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The scientific foundations of the co-expertise process: from risk assessment and management to risk governance

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Abstract

This chapter examines the scientific foundations of the co-expertise process from the perspective of risk analysis theories, focusing on the theoretical and methodological developments related to radiation risk. It highlights how the evolution of modern societies, and particularly the major technological disasters of Chornobyl and Fukushima, have contributed to redefining the concept of radiological risk and its management, emphasizing the importance of the psychological, sociological, and ethical dimensions that shape the notion of risk.

Introduction

The idea of managing risk is multi-millennial. Managing risk historically includes the edging system in case of losing their goods among the Babylonians, or the guild system in ancient Greece and Rome to support craftsmen in the event of an accident or damage. Modern risk management was first associated with the use of market insurance invented by Lloyd's of London in 1688 to protect individuals and companies from various losses associated with accidents (Bernstein, 1998).

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Risk assessment and management as scientific disciplines emerged after the early 20th century when market insurance was perceived as too costly and incomplete for protection against risks. Over the past fifty years, risk research has undergone profound transformations reflecting a broader evolution in how modern societies understand, assess, and manage technological risks.

In the 1960s - 1970s, there was rapid development in the field of risk assessment that was dominated by deterministic and technocratic approaches, based on quantitative assessments carried out exclusively by scientific and technical experts. In conjunction with the quantification of risk, new risk management methods also arose during the 1970s. Initially, the focus was on the development of risk assessment techniques that grounded the management of risks on a scientific basis (the technocratic model).

The succession of major industrial and nuclear disasters in the late 1970s and 1980s — such as Mexico, Bhopal, Three Mile Island, Chornobyl, exposed the limitations of these traditional approaches. These events revealed that populations confronted with hazards do not react solely on the basis of numerical data or expert judgments. Rather, their interpretations of risk are filtered through cultural worldviews, social dynamics, psychological processes, historical experiences, and political contexts. The discrepancy between expert assessments of radiation-related dangers and the lived experience of affected communities highlighted a critical gap between technical rationality and social reality. This gap became especially evident in situations marked by uncertainty, invisibility of contaminants, disruption of daily life, erosion of institutional trust.

In response to these challenges, research in the domain of risk focused during the 1980s and 1990s on the development of risk perception and risk communication as distinct scientific fields emphasizing first that risk is subjectively defined by individuals who may be influenced by a wide range of psychological, social, institutional and cultural factors, and then how to better explain risk data based on risk assessment in order to find ways of bridging the public/expert risk perception gap related to activities raising concerns in the society (nuclear energy, chemical industry...).

These developments led to the refinement of the risk assessment and management techniques by integrating societal, environmental and economic considerations into the decision-making process to control the risks with public participation becoming integral part of the risk management process (the inclusive governance model). This evolution is best illustrated by the series of reports developed by the US National Research Council to foster risk assessment and risk management in the Federal Agencies (National Research Council Committee on the Institutional Means for Assessment of Risks to Public Health, 1983; National Research Council, 1989; National Research Council, 2009).

Figure 1 schematically illustrates the evolution mentioned above. The progressive thickening of the arrow reflects how risk assessment and management, risk perception, risk communication, and risk governance are deeply interconnected, each step building upon and enriching the previous ones.

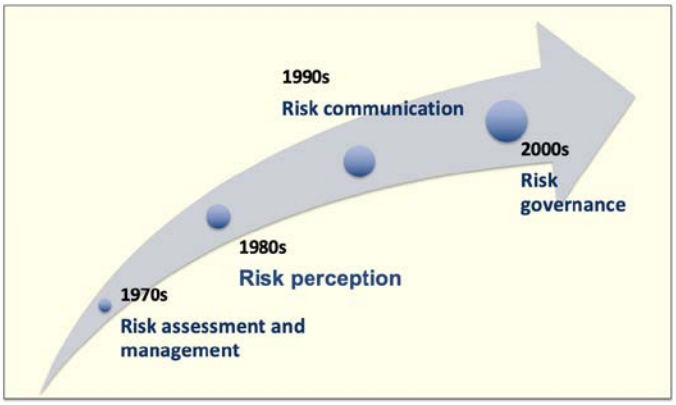

FIGURE 1. From risk assessment and risk management to risk governance (© J. Lochard).

