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Towards a strategic research agenda for social sciences and humanities in radiological protection

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Abstract:

Reflecting a change in funding strategies for European research projects, and a commitment to the idea of responsible research and innovation in radiological protection (RP), a collective of research institutes and universities have developed a prospective Strategic Research Agenda (SRA) for Social Sciences and Humanities (SSH) in radiological protection. This is the first time such a research agenda has been proposed. This paper identifies six research lines of interest and concern: 1) Effects of social, psychological and economic aspects on RP behaviour; 2) Holistic approaches to the governance of radiological risks; 3) Responsible research and innovation in RP; 4) Stakeholder engagement and participatory processes in RP research, development, policy and practice; 5) Risk communication; and 6) RP cultures. These topics were developed through broad stakeholder consultation, in conjunction with activities carried out in the framework of various projects and initiatives (EU H2020 CONCERT programme, the EU FP7 projects OPERRA, PREPARE and EAGLE, the 2015-2018 RICOMET series of conferences, and the 2014 and 2016 International Symposia on Ethics of Environmental Health); as well as through dialogues with members of the European radiation protection research communities. The six research lines open opportunities to integrate a range of key social and ethical considerations into RP, thereby expanding research opportunities and programmes and fostering collaborative approaches to research and innovation.

Keywords: radiological protection, ethics, social sciences and humanities, strategic research agenda, responsible research and innovation

I. Introduction

In this article, we present the contours of a Strategic Research Agenda (SRA) for the Social Sciences and Humanities (SSH) in radiological protection (RP). Despite an increased institutional recognition of the need for SSH research in radiological protection, SSH involvement in the field remains fleeting and dispersed (Van Oudheusden, Turcanu, and Molyneux-Hodgson 2018). Building a more robust role for SSH in RP would open opportunities for scientific research communities (e.g. experts in radiobiology, dosimetry, radioecology) to integrate societal and ethical considerations into radiological protection work. Moreover, this would lead to expanding research options and the fostering of collaborative and co-creative approaches to research and innovation.

In recent decades, SSH researchers in Europe and beyond have demonstrated how social studies can fruitfully inform risk governance and clarify the societal understanding of radiological protection issues, for instance in relation to public response to and engagement in radioactive waste management (Schröder, Bergmans, and Laes 2015, Perko et al. 2012, Jenkins-Smith et al. 2011, Dubreuil, Baudé, and Mays 2013, Bergmans et al. 2014). Other studies shed light on public risk perception of industrial uses of ionising radiation, such as food sterilisation (Turcanu and Perko 2014); identify societal constraints related to environmental remediation and decommissioning processes (Perko, Monken-Fernandes, et al. 2017); and raise public awareness about radon (Lofstedt 2018, Hevey 2017). Research has been undertaken to stimulate mutual learning and contribute to radiation safety and security by identifying and addressing mismatches between emergency management plans and practice (Prezelj et al. 2016, Malesic et al. 2015, Liland and Raskob 2016, Schneider et al. 2016); pinpoint new security challenges (Becker 2004); and to propose novel ways to manage informed consent in the medical field (Friedrich-Nel and Munro 2015). Social studies — often in a comparative perspective across risky objects or technologies, and/or cultural contexts — also clarify how people interpret and take decisions in the presence of radiation related risks. This work highlights, for instance, factors influencing public concern about ionising radiation (Železnik et al. 2016), such as the perception of uncontrollability, involuntariness, invisibility and having potentially catastrophic consequences (Slovic et al. 2000). The direct contribution of SSH practitioners has been recognized to be valuable in the societal and scientific governance of contentious issues related to radiation risks to human populations and the environment, including in post-accidental exposure situations (Bréchignac et al. 2016, OECD/NEA. 2011, OECD-NEA 2003).

