
Authors*

Tanja Perko

Approval information for current revision*

<table>
<thead>
<tr>
<th>Name</th>
<th>Outcome</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catrinel Turcanu</td>
<td>Approved</td>
<td>2021-05-07</td>
</tr>
</tbody>
</table>

Change log*

<table>
<thead>
<tr>
<th>Revision</th>
<th>Version</th>
<th>Status</th>
<th>Date</th>
<th>Description of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1</td>
<td>Approved</td>
<td>2021-04-30</td>
<td></td>
</tr>
</tbody>
</table>

*This automatically generated cover page shows references and document information as were available in the Alexandria document management system on 2021-05-07. Please refer to Alexandria for current and complete metadata, or to the document contents and/or author for additional information.
Assessing radiation risk perception by means of a European stakeholder survey

Sara Della Monaca 1*, Valentina Dini 1*, Sveva Grande 1*, Alessandra Palma 1,5*, Alan H. Tkaczuk 2, Rein Koch 2, Rein Murakas 3, Tanja Perko 4, Tatiana Duranova 5, Sisko Salomaa 6,7, Päivi Roivainen 6,7, Christine Willrodt 8, Mauro Grigioni 1, Simon Bouffler 9

1 Istituto Superiore di Sanità (Italian National Institute of Health), Viale Regina Elena 299, IT-00161, Rome, Italy
2 Institute of Physics, University of Tartu, Ostwaldi 1, EE-50411, Tartu, Estonia
3 Faculty of Social Sciences, University of Tartu, Lossi 36, EE-51003, Tartu, Estonia
4 SCK CEN Belgian Nuclear Research Centre, Boeretang 200, B-2400, Mol, Belgium
5 Nuclear Safety Division, VUJE, Okruzna 5, SK-91864, Trnava, Slovak Republic
6 STUK – Radiation and Nuclear Safety Authority, Laippatie 4, FI-00880, Helsinki, Finland
7 Department of Environmental and Biological Sciences, University of Eastern Finland, Yliopistonranta 1, FI-70210, Kuopio, Finland
8 Federal Office for Radiation Protection (BfS), Ingolstaedter Landstrasse 1, D-85764, Oberschleissheim, Germany
9 Radiation Effects Department, Public Health England, Harwell Campus, Oxfordshire, OX11 0RQ, United Kingdom

*These authors contributed equally

E-mail: alessandra.palma@iss.it

Received xxxxxx
Accepted for publication xxxxxx
Published xxxxxx

Abstract

It is increasingly recognized that stakeholder views can be essential to ascertain the credibility of those entrusted with protection of the public and workers against radiation risks, the robustness of the approaches to protection and the relevance of research underpinning radiation protection. The CONCERT European Joint Programme of radiation protection research included consideration of stakeholder views. These were surveyed by means of a publicly available survey that was made available in fifteen languages to help encourage responses from a wide range of European countries. The survey ran in 2017 and received some 1961 responses over many countries, though response rates varied widely between countries. The survey respondents were largely highly educated with many having a professional connection to radiation protection or the use of radiation in medicine or industry. Survey results indicated a high level of scientific/technical knowledge relevant to radiation protection and indicated a general trust of most actors involved in the radiation protection field, perhaps unsurprisingly given the nature of the sampled population. Most expressed a reasonable level of satisfaction with the information available to them on radiation risk, but there is clearly room for improvement. Additionally, the survey identified potential training needs amongst the groups responding. It is concluded that, while the survey results are limited by the non-representativeness of the respondents by comparison with the EU population as a whole, it has been successful in gaining insights into areas where
1. Introduction


Stakeholder engagement and communication strategies in radiation protection (RP) are an important consideration to ensure that the input and needs of relevant groups are addressed by the scientific community. This crucial aspect has been already highlighted by Perko et al [1], who emphasised the importance of the integration of key social and ethical considerations into RP, fostering collaborative approaches to research and innovation. Work Package 5 (WP5) within the CONCERT EJP was dedicated to this theme, and there is now a group within Europe dedicated to developing the social sciences with radiation protection to improve stakeholder engagement, SHARE (https://www.ssh-share.eu/).

This paper describes the development and results of a survey of the perception of radiation risks and research needs amongst stakeholders of a variety of backgrounds, this specific topic was classified as Task 5.3 within the larger WP5 of the CONCERT EJP. The goal of this survey was to promote more efficient interaction with civil society and the use of social media for public communication. This survey supported our intention to address from an RP perspective the interests and needs of the public, occupationally exposed people, and medical patients as well as professionals and those of the research community.

The public survey was developed taking inspiration from previous work [2, 3] on public risk perception and taking into consideration five categories of stakeholders: Occupational exposure, Medical exposure, Duty holders-decision makers, Specific categories of potentially exposed population, Cultural involvement or interest in radiation protection issues.