The following sections describe in more detail how the evolution of risk research, briefly mentioned above, has been reflected in the field of radiological risk, from the 1970s to the recent integration of the co-expertise process into the radiological risk management system in 2020.

1. The basis of radiation protection

1.1. *Risk assessment and management*

The International Commission on Radiological Protection (ICRP) is an independent international body with responsibility for developing the system of radiological protection system for the public benefit. In particular, ICRP provides recommendations and guidance on all aspects of protection against ionising radiation. The first set of post Second World War recommendations were published in Publication 1 (1959). In this publication it is recognized that some effects may not have thresholds: "The most conservative approach would be to assume that there is no threshold and no recovery... and the incidence might be proportional to the accumulated dose" (ICRP, 1959).

Since then, health effects from radiation exposure are divided into deterministic and stochastic effects. A deterministic effect is a health effect that can occur in a short period of time following exposure, with exposure doses exceeding a certain dose (i.e., threshold dose). For example, the threshold dose for primary infertility in males is 100 mGy (ICRP, 2007). On the other hand, with regard to stochastic effects, health effects are considered to occur with a certain probability even in the presence of low doses. Typical stochastic effects include cancer and genetic effects. Dose-response relationships for stochastic effects are investigated by epidemiological studies in exposed individuals. The largest and most reliable epidemiological study is a survey of atomic bomb survivors in Hiroshima and Nagasaki and their second generations (United Nations

Scientific Committee on the Effects of Atomic Radiation, 2011). Among the survivors of the atomic bombings in Hiroshima and Nagasaki, no genetic effects from radiation exposure have been observed; however, the ICRP takes genetic effects into account as part of a prudent risk management framework.

As far as the management of the risk is concerned, logically ICRP (1959) recommended that exposure be kept below the threshold levels for deterministic effects and for stochastic stated "Any departure from the environmental conditions in which man has evolved may entail a risk of deleterious effects... However, man cannot entirely dispense with the use of ionizing radiation, and therefore the problem in practice is to limit the radiation dose to that which involves a risk that is not unacceptable to the individual... This is called a "permissible dose" (§ 29).

During the 1960's, based on information from Hiroshima and Nagasaki, ICRP prudently adopted the Linear No Threshold (LNT) model, that assumes that even low levels of radiation carry some risk. This approach was chosen because a linear extrapolation from higher-dose data was considered the most protective in the absence of clear low-dose evidence, as described above.

In 1977, ICRP published new General Recommendations (Publication 26) that introduced the important concept of detriment, which combines the probability and severity of stochastic effects to provide an overall measure of radiation risk. The total stochastic risk from uniform whole-body irradiation was set at about 2% per sievert, as an average for both sexes and all ages. Furthermore, from the radiation risk management perspective, ICRP introduced the three key principles that shape the current system of protection; justification, optimisation of protection and dose limitation. It should be noted that the dose limit values have been progressively adopted by all national authorities in the world. The 1977 Recommendations supported an effective dose equivalent limit of 50 mSv/year for occupational exposure based on the risk of cancer mortality level (ICRP, 1977a; ICRP, 1977b). Here, the annual cancer mortality risk for the whole population corresponding to a dose limit of 50 mSv/year was calculated from the LNT model and the cancer mortality to dose ratio, based on epidemiological studies among the atomic bomb survivors of Hiroshima and Nagasaki. Acceptable risk levels, on the other hand, were calculated from annual mortality rates associated with other occupations by comparing these data, it was confirmed that the average risk of occupations involving radiation was comparable to that of other safe occupations.

Thus, by the end of the 1970s, radiation risk was conceptualized as an objective entity that could be measured, controlled, and communicated using numerical indicators, with the recommendation that all exposure be kept as low as reasonably achievable economic and social factors being taken into account (known as ALARA), assuming implicitly that rational decision-makers and the general public would react predictably to scientific evidence and behave prudently. This approach was widely disseminated in the World within government agencies responsible for assessing and managing occupational and environmental radiological risks.