These research studies “open up” (Stirling 2008a) radiological protection to society by questioning RP concepts, programmes and policies, and by incorporating social needs and considerations into science, technology and innovation (Stirling 2008b, Felt and Wynne 2007). More than simply a critique of radiological protection, social studies are an invitation to develop avenues for systematic collaboration between natural scientists and social scientists, and between technical and non-technical communities.. The potential contribution of SSH is acknowledged by the existing European RP research

and technical platforms[1], by various projects in the radiological protection field, for instance RISKEDU[2] (Wojcik et al. 2018), and by CONCERT – the European Joint Programme for the Integration of Radiological Protection Research. As stated in the Public Declaration following the RICOMET 2016[3] Conference, *"[m]any radiological protection fields could profit from social science and humanities input, which could help cover knowledge gaps in complex radiological issues. The practical role of ethics, education and economics in decision making also needs further elaboration."* [14: p.1]

The aim of the SRA, therefore, is to contribute to the improvement of the radiological protection system by coordinating SSH research in radiological protection; supporting education and training; building stakeholder involvement, knowledge management and sharing; and identifying SSH state of the art across disciplines. Enabling SSH research to play a fuller and stronger role in RP through a coordinated SRA mechanism will ensure that societal perspectives on research, policy and practice related to RP will be acknowledged and accounted for.

The members of the collective which has authored the SRA (see Appendix 1) share a commitment to the ideals of *Science with and for society* and to *Responsible Research and Innovation*, both of which emphasize the need for collective, inclusive and system-wide governance involving all relevant stakeholders (Owen, Macnaghten, and Stilgoe 2012). This development coincides with increasing interest in the ethical aspects of radiological protection as reflected, for instance, in the most recent publications of the International Commission on Radiological Protection (ICRP 2018).

The underlying principles that inform the SRA are that:

- SSH can support existing and future research, policy and practice, in all areas relating to radiological protection, to better take into account the concerns, values and needs of a wider range of stakeholders, including citizens;
- SSH research should be coordinated, shared and integrated into existing research and development (R&D) on radiological protection; hence, collaboration with the European radiological protection platforms and associations must be an integral component of the agenda;
- Research relating to RP should be conceived of as transdisciplinary and inclusive, integrating citizen, science and stakeholder input into research and innovation from the start.

With these principles in mind, the SSH SRA identifies priorities for future European Commission-supported SSH research, and beyond, in the field of radiological protection. The SRA is structured along six research lines addressing issues that are relevant for all existing European radiation protection

[1] Multidisciplinary European Low Dose Initiative (MELODI), European Radioecology (ALLIANCE), European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS), European Radiation Dosimetry Group (EURADOS) and European Alliance for Medical Radiation Protection Research (EURAMED), European radon association (ERA), The European NORM Association (ENA).

[2] RISKEDU : How can teachers support the development of scientific literacy through teaching about risk and risk-assessment ; http://www.riskedu.se

[3] RICOMET : Conference on Risk Perception, Communication and Ethics of Exposures to Ionising Radiation http://ricomet2019.sckcen.be/

research platforms (MELODI, ALLIANCE, NERIS, EURADOS and EURAMED), as well as topics of wider interest in the radiological protection area.

The SRA and will be regularly updated in light of changing stakeholder needs, as identified by research performed by the collective's members, under other platforms or in the international research community. Effective adaptation will therefore require continuous engagement of the SSH community in RP and ongoing interactions with all concerned parties, particularly the technical and research platforms.

In the following sections, we outline the state of the art of SSH research on RP, briefly describe the process of SRA development, and then present the scope and topics of the SRA, subsequently identifying the initial top priorities. We conclude by emphasising the need for ongoing and integrated SSH research on RP, for the benefit of society.

II. Current Status of Social Sciences and Humanities in radiological protection research

The field of radiological protection is challenged by particularities of ionising radiation (e.g. scientific and societal uncertainties, different perceptions of risks, societal trust issues) and the evolving societal landscape (e.g. rise in social media, active citizenship). The assessment of health effects from low radiation doses is confronted with the complexity of assessing causal and temporal relationships, alongside sources of uncertainty. This is not only due to limits of the models and data, but also to the inherent boundaries of radiation protection knowledge (Renn 2008).