The present paper provides an overview of the CONCERT EJP public survey and its findings, including a description of the structure, implementation, dissemination, results, analysis, and main conclusions.

1.1 Importance of radiation risk awareness

The investigation of the perception of radiation risk awareness amongst the public is considered essential in a range of different scenarios. For example, as far as the medical field is concerned, it should be noted that the BSS Directive 2013/59/EURATOM [4] emphasizes the need of the practitioner to inform patients of the benefits and risks associated with radiation exposures. In fact, data from the literature show that understanding the resources and developing a comprehensive radiation safety program that addresses equipment, technology changes, and dose and procedure tracking is vital to protecting public health [5, 6]. Imaging professionals should seek information to combat any fears or misunderstandings of the risks associated with medical radiation exposures [5]. Moreover, a recent study performed in Ireland aimed to ascertain the Irish public’s level of understanding of ionising radiation from medical exposures, through a public survey [6]. The authors identified some knowledge gaps in the public’s understanding of radiation risk, suggesting that the justification of procedures should be emphasised and the benefits of an imaging exam should be highlighted; they found some confusion for the public over which modalities use ionising radiation, and at the same time a good awareness of increased sensitivity to ionising radiation in children. Their results could be useful for healthcare professionals in improving the effectiveness of communication with patients [6].

At the same time, it is interesting to investigate the perception of risk for occupationally exposed workers, those culturally involved/interested in radiation protection, as well as the relevant duty holders and decision makers. An exploratory analysis of Korean radiation researchers in the life sciences (biology, medicine, health physics, and epidemiology) revealed that the perception of risks associated with radiation exposures of less than 100 mSv is significantly associated with researchers’ experience level. Risk perception can be affected by many complicated factors including trust in the media’s news statements, personal experience, psychological acceptance, and regional customs. These factors should carefully considered to understand risk perception [7].

Moreover, the study of the perception of radiological risk amongst potentially exposed populations, for example, people living near a nuclear power plant, must also be considered. A recent study of those affected by the 2011 Tsunami in Japan and consequent Fukushima nuclear disaster shows that they suffered issues related to risk perception, well-being, stigmatization, and alcohol/tobacco use in the first 8 years after the disaster; results of this kind are important for a better communication could be improved, where professional training gaps are present and where research could help to build wider trust in radiation protection.
understanding of the emotional and behavioral responses to future nuclear/radiological disasters [8].

Finally, the European Commission has conducted Eurobarometer studies on the European public opinion on nuclear safety [9, 10], on electromagnetic fields [11] as well as attitudes towards radioactive waste [12]. However, there has not been previous surveys on the wider context of radiation protection and use of radiation in medicine or industry or exposure to natural radiation.

2. Methodology

2.1 Implementation of the survey

The formulation of questions used in the survey was based on the SCK•CEN and IRSN Barometers and modified to meet the specific requirements of the CONCERT EJP [3].

The first draft of the survey was formulated in English. Then, to reach as many people as possible, the language barriers were overcome by translating the text of the public survey into fifteen European languages. Translations were performed by volunteers drawn from the CONCERT EJP membership who were native speakers of each language. The platform used to manage the survey was Google Forms utilising a different link for each language version.

Of course, the same language version was planned to be used for different countries (e.g. Slovak version was used for both Slovak and Czech Republics). Finally, the survey links were spread in the corresponding country through several dissemination channels.

The list of the different language versions, together with their translators and contributors, is given in Table 1.

2.2 The structure of the public survey

The survey was divided into three sections each containing closed-ended questions (except one), which provided respondents with a pre-established list of answer options to choose from. These options were simple choices, such as "yes/no/don’t know/no answer", or multiple choice, with verbal rating scales of the Likert type (e.g.: strongly agree, agree, disagree, strongly disagree, don’t know/no answer). The questions fell into the following categories: socio-graphic properties, attitudes, specific knowledge.

Below is a detailed description of each section.

2.2.1 First section - Background

This first part of the public survey consisted of general questions relating to personal information about the responder, such as sex, age, place of residence, job and level of education, as well as the level of experience within the ionizing radiation and radiation protection field.

All the fields of this section provided valuable information about the background profile of the responder, and for this reason it was set as non-mandatory for privacy and ethical reasons.

