeholders and the public take part in the decision making itself, relies on involvement, the assumption that citizens think that involvement is worthwhile and shared accountability which may be impossible for some stakeholders to take.
- Use existing decision making processes and democratic institutions, relies on representation.
- Stakeholder involvement to support existing decision making processes and democratic institutions relies on representation and the ability of the involvement process to increase the quality of decision making.

The ways of organising stakeholder involvement all have their own peculiarities and limitations.

One way to support the normal political decision making process, is to create a "safe space", an arena for clarification of issues and for enhancing the understanding between stakeholders about their arguments and positions, while safeguarding their integrity, thus maintaining their independence in the legal and political decision making processes. This can be done using a RISCOM process. Factors to take into account are: who are you, what is the aim of participation, what do you want, signals you send (funding, chairperson, secretariat, venues) and trust.

All these issues were illustrated in the PLATENSO project (EC FP7 framework program) to build a platform for enhanced societal research related to nuclear energy in Central and Eastern Europe. The results of the project showed a number of challenges in building stakeholder participation like lack of trust in government bodies, lack of interest of government bodies, dialogue is seen as another way of providing information, regulators are seen as proponents of nuclear power and stakeholders sometimes don’t want to participate. Approaches to stakeholder participation must take these challenges into account.

6.4 Summary of the Roundtable discussion

Tanja Perko, Richard Wakeford, Julia Pearce, Fiona Fox, Kjell Andersson, Horst Miska, Patrick Smeesters, Anna Friedl (Moderator)

The round table discussion started with two short presentations.

First, **Patrick Smeesters** addressed some challenging issues in risk communication. After the Fukushima accident, one of the touchiest ethical issues concerned the fairness, quality and adequacy of risk communication. Downplaying of the risk of health effects or even denying such risks by some experts or organizations have been frequently denounced and attributed to conflicts of interest. But there are also some underlying epistemological issues that are at stake: the misuse of the evidence-based approach and the questioning of the legitimacy of a precautionary attitude within the scientific work.

Evidence-based approach is currently become a dominant scientific paradigm, particularly in the medical field. The basic concern is to avoid concluding that a causal relationship exists before it is strongly proved. In other words, the main concern is avoiding the “false positives”. The problem is that, in the currently frequent new situations with potential long term effects, decisions are to be made while strong evidence is lacking. Such decisions must be based on all available data, even if uncertainties persist, and have to avoid also false negatives (dismissing of real effects). This means that a precautionary approach is relevant in science, with an attention for risk plausibility and not only for hard evidence, with a systematic search for surprises (“thinking the unthinkable”), particularly for possible long term effects, and responsiveness to the first signals (“early warnings”).

A fair communication requires then science-based comprehensive and balanced information, allowing for responsible and autonomous decision, as well by decision-makers as by population. Communication such as “no detectable (or discernible) effect is expected under 100mSv” or “situation is safe under 100 mSv” is misleading and unfair since it does not inform about radiobiological and epidemiological studies showing effects below 100 mSv.

Second, **Horst Miska** addressed risk communication during nuclear emergencies. Risk communication has two major problems: in “peacetime”, no one is really interested, but after an incident or accident, when risk communication turns into crisis communication everybody wants immediate answers to everything. The media will search for discrepancies in public statements. Coordination between responsible agencies is very difficult and time consuming. Therefore, his personal advice is that everybody only reports out of his own area of responsibility; then, the risk of contradicting statements is minimized. The US Environmental Protection Agency EPA provides a helpful brochure on the topic of communicating radiation risk[3].

A German translation[4] is available as pdf-version from the author (horst.miska@t-online.de).

During the roundtable discussion, a remark was made that there is an urgent need for harmonisation between EU countries in crisis communication after an accident. Is there a way to coordinate this? Mrs Perko answered that as coordinator of the EAGLE project she recognized that coordination is very difficult and almost impossible. The PREPARE[5] project came to the same conclusion with regard to crisis communication. Harmonising the curriculum of communication experts is possible.

It was argued whether one message/opinion is desirable.

With respect to risk, scientists speak the same language but the public does not always understand. It might be favourable to introduce the concept of risk and risk perception at schools.

Who is the real expert? Answer is not so easy, there may be restrictions and not every expert can be asked for their opinion. In the UK for instance experts working for the regulatory body are not allowed to give their opinion to the press.