While SSH research has been conducted for many years on multiple aspects of radiological risk, this research is fragmented and often circumscribed by input from actors beyond the SSH community (Lazo et al. 2016). Therefore, SSH research has addressed in depth only some areas of relevance, directly or indirectly, related to radiological protection, whereas many areas have remained largely unexplored. Understanding how societies have engaged (or not) with nuclear energy and radioactive waste management has been the object of several studies (Bergmans et al. 2014). Recently the relationships between societies and actors in the nuclear energy sector, and how these have changed over the course of the past 60 years, have been investigated from historical and sociological perspectives (HONEST[4]). Linguistic and discursive analyses have been conducted mainly in relation to nuclear emergencies (PREPARE[5]), while research on techno-cultural questions on the preservation of records, knowledge and memory of nuclear waste across generations has been undertaken by the OECD Nuclear Energy Agency (RK&M[6]). Extensive literature has addressed the perception of radiological risk and its influence on trust, attitudes, or governance of ionising radiation applications and their life cycle (Slovic 2012, Sjoberg 2004, Visschers and Siegrist 2013, Perko 2014, Perko et al. 2015). However, there is a dearth of studies addressing these factors in specific long-term exposure situations such as those

[4] HONEST: History of nuclear energy and society, http://www.honest2020.eu
[5] PREPARE: Enhanced emergency preparedness and response for nuclear and radiological incidents https://www.eu-neris.net/projects/prepare.html
[6] RK&M: Preservation of Records, Knowledge and Memory across Generations https://www.oecd-nea.org/rwm/rkm/

relating to Naturally Occurring Radioactive Material (NORM), radon in homes, legacy sites, or recent applications of ionising radiation in the context of food sterilisation or security threats. In sum, while different SSH disciplines have addressed some areas of RP to varying levels of detail, there remain large gaps in the knowledge base and a lack of integration of knowledge across domains.

A gap is also observed between state-of-the-art SSH concepts, theories and outcomes and their rate or rigor of application in the radiological protection field. Although a number of national and international recommendations and legal requirements for stakeholder engagement in radiological protection have been developed (e.g. Basic Safety Standards, Aarhus Convention, IRPA guiding principles), there remain gaps between those policies and actual practice, as highlighted for instance by the 'Aarhus Convention in Nuclear' initiative conducted by ANCCLI[7] and European Commission DG-ENER from 2009 to 2012 (UNECE 2013), and the FP7 European projects EAGLE[8] and PREPARE (Perko, Raskob, and Jourdain 2016).

From a methodological perspective, there is insufficient dissemination of reliable and validated quantitative measurement scales for concepts relating to radiological protection. There is a need to harmonise qualitative research protocols and disseminate already existing, systematic, and transparent protocols for qualitative research. Such research protocols may concern, for instance, media studies, living- laboratory observations, and 'social laboratory workshops'. Currently, there are no publicly accessible databases of methods or tools for SSH research on radiological protection. Hence, there is methodological development yet to be undertaken.

Social sciences and humanities can lend insight and method to bridge gaps between technical experts and wider society in complex radiological issues (Perko 2014). SSH can also facilitate the development of RP research programmes that take into account: responsible research and innovation imperatives; citizen-centered RP governance (e.g. citizen science, environmental citizenship); vulnerability and resilience of societies and individuals; and cultural perspectives on technical solutions for radiological protection. The SSH SRA presented in Section IV below addresses these and other areas and proposes new research lines and topics with a view to improving the radiological protection of individuals and society.