<table>
<thead>
<tr>
<th>Language</th>
<th>Translators/contributors</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>All TG</td>
</tr>
<tr>
<td>Bulgarian</td>
<td>Nina Chobanova, CRMP, Bulgaria</td>
</tr>
<tr>
<td>Croatian</td>
<td>Ivica Plic, Marija Suric Mihic, IMROH, Croatia</td>
</tr>
<tr>
<td>Dutch</td>
<td>Merlo Arnaud SCK•CEN, Belgium</td>
</tr>
<tr>
<td>Estonian</td>
<td>Alan Tkacz, Reim Kech, Reim Murakas, Heleene Suija, Lotta Leemaa-Tuus, University of Tartu, Estonia</td>
</tr>
<tr>
<td>Finnish</td>
<td>Sisko Salomaa, STU, Finland</td>
</tr>
<tr>
<td>French</td>
<td>Merlo Arnaud SCK•CEN, Belgium</td>
</tr>
<tr>
<td>German</td>
<td>Christine Willrich, BFS, Germany</td>
</tr>
<tr>
<td>Greek</td>
<td>Retis Economides, EEAIE, Greece</td>
</tr>
<tr>
<td>Italian</td>
<td>Sara Della Monica, Valentina Dini, Sveva Grande, Alessandra Palma, Mauro Grigioni ISS, Italy</td>
</tr>
<tr>
<td>Latvian</td>
<td>Elina Pajuste, LU, Latvia</td>
</tr>
<tr>
<td>Polish</td>
<td>Michalik Bogdanow, GIG, Poland</td>
</tr>
<tr>
<td>Portuguese</td>
<td>Maria José Bação Madruga, IST, Portugal</td>
</tr>
<tr>
<td>Slovak</td>
<td>Tatiana Duranova, VUJE, Slovakia</td>
</tr>
<tr>
<td>Spanish</td>
<td>Almudena Real Gallego, CEMAT, Spain</td>
</tr>
</tbody>
</table>

Table 1. Different versions, and translator or contributors for each language

2.2.2 Second section - Radiation protection context

This section represented the core part of the public survey. It provided essential information about individual perception of radiation risk. For this reason, all the fields were mandatory. The section includes questions about the respondent’s attitudes towards science and technology, the satisfaction with the bodies and actors in the domain of radiation protection and the actions undertaken by radiation protection authorities and opinions on the communication channels about radiological and nuclear risk. A last question was added to the general section, in order to prepare the future consultation on the results of the research roadmap to help ensure that future scientific work is consistent with societal priorities. The drafting of a unified roadmap for radiation protection research is the responsibility of CONCERT EJP’s WP3. The willingness of the respondents in giving their opinion on this topic was investigated.

2.2.3 Third section - Experiences within radiation protection

After the general part, the respondents were invited to fill certain specific subsections, according to their roles and/or experience in matters relating to ionizing radiation and the radiation protection field. The subsections are addressed to the following categories of respondent:
2.3 Dissemination of the public survey

To guarantee strong publicity of the survey in as many European countries as possible, the involvement of the CONCERT EJP programme owners and managers was considered crucial in the dissemination of the survey. Most of the countries disseminated the survey through the following multiple routes: freely accessible web survey link shared via social media, as well as targeted e-mail distribution of the survey link to professional (like consumers and patient associations or mediator associations) and personal networks. Moreover, the survey was presented and published in different national and international conferences and workshops. The survey was launched on 31 May 2017 with a deadline for completion of 31 October 2017 though this was later extended to 31 December 2017. A total of 1961 replies were received at 31 December 2017. Answers were distributed as follows among the fifteen different language versions: Bulgarian, 24; Croatian, 87; Dutch, 3; English, 105; Estonian, 83; Finnish, 269; French, 21; German, 107; Greek, 38; Italian, 588; Latvian, 20; Polish, 21; Portuguese, 85; Slovak, 256; Spanish, 254.

2.4 Description of the sample.

The data concerning the respondents are derived from the answers to the questions asked in the first part of the survey, the background section. In the following, just an overview of the characteristics is reported. The respondents to the public survey were almost equally distributed between men (50.6%) and women (49.6%). Age of the respondents covered the range 18-87 with a clear prevalence in the range 40-59.

2.4.1 Country of residence.

The bar graph in Figure 1a shows the percentage of responses coming from people living in different countries, independently from the language version they used. This data is different with respect to the number of answers for language (previously reported), as expected. In particular, the English version of the questionnaire was filled by people from the United Kingdom but also from Norway (34 replies).

The most responding countries (number of replies >200) are Italy, Spain and Finland but from Figure 1b, where the number of replies per million of citizens is shown, it is clear that the response rate from the different countries is quite heterogeneous and that is an issue to take into consideration in the analysis.

For example, although Italy, Spain and Finland have the highest number of responses, nonetheless Estonia, Finland and Croatia result to be better represented. The category “Other (Europe)” includes replies from Belgium, Netherlands, Sweden, Ireland, Slovenia, Serbia, Hungary, Cyprus, implementing, defining, funding and/or managing research programmes in radiation protection.
Denmark and Romania, belonging to the European Community. The category “Other (not EU)” includes replies from Switzerland, Japan, United States of America, Australia, Canada, Algeria, Colombia and Argentina.