1.2. *Risk perception*

As described above, risk management involves complex societal value judgments, such as how to assess risk in a conservative manner, whether to protect the population as a whole or vulnerable individuals (e.g., most exposed individuals), what indicators to use, and what risk levels to accept. Despite refinements in the assessment and management of radiological risk, the acceptability to the population of situations involving radiation risk has become increasingly challenging over time, which pushed a group of US researchers in the 1980s–90s to explore the factors explaining the perception of risk to understand why the public tended to over-estimate the risk.

Risk perception research transformed understanding of how individuals interpret, evaluate, and emotionally respond to risk. This was done by building on a pioneering contribution by Chauncey Starr (1969) demonstrating that people are willing to tolerate significantly higher levels of risk when they associate the activity with substantial benefits, illustrating a fundamental asymmetry between voluntary and involuntary exposures. Slovic, Fischhoff, and colleagues clarified that factors such as dread, catastrophic potential, unfamiliarity, voluntariness, controllability, and trust play essential roles in shaping perceived risk (Slovic, 1987). These elements helped explain why risks with low statistical probability — such as radiation accidents — may nonetheless generate profound public concern. This foundational insight challenged the prevailing assumption that risk tolerances were primarily determined by objective probabilities, highlighting the importance of considering value judgments of the public.

A major conceptual shift in risk tolerability/acceptability and risk management was introduced in the next ICRP general recommendations, the publication 60 (ICRP, 1991). The dose-response equation allowing risk to be calculated was updated by epidemiological studies from the atomic bomb survivors. Progress was also made in social science research on acceptable levels of risk. Following work carried out by the UK Royal Society (1983), ICRP introduced the tolerability of risk model. The publication was also adding to the understanding of population-based risk management (i.e., average exposure) and the consideration about individual risk management (i.e., maximum exposure). Various outcomes including lifetime mortality risk, loss of life expectancy, age-specific mortality risk, and age-specific mortality increase, were used as risk indicators.

In ICRP Publication 60, the tolerability of risk is described using three qualitative terms — unacceptable, tolerable, and acceptable — to support normative judgments on radiation exposure. Within this framework, dose limits are positioned as a selected boundary between unacceptable and tolerable exposures for the control of practices, while exposures below this boundary remain subject to optimisation of protection.

2. Stakeholder involvement and the ethical foundations of the system of protection

In its most recent General Recommendation Publication 103 (ICRP, 2007), the Commission introduced stakeholder involvement as a key dimension associated with the principle of optimisation of protection.

Concretely stakeholder involvement emerged in the field of radiation protection in the late 1980s and early 1990s in the context of the management of exposures in areas contaminated by the Chornobyl accident and sites contaminated by past military activities in the US. These experiences demonstrated that engaging stakeholders was an effective way to take into account the concerns and expectations of those affected and also the prevailing circumstances of the exposure situations. It was also a way to adopt more effective and fairer protective actions, to disseminate radiation protection culture, and to favour the empowerment and autonomy of affected people i.e. to promote their dignity.

Despite these experiences had clearly demonstrated the value of stakeholder involvement, it took more than 20 years for ICRP to incorporate it into its general recommendations. Many professionals believed that seeking input from those affected by a radiological situation who were unfamiliar with radiation science could only lead to unrealistic and ineffective solutions, and would also unnecessarily slow down decision-making processes.