III. Development of the SRA

The research topics to be included in the SRA were collected through several activities carried out in the framework of the H2020 CONCERT project (http://www.concert-h2020.eu, specifically WP 2.6) and the FP7 projects OPERRA[9] (Perko, Turcanu, and L. 2015), PLATENSO[10] (Meskens 2016), PREPARE (Schneider et al. 2017), and EAGLE (Perko, Zeleznik, et al. 2016). The topics were further developed using a stakeholder consultation and dialogue approach. This process was initiated by social scientists at the annual RICOMET conferences (2015, 2016, 2017 and 2018), and the International Symposia on

[7] ANCCLI: The Association Nationale des Comités et Commissions Locales d'Information; http://www.anccli.org/

[8] EAGLE: ENhancinG stAkeholder participation in the GovernancE of radiological risks for improved radiation protection and informed decision-making; http://eagle.sckcen.be

[9] OPERRA: Open project for the European radiation research area; https://cordis.europa.eu/project/rcn/109481/en

[10] PLATENSO: Building a platform for enhanced societal research related to nuclear energy in Central and Eastern Europe; http://www.merience.eu/en/ortfolio-items/platenso-2013-2016

Ethics of Environmental Health (2014 and 2016) and included also other dialogues with members of the radiological protection research platforms. The first meeting of the persons engaged in the SRA collective took place in June 2016 at the RICOMET conference in Bucharest and an outline SRA was produced. The refinement of research topics identified through a series of dialogues was further discussed at the September 2016 Radiation Protection Week in Oxford with members of the CONCERT task group, SSH community and technical platforms, and resulted in an early draft of the SRA document. Following these interactions, a consensus was formed through discussion as to the most urgent topics for SSH research and the principles that would underlie the SRA work.

A systematic verification of the research priorities was conducted in June 2017 through an email-based consultation of 1400 individuals from the RP field. Respondents were asked to share their opinions, remarks and advice on the existing version of the SRA. They were, moreover, invited to participate live or online in a dedicated discussion and debate at the 2017 RICOMET conference in Vienna. At that session, the collected comments and the existing SRA version were discussed by 130 physically present delegates, and live streamed from the IAEA venue using technology that allowed distance-attendees to submit further input in real time.

Toward the end of 2017, the first steps to build a joint roadmap for radiological protection research were taken by the scientific platforms (Impens et al. 2017). At this time, a specific challenge for SSH was identified and integrated into the draft Joint Roadmap for Radiation Protection Research: "Enhancing integration of radiation protection science with society" (Salomaa et al. 2017).

By using a range of events and processes for engaging the SSH community and stakeholders, a robust SRA has been developed. In the following section, we present the key features of this Strategic Research Agenda, as agreed upon by the aforementioned contributors and based on the priorities identified in the consultations.

IV. Strategic Research Agenda (SRA) for Social Sciences and Humanities (SSH) in the radiological protection field (RP)

The SRA aligns with recent calls for more open and responsive modes of research and science policy-making, and attends to four challenges put forward in contemporary EU-wide policy discourses on *Science with and for society* and *Responsible Research and Innovation (EC 2018)*: health and wellbeing; secure, safe and resilient societies; communication, collaboration and citizenship; and integration, impact and reflexivity.

Firstly, *health and wellbeing* comprise the social, mental and physical health of individuals, as well as social factors such as the strength and diversity of social bonds within a community and its capacity for autonomy within a healthy environment. Research in the field of SSH can explicitly address these aspects in connection to radiological exposure situations, with the aim of ensuring a good quality of life for all. Achieving health and wellbeing requires investments on behalf of decision makers and research communities at a time of economic restraint and the aging of populations across Europe and the world.

Secondly, on the topic of *secure, safe and resilient societies*, European nations face major natural hazards and human-induced threats. SSH research seeks to make significant contributions towards

enhancing societal resilience and preparedness in the face of these threats by examining contemporary approaches to safety and security, and by opening a broader societal debate on the kinds of resilience that can, and should, be achieved.

Thirdly, SSH research on *communication, collaboration and citizenship* advances our understanding of how individuals and communities are included and excluded, and how processes such as communication and collaboration foster novel forms of identity, sense making and belonging. It does so with the aim of creating societies in which citizens thrive, feel confident to express themselves and empowered to take decisions concerning radiological risks and connected issues.

Finally, SSH research on *integration, impact and reflexivity* assesses the impact of research activities on the values and choices made by researchers in their communities. This includes giving due consideration to the societal and ethical implications of scientific research agendas, processes, and outputs.