2.4.2 Place of residence.
Half of the respondents declared that they came from big cities and 21.7% declared to have ever been living close to a nuclear power plant (a radius of 20 km) in their lifetime. Of course, this percentage is strongly dependent on the country of origin of the respondent, e.g., nuclear vs. non-nuclear energy countries. As an example, only the 5.6% of Italians have answered affirmatively to the question, as Italy is non-nuclear energy country since 1987. In Finland, 30.6% of respondents said that they live or have lived within 20 km from nuclear power plants. However, Finland is sparsely populated and Nuclear Power Plants (NPPs) are typically located in remote areas and have less people living in the surrounding areas compared to other countries. Rossi [13] reports that there are less than 10,000 inhabitants within the 10 kilometres zone around the two sites in Finland, whereas there can be close to a million in some other countries. This means that there is a very strong bias towards respondents living close to nuclear power plants.

2.4.3 Education.
The sample was characterized by a very high level of schooling; indeed, 77% of the respondents have a university or post-university qualification. Among these, 84.5% have a degree in a scientific/technical subject, while the remaining 14.5% hold degrees in an arts/humanities/social science discipline. Of course, this high level of schooling amongst those responding makes the sample different from the 39.1% of those aged (30 - 34) y in the European Union (EU) who have completed tertiary education (data from 2016) [14] thus our sample was biased, most likely due to the chosen dissemination routes of the questionnaire.

2.4.4 Training in radiation protection field.
A specific question about the level of training in the IR and radiation protection field was asked and the results are shown in the Figure 2. A percentage equal to the 41% of the respondents declared to have received more than one form of training (selecting multiple answers). It is worth noting that, analysing the responses to a direct question (Have you ever had a job that involved the use or exposure to ionizing radiation?), 49% of the total of the respondents declares to have a job involving the use of ionizing radiation. This indicates a possible bias in the sample, which clearly includes many IR experts.

2.4.5 Roles dealt with ionizing radiation and radiation protection field.
An overview of the composition of the respondents and their roles in the radiation protection field is illustrated in Figure 3, from which it is clear that many respondents, about the 59.5%, had been subject to a medical exposure.

![Figure 2. Different kinds of training received in radiation protection field by the respondents. Multiple answers were allowed.](image1)

![Figure 3. Distribution of the respondents who recognized themselves in one of the mentioned categories. Multiple answers were allowed.](image2)
3. Results

3.1 General Part

The first question of the main section of the questionnaire, “General Part”, investigated attitudes of the respondents towards science and technology.

Figure 4 shows that almost the 50% of the respondents strongly agree that “Science and technology will make our lives easier” (46.6%) and also that future generations will have a better quality of life as a result of science and technology (43.5%). A strong agreement (41.8% percentage of answer “Agree”) is shown also with the statement “Science and technology development have unforeseen side effects that harm human health and the environment”. Finally, almost 33% of the respondents indicated that they believed science and technology have made life more dangerous.

The second question related to risk perception; in particular, for each respondent’s own relatives’ health (Figure 5).

The situations mainly considered at very high risk by the respondents are an accident in a nuclear installation (33.0% - “Very high”) and a terrorist attack with a radioactive source (30.9% - “Very high”), followed by air pollution, chemical waste and an accident in a chemical installation.

On the other hand, the lowest risk perception of the respondents was for Medical X-rays, CT Scans or PET for medical examinations but also the sterilization of food by irradiation.

Interestingly, the separate analysis for Italy and Finland showed very different results about the perception of risk.

In particular, the percentage of respondents who have high risk perception of an accident at a nuclear installation is indeed much lower in Finland than the overall result (20.4% in Finland with respect to 33% in all participating countries), while it is higher for the Italian respondents (42.3%).

The analysis for responses from Spain, shows very similar results to the results from Finland.

Figure 5. Risk perception towards relatives’ health about items involving, or not, ionising radiations. The bar graphs restricted to Italy, Finland and Spain are reported in panels a, b, and c respectively.
Nonetheless, at this stage only a qualitative analysis has been performed and the significance of each data, by means of the definition of levels of confidence should be estimated before drawing any conclusion (Figs. 5a, 5b and 5c).

The fields for which the benefits are considered higher than detriment (question “RBD- “Please select the items for which you think that the benefits are higher than detriments”) are mostly medical diagnostic examinations (Figure 6). Only slightly more than a half of the respondents considered the benefits of the high voltage power lines higher than detriments. Again, comparing the percentage of people considering that there is more benefit than detriment for nuclear installation, for countries non-nuclear energy countries like Estonia and Italy the percentage is rather smaller than the total.