Regarding ethical values, although long recognized and regularly discussed by prominent members of the Commission (Lochard, 2016) it was not until the beginning of the 21st century that the Commission asked its Committee on the Application of Recommendations to clearly formulate the ethical values underpinning the principles of justification, optimization of protection, and dose limitation. The concrete involvement of several members of the working group responsible for this formulation in the experience of the Suetsugi community affected by the Fukushima accident (Ando et al., 2026) and in the ICRP dialogue initiative in Fukushima (Lochard et al., 2019) was crucial in finalizing the reflection that led to ICRP Publication No. 138 (ICRP, 2018), entitled "Ethical Foundations of the Radiation Protection System". This publication highlights four core ethical values: beneficence and non-maleficence, prudence, justice and dignity, as well as three procedural values considered fundamental to facilitate the practical implementation of the radiation protection system: accountability, transparency and inclusiveness (Takahashi et al., 2026). By disseminating the values and ethical principles that underpin the radiation protection system, not only professionals but also the public can have a clearer idea of the societal implications of the Commission's recommendations.

3. Risk communication

As research progressed, it became increasingly clear that risk perception cannot be fully explained by cognitive evaluations alone. Socio-psychological components were shown to exert powerful influence on risk judgments. Kahneman's

dual-system theory, which distinguishes between fast, intuitive thinking (System 1) and slow, analytical reasoning (System 2), provided a conceptual framework for understanding why intuitive, emotionally driven reactions often dominate public responses to technological hazards, particularly under conditions of uncertainty, threat, or stress (Kahneman, 2011). Studies across psychology, sociology, and anthropology revealed that cultural worldviews, gender differences, social norms, and broader political contexts further shape how risks are interpreted, communicated, and acted upon. These insights highlight the importance of integrating psychological, emotional, and cultural dimensions into effective risk communication, emphasizing that technical expertise alone cannot address the complex human realities inherent in radiological emergencies.

In the field of radiological protection, this research on risk perception has particular significance. Populations affected by nuclear accidents face chronic uncertainty, invisible contaminants, and disruptions to daily life that profoundly shape their psychological and emotional well-being. Under such conditions, institutional trust often becomes fragile, and intuitive reactions may override analytical assessments — even when authorities provide accurate technical information. Experiences from Chornobyl and Fukushima illustrate how fear, stigma, and social fragmentation can escalate when risk communication does not adequately account for cultural sensitivities, emotional experiences, and historical memories.

Radiation-related risk communication has a central role both in supporting the mental health of affected people and in discussion of post-disaster recovery. As academic fields, risk communication has both psychological and social psychological aspects. Several representative case studies on the psychiatric aspect have shown the relationship between radiation risk perception and mental health. For example, after the Chornobyl disaster, it was reported that people with strong anxiety about radiation had worse mental health (Bromet, 2012), and many similar cases have been reported after the Fukushima disaster (Ito et al., 2018; Suzuki et al., 2015). In addition to mental health, perceived radiation risk has been linked to a wide range of outcomes, including attitudes toward sightseeing in Fukushima, perceptions of environmental safety, intentions to relocate or return to one's hometown after the lifting of evacuation orders, intentions to leave one's job or not return to work in Fukushima, health-related behaviours such as drinking, experiences of discrimination or social division, food avoidance, pregnancy intentions, and self-esteem or self-efficacy (Murakami et al., 2022).

The debate on the socio-psychological dimension was deepened by the question of how to communicate about radiation risk. Importantly, regardless of nationality, radiation-related risks are perceived as highly dreaded (Kleinhesselink and Rosa, 1991; Slovic, 1987). Furthermore, it was argued that acceptance of nuclear power plants is influenced by perceived risk and perceived benefits, which were governed by trust (Visschers and Siegrist, 2013). Similarly, acceptance of radiation-related facilities varies greatly depending on whether distributive or procedural fairness is ensured (Takada et al., 2022). These findings suggest that authorities and experts must look not only at people's knowledge of radiation risks, but also at the broader social aspects.

Indeed, it has been shown that affected people's views on radiation risk after the Fukushima disaster was only minimally governed by knowledge but also strongly influenced by demographic factors, trust, and other disaster experiences (Murakami et al., 2016).

In view of the above, it is important to carefully examine the results of communication on radiation-related risks. Risk communication was never addressed directly by ICRP. Nevertheless, many ICRP publications contain recommendations on informing stakeholders about the issues addressed in these publications; for example, it is clearly recommended to inform nuclear workers about the radiological conditions of their interventions; patients undergoing radiological examinations about the exposure they receive; or travellers by plane about the enhanced levels of natural radiation they receive in altitude.