The SRA has six research lines that reflect areas for which the need for a concerted effort has been identified as a prerequisite to addressing the contemporary societal challenges outlined above. Each of these research lines includes a number of specific research topics relevant to the future European research agenda in the field of radiological protection. Indeed, we anticipate that the relevance extends beyond Europe. Exchanging views on these joint challenges will be an integral part of developing and improving the SRA further, setting priorities and initiating research projects.

Research line 1: Effects of social, psychological and economic aspects on radiological protection behaviour and actors' choices

Research line 1 is geared towards understanding behavioural aspects related to radiological risks, including the interrelation between behaviour, perception of risks, economic aspects, knowledge, culture, historical memory and other factors.

Relevant topics include:

1.1 Links between perception of radiological risk and radiological protection behaviour, or individual strategies to cope with perceived risk in relation to radiological exposure. Using cross-sectional and longitudinal studies, multiple aspects will be brought into focus:
- different exposure contexts (e.g. workers, populations living in areas affected by radiological contamination)
- different time scales (e.g. different generations)
- cultural contexts,
- socio-economic issues.

1.2 Perceptions of radiological risk and environmental remediation actions in post-accident and existing exposure situations (e.g. human ecology, psychology, epidemiology)

1.3 Media impacts (social media, traditional media) on perception of radiological risk and ideas of well-being linked to radiological exposures. This includes the influence of citizen journalism on radiological protection behaviour in different exposure situations and examining if, and how, citizen science journalism can be integrated into RP.

1.4 The interplay of individual differences, such as psychological aspects associated with radioactivity, social environment and radiological protection behaviour.

1.5 Capturing different understandings of ionising radiation concepts, risks and uncertainty as byr stakeholder group (e.g., practitioners, patients, local population) and the respective amplification or attenuation of radiological risks. Contexts are medical exposures, industrial applications, natural radiation and nuclear or radiological accidents.

1.6 Perception of radiological risks by individuals and groups when exposed to low radiation doses, accounting for cultural differences in routine, emergency and other exposure situations.

1.7 Socio-psychological and economic aspects of medical follow-up after accidental or other exposures.

1.8 Societal approaches to dealing with uncertainties and the potential for bridging the gap between different concepts of uncertainty.

Research line 2: Holistic approaches to governance of radiological risks

The aim of this research line is to develop inclusive approaches for the governance of radiological risk situations by integrating technical assessments and social assessments, raising public awareness on the social scientific aspects and integrating these into knowledge building, framing of issues and the decision-making process together with technical assessments. Evaluation of radiological and non-radiological aspects by the various stakeholders should serve as inputs for decision-making. Stakeholders comprise formal institutions, as well as actors without a predefined institutional role that have to manage their own decision-making processes, stakes, and expectations. A core emphasis here is on providing insights and guidance on multi-dimensional, multi-actor and multi-institutional decision-making and policy-making and on resolving emerging trade-offs in radiological protection. As radiological protection is a burgeoning multidisciplinary field, special attention will be devoted to the added value of SSH in relation to contributions from other fields and sciences.

Relevant topics include:

2.1 Assessment of the radiological and non-radiological effects of radiological accidents through transdisciplinary research, for instance in the case of a medical overexposure or in industrial radiology.

2.2 Holistic approaches to accident preparedness, management and recovery, taking into account multiple risks, social, economic and psychological factors. These approaches should account for the development of psychological support for evacuees as part of preparedness policies; socio-economic aspects of preventive distribution of iodine tablets in different EU countries; and psychological consequences of emergency management decisions. Inappropriate responses of individuals and groups (e.g. voluntary evacuation when sheltering is advised) and how to avoid such responses is also important.

2.3 Social, ethical and psychological issues related to preparedness and response to nuclear and radiological terrorism and other criminal behaviour.

2.4 Ethical aspects of crisis situations, particularly ethical questions around evacuation, post-accident management, and the transition from emergency to recovery radiological exposure situations.

2.5 Development of socio-economic valuation and multi-criteria decision methods as one approach to formally structure the evaluation and integration of radiological and non-radiological factors for different ionising radiation exposure situations.