![Figure 6. Selection of items for which responders thought that the benefits were higher than detriments.](image)

The attitudes towards the actors in the field of radioprotection were then investigated in this study. The actors taken into consideration are listed in Table 2.

<table>
<thead>
<tr>
<th>Table 2. Actors in the field of radioprotection</th>
</tr>
</thead>
<tbody>
<tr>
<td>National radiation protection authorities</td>
</tr>
<tr>
<td>Environmentalist organisations</td>
</tr>
<tr>
<td>Nuclear industry</td>
</tr>
<tr>
<td>The journalists</td>
</tr>
<tr>
<td>National Agencies/Institutes for nuclear safety or control</td>
</tr>
<tr>
<td>General practitioners</td>
</tr>
<tr>
<td>Medical personnel in hospital</td>
</tr>
<tr>
<td>The national agency for radioactive waste and enriched fissile materials</td>
</tr>
<tr>
<td>IAEA (International Atomic Energy Agency) in Vienna</td>
</tr>
<tr>
<td>Scientists from Universities / Public Research Institutes</td>
</tr>
<tr>
<td>ICRP (International Commission on Radiological Protection)</td>
</tr>
<tr>
<td>Scientists from private companies</td>
</tr>
<tr>
<td>The European Commission</td>
</tr>
</tbody>
</table>

Overall, it can be seen that, considering a percentage of more than 50% of the positive answers, of the thirteen actors identified, most are considered aware of public concerns about radiation by the respondents. Some of them are also considered technically and scientifically competent to point out the risks and benefits of the use of ionising radiation and that they are telling the truth about risks and benefits of the use of ionising radiation. In fact, it is interesting to underline that although the industries were considered aware and competent (59.7% and 54.7% respectively) they were not perceived to tell the truth (42.3%) in the opinion of the respondents.

On the other hand, the environmentalist organizations and journalists, despite being considered aware (64.8% and 39.3% respectively), were considered competent (26.7% and 6.2% respectively) and truthful in spreading the news about the radioprotection (25.4% and 8.0% respectively) in very low percentages.

Figure 8 shows the satisfaction with the actions that authorities undertake to protect the population against different risks (question: “RC - SATISFACTION WITH ACTIONS OF THE AUTHORITIES”). About risk such as “an accident at a chemical installation”, “a terrorist attack with a radioactive source”, “a terrorist attack with chemical/biological agents (or sources)” and “residues of radioactivity in food”, 30% of the respondents answered “Don't know/no answer” while there is...
rather high satisfaction for the actions undertaken by authorities in case of “medical X-rays” and “CT scans for medical examinations” (overall about 70%). Instead, respondents are rather dissatisfied with actions that authorities undertake in case of chemical waste, and to a lesser extent in case of radioactive waste.

Nonetheless, for four of the seven questions the sum of percentages of wrong answers and “don’t know/no answer” is more than the 25%, in two of the seven questions it is even close to 45%.

Finally, about the degree of satisfaction with the communication on the ionizing radiation received from different actors (question C - COMMUNICATION ABOUT IONISING RADIATION IN GENERAL), the respondents showed satisfaction towards national agencies/institutes for nuclear safety and towards scientists from universities, while they declared clear dissatisfaction towards mass media. Almost the same percentage of satisfaction and dissatisfaction towards medical personnel in hospital, general practitioners or dentists and nuclear industry was declared (see Figure 9).

Figure 8. Percentage of satisfaction with the actions the authorities undertaken to protect the population against the reported risks.

In Table 3, results of question AW - KNOWLEDGE ABOUT THE RADIATION PROTECTION DOMAIN are reported to make the distinction between the percentages of correct and wrong answers. It is clear that for all questions more than the 50% of the respondents gave the correct answer.

Figure 9. Satisfaction with public information related to IR in general.
Table 3. Distribution of answers to the question AW - KNOWLEDGE ABOUT THE RADIATION PROTECTION DOMAIN

<table>
<thead>
<tr>
<th>Correct answer</th>
<th>NO</th>
<th>YES</th>
<th>NO</th>
<th>YES</th>
<th>NO</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of correct answers</td>
<td>71.6</td>
<td>92.9</td>
<td>57</td>
<td>75.5</td>
<td>54.9</td>
<td>88</td>
</tr>
<tr>
<td>% of wrong answers</td>
<td>16.1</td>
<td>2</td>
<td>26.1</td>
<td>13.4</td>
<td>23.1</td>
<td>2.8</td>
</tr>
<tr>
<td>% of &quot;Don't know/no answer&quot;</td>
<td>12.3</td>
<td>5.1</td>
<td>16.9</td>
<td>11.1</td>
<td>22</td>
<td>9.2</td>
</tr>
</tbody>
</table>

3.2 Specific sections

3.2.1 Specific Section S1 OCCUPATIONAL EXPOSURE

The S1 section of the questionnaire was aimed at occupationally exposed workers to ionizing radiation. 830 people out of 1961 declared to belong to this category and consequently replied to this section.