The significance of providing information can be organized into two dimensions: (1) an obligatory aspect from authorities and experts, and a human rights aspect from citizens (e.g., the right to know and to be involved in decision-making), and (2) an effective aspect through a collaborative process. The former is the value represented by President Kennedy's "consumer rights" (i.e., consumers have the right to safety, to be informed, to choose, and to be heard) (Kennedy, 1962). For example, it is a natural right of people to express their opinions and be involved in decision-making regarding measures after a nuclear disaster. The latter is that dialogue and collaboration can function effectively in identifying values to be assessed and risks to be managed, and in promoting such measures. For example, the wisdom and collaboration among stakeholders including residents within a community lead to the introduction of measures that truly meet their needs. In fact, other examples are presented in previous chapters of this book how stakeholder involvement has actually moved measures forward and led to the resolution of issues.

This is a way to ensure equity while building trust and encouraging updates on the experiences of affected people and other stakeholders. This approach is based on the experience after the Chornobyl disaster, as stated in ICRP Publication 111: "For management of the radiological quality of foodstuffs in a country with a contaminated territory, relevant stakeholders (authorities, farmers' unions, food industry, food distribution, consumer non-governmental organisations, etc.) and representatives of the general population should be involved in deciding whether individual preferences of the consumers should outweigh the need to maintain agricultural production, rehabilitation of rural areas, and a decent living for the affected local community" (ICRP, 2009). Furthermore, ICRP Publication 146 also recommends that "the authorities, experts, and stakeholders should co-operate in the so-called 'co-expertise process' to share experience and information, promote involvement in local communities, and develop a practical radiological protection culture to enable people to make informed decisions" (ICRP, 2020).

In light of the above considerations, it is important to carefully examine the results of communication by experts on radiation-related risks. The Chornobyl and Fukushima disasters amply demonstrated that communication is not simply a matter of numbers; and that knowing whether safety is being sought, but also whether trust exists, and whether we are progressing towards "a world where life

is good" (Select Committee on Science and Technology, 2000) is essential to understanding how individuals interact with radiation and society (Murakami, 2016).

Risk communication initially focused on improving public understanding of numerical risk information, operating under the assumption that clearer data and more effective explanations would narrow the gap between expert analysis and public perception. This so-called expert-to-public "deficit model" presumed that misunderstandings and public resistance to risks stemmed primarily from a lack of knowledge, and that education alone would correct these deficits. However, experience rapidly showed that this model was insufficient, particularly in contexts of high uncertainty and emotional distress such as nuclear emergencies. During crises, people do not process information in a purely rational or linear manner. Instead, they interpret messages through personal values, fears, memories, and levels of trust. Research by Fischhoff, Slovic, Covello, and others demonstrated vividly that effective communication requires far more than accurate data—it requires empathy, transparency, openness to dialogue, and genuine engagement with the concerns and experiences of affected populations (Slovic et al., 1979; Covello et al., 1988).

The cardinal rules of risk communication emphasize listening, honesty, respect, and collaboration with trusted community voices. These rules highlight that communication is not simply an act of transmission but a relational and ethical practice. Siegrist, Earle, and Gutscher's distinction between trust and confidence (Siegrist et al., 2010) further clarified why communication strategies often fail in contexts where institutional trust is weakened. Confidence may depend on technical performance and past reliability, but trust is rooted in shared values, perceived fairness, and social relationships. When people are stressed or afraid, they experience a phenomenon known as "mental noise," which significantly reduces their ability to hear, remember, or interpret information. Under such conditions, emotional reassurance, acknowledgment of suffering, and respect for people's lived experience become essential components of effective communication. In nuclear accidents, where risks are invisible, complex, and long-lasting, such elements are indispensable for preventing social amplification of fear and restoring a sense of control.