2.6 Decision making mechanisms in post-accident situations, with emphasis on local knowledge, values and decision-making.

2.7 Analysis of existing policy and regulatory influence on the radiological protection field.

2.8 The development of joint actions with institutional and non-institutional actors in radiological protection governance.
2.9 Analysis of the values and principles that inform radiological protection programmes and practices in the medical field.
2.10 Assessment of how uncertainties are identified and managed in different professions, for instance general practitioners, surgeons, food scientists, environmental scientists, publics.
2.11 The ethics of compensation for radiological risks in different countries.
2.12 Assessing values and expectations that come with the integration of SSH in radiological protection.

Research line 3: Responsible Research and Innovation in Radiological Protection

Research line 3 aims at assessing how radiological protection research, development and innovation is conducted, with the aim of inciting more socially responsive and ethically sound processes and outcomes. The design of transdisciplinary activities is emphasised in this research line, for example through co-creation agenda setting-processes that engage technical and social scientists alongside publics.

Relevant topics include:

3.1 Enhancing the reflexive awareness of actors involved in technical R&D about the societal implications of nuclear technology applications and radiological exposure situations that require radiological protection research.
3.2 Examining the social, cultural, and historical context of radiological protection research; the rationales, possibilities, and limitations of research approaches and methods; the social relevance of research hypotheses.
3.3 Ascertaining conflicts of interest in radiological protection research and finding ways to manage such conflicts.
3.4 Identifying and developing sound ethical principles and approaches to guide radiological protection research in a socially responsive, inlcusive and responsible manner.
3.5 Operationalising, as well as problematising and developing, principles such as trans-disciplinarity, which sustain the integration of SSH into radiological protection research.
3.6 Evaluating the institutional uptake of research projects and findings.
3.7 Determining how to make SSH integration meaningful and effective for all stakeholders.
3.8 Developing methodologies and tools for the dynamic mapping of stakeholders' concerns, views and needs to identify R&D priorities in the radiological protection field.

Research line 4: Stakeholder engagement in radiological protection research and development, policy and practice

Research line 4 aims at fostering stakeholder engagement in radiological protection research, policy and practice in ways that enhance responsiveness to societal needs and concerns. By "stakeholder" we denote anyone who has a stake in radiological protection research, its development or applications and/or is potentially affected by radiological protection R&D and the outcomes it generates.

Relevant topics include:

4.1 Mediation and facilitation between authorities, scientists, publics and other stakeholders for different exposure situations and nuclear applications, research and development. This implies giving due attention to issues of representation and lessons learned.

4.2 Establishment of a collaborative framework for stakeholder engagement in radiological protection research, policy and practice in ways that enhance responsiveness to societal needs and concerns.

4.3 Analysis and evaluation of societal needs to shape the legal requirements and governance frameworks in ways that support access to information, public participation and access to justice.

4.4 Assessment and development of stakeholder and public participation tools and methodologies for different radiological exposure situations; including roles, rules and responsibilities of stakeholders in the engagement process, motivations, values and links between theory and practice.

4.5 Potential and limitations of involving citizens in the production of knowledge for radiological protection. Examples include citizen science, citizen journalism, and partnerships with local communities.

4.6 Preservation of knowledge and experience of local stakeholders' (e.g. local community, schools, citizens) involvement and participation. Community research and tracing of the development of a participation culture in relation to different exposure situations

Research line 5: Risk communication

This area covers issues related to communication of risk, how affect and trust influence risk perception and behaviour, and how exchange or sharing of risk-related data, information and knowledge between and among different parties (such as regulators, experts, consumers, media, general public) can be provided. Research line 5 aims at developing research to support communication about ionising radiation between different stakeholders and citizen-centred risk communication, in order to clarify choices and options in a variety of exposure situations. It also seeks to empower citizens and other stakeholders to make more informed decisions.

Relevant topics include:

5.1 Risk communication about radioactivity and radiological protection principles in medical applications of ionising radiation, and the impact of communication on the radiological protection behaviour of practitioners.