From the answers received, it emerges that for both the implementation of radiation protection provisional plans and for professional training in radiation protection, the majority of the respondents declare to be satisfied. Nonetheless, for both questions there is still about the 22% who declared to be rather or very unsatisfied or did not answer at all (SP1 and SP2, Figure 10).

Respondents indicated that they were satisfied with the different learning materials used, in particular with official documents and books, but also with practical experience on field (Figure 10). Nonetheless, as in the previous question, there is still about the 30% or even 35% of respondents who declared to be rather or very unsatisfied and the percentage of “don’t know/no answer” is in some cases very high. The option “other” was removed from the graph. Moreover, to specific question (SP4) a very high percentage of respondents (73%) declared that they considered the guidelines a useful working tool.

Finally, from responses to question SP5 it emerged that occupationally exposed workers think that issues concerning regulations, early and late radiation effects and the use of personal and collective protective equipment require further attention in the professional training. This suggests that there are opportunities to improve and increase the provision of training for professionals in each of these areas (Figure 10).

The most frequent request emerging from the answers to question SP6 (open comments about SP5, “What’s the field you feel more necessary to be deepened in the professional training?”) was the strong desire for more information concerning early, intermediate and late effects caused by acute and chronic radiation exposure. This need is particularly felt by physicians who are often questioned about this issue and do not feel confident in giving clear and indisputable answers.

Another issue concerns individual and collective protection devices, which are often misused or not used at all mainly because of the lack of appropriate practical training. It was observed by some respondents that professional trainers are sometimes expert in radiation protection but not very familiar with practical aspects of the use of protection devices. In addition, the need was identified for more education and training in verification of radiological safety plans and real time simulations in case of radiological emergencies situations.
Figure 10. Level of satisfaction of occupationally exposed workers (a) and exposed workers' opinion about the field that they should be more deepened in the professional training (b).

Figure 11. Percentage of the degree of patient satisfaction with the various steps of informed consent (a) and percentage of answers about the procedures for which respondents would like more information (b).
Besides the practical training about protection devices, the need for a deeper knowledge and understanding of radiation protection rules emerged, possibly following the updates of the radiation protection laws in order to keep workers constantly aware of the legal scopes of the actions taken. An important issue linked to this aspect is the accessibility to the radiation protection norms, too often written exclusively in English, thus not easily accessible to everyone. In this respect, it was also indicated that an increase of the communication of RP experts with journalists, NGO and public could help in view of a clear and wider explanation of the RP rules.

3.2.2 Specific Section S2 MEDICAL EXPOSURE

The S2 section of the questionnaire was aimed at investigating opinion and attitudes related to medical exposure to ionizing radiation and only people (860 out of 1961) that have declared to belong to this category in BG10 or answering to BG7 replied to this section.

The Table in Figure 11 shows the percentage of satisfaction with the different steps of the Informed Consent (question SP7).

Informed consent is a process for getting permission before conducting a healthcare intervention on a patient, for conducting some form of research on a patient, or for disclosing a patient’s information. The most significant data is that 40.1% of the respondents consider themselves rather satisfied of the description of the clinical issue and suggested treatment. This percentage decreased considering other aspects, e.g. “Discussion on alternatives to the suggested treatment (including the option of no treatment)”; “Discussion on risks and benefits of the suggested treatment (and comparing them to the risks and benefits of alternatives)”; “Assessment of the understanding of the information provided, and thereby consent”. In particular, the percentage of satisfaction is almost similar to the percentage of dissatisfaction. In SP8 question (Figure 11) it was asked for which procedures, among those listed, respondents would like to have more information. It came out that the percentage is higher than 40% for each procedure. In particular, the diagnostic tests for which respondents would like to receive more information are CT scans (60.9%) followed by Medical X Ray (55.5%) and Interventional Radiology (48.5%). Interestingly, the PET is the procedure with the lowest percentage of responses (43.7%).

Figure 12. Level of satisfaction of duty holders and decision makers with communication channels in scientific research field (a). Opinion about the link of a more direct involvement of the population and the facilitation of the work of duty holders and decision makers (b) and opinion on the most useful tools to actively involve the population. Multiple answers were allowed (c).
Figure 13 Percentage of satisfaction of potentially exposed population with the quantity (a) and quality (b) of information about radiation risk received by the authorities. Table (c) reports on communication channels by which the responders, who claimed to be in contact with other people potentially exposed, have chosen to exchange information within the association. Multiple answers were allowed.