Then the question was raised whether it would be desirable or necessary to define a safe risk level, for example at a dose of 100 mSv. In Japan after the Fukushima accident, many individuals experienced anxiety when fearing to have received a dose of 100 mSv. Horst Miska reacted by answering that the LNT model is an acceptable hypothesis in planned exposure situations to define strict dose limits, but after an accident in an emergency situation, when the source of exposure is not under control, dose limits are not applicable

[3] http://www2.epa.gov/sites/production/files/2015-05/documents/402-k-10-008.pdf

[4] Called „Information der Öffentlichkeit über Strahlenrisiken“

[5] PREPARE: Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe. Research project under the European Commission’s 7th Framework Programme, EURATOM for Nuclear Research and Training Activities (work programme 2012), Fission-2012-3.3.1, Grand Agreement Number 323287

and replaced by flexible reference levels, as defined by ICRP in a range of 20 to 100 mSv for the public. Differentiation between situations is required. An Expert reacted that it is also a matter of awareness of the public and gave the national strategy of communicating about radon as an example. It was also argued that "safe" does not mean "no risk", but that the risk is "acceptable" or "tolerable". In Japan, there was no trust in the Government.

In the discussion about the 100 mSv as safe dose, it was concluded that the fact that in most cases no statistically significant increase in cancer has been detected does not mean that there is no risk. Communication on this issue is therefore crucial. Scientists should include uncertainties and inconsistencies when addressing risk after an exposure to radiation.

It is a process of optimization and the communication hereof. Avoid oversimplifying the message. The medical doctors as trusted experts might play a role herein but they need to be educated and trained to do so.

With respect to new media, twitter, facebook, blogs are useful but don’t forget using the classic media.

7 CONCLUSIONS

Working Party on Research Implications on Health and Safety Standards of the Article 31 Group of Experts[6]

From the presentations and discussions, the members of the Working Party identified the following important issues.

Expert and non-expert judgement about risk differ and both are unaware of this fact. There are differences in mental models. Also instrumental or scientific rationality versus value rationality play a role in risk perception.

Experts among themselves also differ in their risk perception and don't speak with one voice. They may be biased or driven by their own interests. For a non-expert it is difficult to judge the credibility of experts. Radiological risk perception of experts/professionals is influenced by control and familiarity. Experts tend to emphasize false positives and ignore false negatives.

The gaps between experts and non-experts could be decreased by good communication and education. Non-experts seem to miss being recognized as a competent stakeholder and they also miss empathy. To bridge the gap stakeholder participation is recommended which avoids narrow framing and builds trust. An appropriate approach is to create a safe space, an arena for clarification of issues and for enhancing the understanding between stakeholders about their arguments and positions, while safeguarding their integrity, thus maintaining their independence in the legal and political decision making processes. However, stakeholders are not committed to find consensus thus maintaining interest groups with individual form of risk perception.

In addition, one has to consider that radiation protection – and therefore also the "expertise of the expert" – is largely based on dose (dose evaluation, dose reduction and optimization, etc.) rather than health risk (risk evaluation, risk reduction, etc.). This will also have some impact on risk communication and risk perception.

Risk perception of non-experts is influenced by trust, controllability, familiarity and fairness of the message. Trusted communicators are needed. This implies the availability of experts and regularly updated forms of information. In order to improve risk perception there is a need for balanced scientific information, which addresses both uncertainties (statistical and due to current lack of knowledge) and inconsistencies. Risk communication differs during 'peace time' when nothing is happening and during the crisis after an incident or accident. The availability of experts from governmental agencies for communicating about risk is considered to be helpful. Some professions, such as medical doctors or fire fighters, enjoy social trust within the population and could therefore constitute a trustworthy source of information. They could play an important role in risk communication. This requires, however, that these professionals receive appropriate education and training in radiation protection and radiation risks.

With respect to policy implications, there is a need for preparedness of risk communication dealing with radiation exposure during the onset, development and recovery phase of a

[6] The following members of the Working Party on Research Implications on Health and Safety Standards of the Article 31 Group of Experts contributed to the preparation of these conclusions: H. Janžekovič, L. Lebaron-Jacobs, F. Bochicchio, F. Hardeman, R. Huiskamp, P. Krajewski, J. Pedroso de Lima, and P. Smeesters. They were assisted by S. Mundigl from the European Commission.

crisis/incident/accident. This would involve improved interaction with both the classic and new media.

Risk communication should be promoted as part of a scientist’s job.

Numerous research needs were identified concerning the impact of risk communication on the general public. Topics like risk at low doses, risk uncertainty, numerical risk approach in relation to risk perception, dose justification and optimisation, the best way to engage stakeholders and the use of new media need to be addressed more extensively. In addition, how to communicate with disinterested populations needs attention and the way risk is perceived remains important. Risk should be put in perspective.

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