5.2 Improving decision-making through informed consent of patients for medical procedures involving ionising radiation; by empowering patients in decision making; ethical issues and communication about uncertainties; informed consent vs the right not to know.

5.3 Developing long-term communication models to improve radiological protection culture and public well-being in long-term existing exposure situations.

5.4 Use and perception of technical information and risk estimates in communication with various publics (lay people, experts, informed civil society).

5.5 Media communication about ionising radiation, in particular low radiation doses and related uncertainties in the field of radiological protection including inter-media agenda setting in different exposure situations.

5.6 Ethical basis and values underpinning risk communication about ionising radiation exposures.

5.7 Risk communication and stakeholder involvement in post-accident recovery in order to support decision-making process related to daily life and improving public health.

5.8 Developing risk communication about low doses: Use of state of the art knowledge from socio-psychological research with focus on low doses of ionising radiation and related uncertainties.

5.9 Ethical principles guiding deliberative processes on questions that cannot be decided by radiological specialist alone: role of uninformed risk perceptions, applicability of informed consent, appropriateness of risk comparisons, dealing with refusal to communicate.

5.10 Perception and communication related to radiosensitivity and radiosusceptibility including mental maps, ethical aspects.

Research line 6: Radiological protection culture

Research line 6 involves research concerning the assessment and development of a radiological protection culture among all RP stakeholders, in various exposure situations (planned, existing and emergency), and for different categories of exposure (occupational, patient, general public). The aim of this research line is to increase the understanding and application of radiological protection principles, norms and standards; to enhance the decision-making processes concerning the management of radiological exposure situations, and the identification and implementation of RP actions. At the same time, it aims to enable individuals and collectivities to reflect on their own protection and/or that of others; to consider consciously radiological protection aspects in their activities or decisions; to make their own decisions with regard to their own protection against ionising radiations; to participate in decision-making processes related to the management of exposure situations. By enabling the dialogue between professionals in the RP field and other stakeholders, Research line 6, contributes to enhancing the efficiency and reliability of the radiological protection system and its capacity to effectively address the concerns of all stakeholders.

Relevant topics include:

6.1 Characterization of RP culture, including

- Specificities associated with exposure situations;
- Organisational, social, political, economic, cultural and psychological aspects influencing RP culture or RP behaviour;
- Ethical frameworks and value judgments underlying RP cultures;
- Interactions between the RP culture at the level of an organisation or community, and at individual or sub-group level;
- Impact of evolving RP technologies, knowledge, information, and communication technologies on RP culture;
- Relationships between RP culture and safety or security culture.
- Analysis of processes of RP knowledge production, values and expectations.

6.2 Qualitative and quantitative evaluation of RP culture, at group and or individual level.

6.3 The role of RP culture for the implementation and improvement of the RP system; and the health and well-being of populations.

6.4 Development of tools, methods, processes and guidelines to build, maintain, enhance and transmit RP culture, taking into account the needs and concerns of various stakeholders regarding RP culture, including future generations, and the specificities of RP fields (eg. emergency and recovery preparedness, NORM activities, radon exposures, paediatric imaging).

6.5 Social, psychological and economic aspects of radiological protection choices by different actors.

V. Research needs in short-term and medium-term

Social and ethical aspects in radiological protection research, policy and practice involves research that must be addressed to numerous fields related to ionising radiation and its applications, for example: medical exposures to ionising radiation, naturally occurring radioactive materials, nuclear waste management, environmental remediation, emergency and recovery management, and decommissioning. On the one hand, the Social Sciences and Humanities community encourages multi-disciplinary approaches that ensure attention to social and ethical considerations. On the other hand, the SSH community has its own SSH SRA dedicated research priorities, which are not currently addressed by the research agendas for RP produced by other, non-SSH disciplines.