Figure 14 (a) Opinion of the respondents (Specific Section “Cultural involvement or interest in radiation protection issues” on the main sources of information about radiological and nuclear risk. Table (b) reports on the number of multiple choices selected by respondents. Opinions on the most important criterion to decide whether a source is trustworthy and on the availability of sources of comprehensible and reliable information about radiation protection and radiation risk are reported in panels c and d, respectively.
3.2.3 Specific Section S3 DUTY HOLDERS-DECISION MAKERS

The S3 section of the questionnaire was aimed at the duty holders-decision makers category (e.g. general practitioners, industrial managers, regulators…), and only people that have declared to belong to this category in BG10 replied to this section.

Out of 257 respondents, 51.0% considered themselves satisfied and 12.1% very satisfied with the communication channels with the scientific research field (SP9, Table in Figure 12), while 43.3% and 22.2% are very and rather unsatisfied respectively (10.5% of respondents don’t known); a very high percentage (80.0%) think that the quality of his work would take advantage from a correct radiation protection culture spreading among the population (SP10); only 10% of respondents think that it doesn’t take advantage and another 10% did not provide any answer (option “don’t know/no answer”).

Moreover, in their experience a more direct involvement of the population, already in the early stage, could make a radiation protection decision process easier and more efficient (54.1%). In this case, the number of people who did not provide a specific answer was slightly higher (15.4%) (SP11, Figure 12).

While these responses can be viewed as generally encouraging with respect to communication to decision makers, there is clearly room for improvement to try to reduce the numbers indicating ‘very’ or ‘rather’ unsatisfied that in sum amount to more than 25% of respondents.

Among those who answered yes to question SP11 (140 respondents) the 46.3% considered forum the most useful tool (SP12, Figure 16) to actively involve the population compared to meetings, working groups and round tables (lowest percentage, 13.6%)

3.2.4 Specific Section S4 SPECIFIC CATEGORIES OF POTENTIALLY EXPOSED POPULATION

254 people out of 1961 declared to belong to category of people potentially exposed, e.g., people living near a nuclear power plant. Regarding the degree of satisfaction in relation to the quantity and quality of the information about radiation risk received from the authorities, 34.8% and 31.2% of the respondents (229, 230, respectively) consider themselves rather unsatisfied (Figure 13 a and b). Nevertheless, the 59.9% of respondents felt adequately protect from ionizing radiation exposure risks and the 45% said they were not in contact with others who are in the same situation of potential exposure (Questions SP15 and SP16, data not shown). Finally, the last question SP17 “If you answered yes to SP16 question, in which way you exchange information with the association?” allowed multiple answers. The 56% of those who answered affirmatively to the SP16 question (87 respondents) selected only one option and 22% did not respond. Most of the respondents declared to be in contact with others in the same situations of possible exposure to ionizing radiation through social media, secondly with periodical meetings and mailing lists (see Table c in Figure 13).

3.3.5 Specific Section S5 CULTURAL INVOLVEMENT OR INTEREST IN RADIATION PROTECTION ISSUES

551 people out of 1961 declared to belong to category of cultural involvement or interest in radiation protection issues. 71% of these respondents uses scientific journals as the main sources of information, perhaps suggesting that respondents’ area largely drawn from a professional/scientific background; 56% use websites, blogs, and e-magazines for science dissemination (Figure 14 a). Only 344 respondents answered question SP19 “What is the most important criterion do you use to decide whether a source is trustworthy or not?”. For these respondents the main criterion for choice to decide whether a source is trustworthy is “competence” (63.4% as shown by the pie graph in Figure 14 b) Finally, out of 514 respondents at the SP20 question “Do you generally find sources of comprehensible and reliable information about radiation protection and radiological risk?”, 43% finds the sources comprehensible and reliable “sometimes”, whereas 37.7% “often” (Figure 14 c). Surprisingly, only 1.8% answered that the sources of information are never comprehensible and reliable.

4. Discussion

The analysis of the results brought to light, a posteriori, some limitations of the survey structure.

The first, and more relevant one, is the polarization of the survey sample towards a high level of education in radiation protection field. It is evident that respondents are unbalanced as many of them are involved in IR and RP activities; 33% of the respondents declared to have had some training in RP at university level, which is not very representative of the general public picture. Some possible reasons of this imbalance include: i) only people already working or dealing with IR are interested in answering questions about RP (especially in countries without nuclear energy production); ii) the dissemination of the survey through CONCERT EJP contacts may have tended to involve acquaintances, colleagues and friends working in the IR and RP scientific fields.

Among others, this aspect is reflected by a generally positive attitude towards science and technology and a relatively low perception of risk about ionizing radiation, with the exception of significant events such as accidents at nuclear installations or terrorist attacks with radioactive sources. The
participants indicated a general trust of most actors involved in the radiation protection field, except for journalists or scientists from private companies when reporting on IR and RP issues.

Nonetheless it is surprising, especially considering the high level of education of the survey sample, that only 64% of survey participants considered high voltage power lines as providing more benefits than detriments. A possible explanation for this is that respondents consider as detriment other factors than electromagnetic fields, e.g. land use or how a power line next to a house may impact the value of property (the effect can be considered beneficial by some individuals, e.g. by those who are happy to be connected to the grid for the first time, or detrimental, e.g. by those who are frightened about the health effects of the power line or bothered by its negative aesthetic impact on the landscape).

Another limitation of the survey also concerns sampling. The distribution of responses within Europe is not representative of the relative population sizes in each country, as some countries had significantly larger response rates than others, and this was not related to population size. This has an impact on the risk perception: as an example, it came out that a different perception of risk for nuclear accidents appears in countries where NPPs are present (like in Finland and Spain) and countries where they are not (like in Italy). In the former, the fear of a nuclear accident is much lower than in the Italian case.

Sample heterogeneity is the possible cause for the ambiguity in the interpretation of some questions; for example, the concept of “small village” may be different in Finland or in Italy, although this is not an easy point to solve.

In general, a posteriori, it became clear that some questions were cumbersome, assuming too much prior knowledge and/or experience from survey participants. As an example, from results of question “AW - KNOWLEDGE ABOUT THE RADIATION PROTECTION DOMAIN” (Table 3), it is clear that for all questions more than the 50% of the respondents gave the correct answer. Nonetheless, for four of the seven questions the sum of percentages of wrong answer and “don’t know/no answer” is more than the 25%. In two of the seven questions it is even close to 45%. These results are quite surprising, especially considering that almost half of the respondents declared to work in the ionizing radiation field.

Finally, some messages for future EU programmes and RP European platform may be extracted from the survey analysis.

Concerning medical diagnostic examinations, they are generally considered as providing more benefits than detriment, even though ways to improve the provision of information on medical procedures might be considered by the EURAMED platform in the future, as the satisfaction of survey participants was not very high in that regard.

Similarly, a large proportion of respondents reported “never” or “sometimes” to the specific question “Do you generally find sources of comprehensible and reliable information about radiation protection and radiation risk?”; one of the most crucial ones. This indicates a gap in the available provision that future EU programmes or the RP European platforms should consider in the future.

5. Conclusions

This work only partially achieved its goal of undertaking to provide an overview of key trends in perceptions of the public, occupationally exposed individuals, and medical patients. In fact, a sample polarization was observed due to the prevalence of ionizing radiation specialists among responders, in particular researchers and health professionals (medical physicists, physicians, …). Nonetheless, in view of a more extended survey, this can be taken as a good probe for opinions and perceptions among ionizing radiation workers.

It has been carried out mainly by physical and life scientists active in the IR and RP fields, with some guidance from social scientists.

An area of future research could include a more detailed study implementing rigorous sampling (i.e. hiring professional polling firms) and advanced social analysis techniques, in order to extend the number of non-specialist responders and thus to provide a framework for a more reliable and valid representativeness of the actual social composition.

The main result of the survey was a general view that there is a widespread lack of information about ionizing radiation risk available and a subsequent lack of trust in institutions and professionals. This outcome may serve as a basis for professionals, researchers and decision makers to improve training programmes, information tools and communication channels in the RP field. These suggestions are in line with what was already suggested by Perko et al. [1], who promoted an holistic approaches for governance of radiological risk, together with the need of stakeholder engagement in RP research and development, policy and practice.

Acknowledgements

This work is supported by the EJP-CONCERT (European Joint Programme for the Integration of Radiation Protection Research) of the EURATOM research and training programme 2014-2018, under the grant number No. 662287.

We thank Merlo Arnaud (Belgium), Maria José Bação Madruga (Portugal), Nina Chobanova (Bulgaria), Sotiris Economides (Greece), Heleene Suija (Estonia), Lotta Leesmaa-Tuus (Estonia), Boguslaw Michalik (Poland), Marija Suric Mihic (Croatia), Elina Pajuste (Latvia), Ivica Plric (Croatia), and Almudena Real Gallego (Spain) for the translation of the survey to their native languages. Furthermore, we thank Paola Fattibene, Antonella Rosi, Antonella Tabocchini, Heleene Suija, Lotta Leesmaa-Tuus
and Johanna Vahtola for the fruitful discussions in developing the survey.

References