A gap analysis was carried out in order to identify the top SSH research priorities to be addressed by projects responding to the EURATOM NFRP[11] 2018 calls (Vanhavere 2018). The gap analysis considered topics included in the SSH SRA (Perko, Pölzl-Viol, et al. 2017, Perko, Turcanu, et al. 2016) and/or defined as priorities by radiological protection stakeholders (Impens et al. 2017). The analysis highlighted key topics that have been addressed to only a limited extent in recent or ongoing EU projects, namely:

- Risk communication in medical exposures; impact of communication on RP behaviors of practitioners.
- Risk communication on low doses and related uncertainties.
- Ethical basis and values underpinning risk communication exposures to ionising radiation.
- The understanding of ionising radiation concepts, risks and uncertainties by different stakeholders in the context of planned, existing and emergency exposure situations.
- The interplay of psychological aspects associated with radioactivity, social environment and radiological protection behaviour.
- Potential and pitfalls of citizen involvement in knowledge production for radiological risk governance.
- Socio-economic valuation and multi-criteria decision-aiding methods to formally structure the evaluation and integration of radiological and non-radiological factors.
- Enhancing the reflexive awareness of actors involved in radiological protection R&D as to the societal implications of research.
- Democratic culture in RP in order to construct joint actions with institutional and non-institutional actors.
- Mediation, facilitation and representation on the triangle scientists, public and other stakeholders for different exposure situations.

[11] NFRP: Nuclear fission and radiation protection research

- Collaborative framework for stakeholder engagement in RP research, policy and practice in ways that enhance responsiveness to societal needs and concerns.
- Societal needs for and evaluation of legal instruments and governance frameworks supporting access to information, public participation and access to justice in relation to RP issues.
- Stakeholder and public participation tools and methodologies for different exposure situations. Roles and rules for stakeholders in the engagement process. Motivational factors, ethics, and links between theory and practice.
- Characterization of RP culture.
- The role of RP culture in the implementation and improvement of the protection system.

The SSH community encourages multi-disciplinary approaches that address one or more of the above topics and facilitate the integration of social and ethical considerations into radiological protection agendas and programmes at an early stage. This vision of priorities will guide further development of the SRA with a view towards enhancing the role of SSH research in RP for the mutual benefit of science and society.

VI. Conclusions

In this article, we outlined a prospective Strategic Research Agenda for the Social Sciences and Humanities in radiological protection. The SRA represents the views and commitments of a wide range of stakeholders in the RP arena (researchers, policy makers, implementers, authorities, and members of technical and research platforms). In line with European science policy appeals to responsible research and innovation, the proposed SRA seeks to facilitate more socially responsive science and technology processes by systematically integrating social and ethical considerations into RP research programmes and policies. It extends, unifies and builds on previous European efforts to integrate SSH into radiological protection research in fields such as medicine, radioecology, energy, dosimetry, and waste, with due consideration to the social, political, ethical, cultural and historical factors that shape research. Among the benefits of conducting scientific intra-, inter-, multi- and trans-disciplinary research in radiological protection may be the fostering of user-friendly technologies for radiological protection, helping citizens make informed decisions, and improving radiological risk governance. As evidenced by numerous studies, SSH researchers can fruitfully inform RP research and decision-making in these and related areas.

Far from a conclusive declaration, the SRA is intended as a dynamic document to encourage debate on what are SSH research priorities in RP; provide guidance on what subjects could and should be covered in new research programmes on radiological protection research (for example through Ph.D and Postdoc programmes); and offer a list of key SSH topics for research programmes on specific radiological protection subjects. The SRA will be adapted in view of changing stakeholder needs, through ongoing interactions with all concerned parties, including the technical and research platforms.

We anticipate that the SSH SRA presented here will have significant scientific and policy impact in the intermediate and long run, as social scientists and humanities scholars increasingly engage with RP stakeholders, policies and practices. These engagements open up new possibilities to embed social

and ethical considerations in RP research and development, thereby expanding research options, addressing stakeholder needs and values, and fostering forms of inter- and transdisciplinary research collaboration.

Now is the time for European research institutions, as well as national and international authorities, including the European Commission, to invest resources in the identified research lines and topics. This will facilitate the further development of SSH research, under a broad, engaged, and reflexive agenda, whose effect will be to promote responsible RP practices and benefits for both science and society.

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