As a result, narrative approaches, storytelling, and dialogical communication have emerged as critical tools in radiological protection. These approaches recognize that people make sense of their experiences through stories and that dialogue creates spaces for shared meaning, mutual recognition, and collective problem-solving. After the Chornobyl and Fukushima accidents, personal testimonies, shared measurements, community meetings, and dialogue circles proved powerful in rebuilding trust and empowering affected citizens. Through these communication processes, individuals were able to voice their fears, confront uncertainty collectively, and regain agency in their daily lives. Today, risk communication is widely understood as inseparable from trust-building, stakeholder participation, and inclusive governance. It serves not only to convey information but to strengthen resilience, foster cooperation, and support ethical decision-making in complex radiological contexts (ICRP, 2018).

4. Risk governance

Risk governance is the way that societies make collective decisions about technologies and activities that are complex and have uncertain consequences. Risk governance goes beyond traditional risk assessment and management analysis to include the involvement and participation of the concerned stakeholders in the assessment and management of the risk. Research on risk governance also highlighted the fundamental role of trust in the decision-making processes related to risk management.

It has long been argued that risk assessment and management should be functionally separated (National Research Council Committee on the Institutional Means for Assessment of Risks to Public Health, 1983). However, as described above, the public plays an important role in risk-related decision making, highlighting the importance of addressing risk through a risk governance approach that deals with risk assessment, management, and communication in an integrated manner (Renn, 2008). This has also led to a solution-focused risk assessment (Finkel, 2011), i.e. an assessment in which the effectiveness of protective actions and other activities are evaluated by assuming in advance what kind of measures will lead to the solution of the issues. In the case of the Fukushima disaster, measuring radiation doses to individuals and in residences highlighted what actions and measurement options were available. This led to risk management including decision-making, through dialogue among stakeholders. This kind of integrated approach has its own beneficial implications for affected residents, experts, and governments.

Risk governance expands traditional risk management by recognizing the multiplicity of actors involved in decisions about hazardous technologies and the broad range of factors that shape these decisions. Unlike classical risk management, which relies heavily on expert judgment and quantitative assessments, risk governance acknowledges that societal expectations, ethical constraints, cultural worldviews, political systems, and institutional arrangements profoundly influence how risks are defined, evaluated, and addressed. According to Ortwin Renn, governance frameworks must integrate legal, social, economic, and technical dimensions, reflecting the complex interplay between scientific knowledge, public perception, and societal values (Renn, 2008). This makes risk governance particularly relevant for ambiguous, long-term, or uncertain risks — such as those associated with radiological contamination after a nuclear accident — where no single actor holds all necessary competencies or legitimacy.

Beyond recognizing multiple dimensions of risk, risk governance emphasizes inclusiveness, transparency, and the active involvement of diverse stakeholders. Governments, regulatory authorities, scientific experts, industry representatives, civil society, and local communities all contribute to the processes through which risks are assessed and managed. This plurality of perspectives is not a limitation but a strength: it ensures that decisions are informed by technical expertise while also reflecting lived experiences, moral considerations, and social priorities. Such an approach is particularly important when dealing with radiological risks, where uncertainty, invisibility of hazards, and potential long-term consequences challenge traditional expert-driven decision-making and heighten public sensitivity.

The co-expertise process exemplifies inclusive risk governance in practice. Originating from the ETHOS project in Belarus and later refined following the Fukushima Daiichi nuclear accident, the co-expertise model provides a structured way for experts and affected communities to work collaboratively. Ethical principles such as transparency, equity, prudence, autonomy, and loyalty underpin the co-expertise model. Transparency ensures that information is openly shared and that uncertainties are acknowledged. Equity reinforces fairness in participation and decision-making, ensuring that all voices — including the most vulnerable — are heard. Prudence guides protective measures by balancing scientific, social, economic and environmental considerations. Autonomy respects each individual's right to make informed decisions about their own life, while loyalty reflects the long-term commitment of experts and authorities to support affected communities. By engaging populations directly in the decision-making process, the co-expertise approach shifts the paradigm from top-down management to participatory governance. It enables individuals and communities to regain control over their lives, rebuild their social fabric, and develop practical radiological protection culture. As such, it represents one of the most significant evolutions in modern radiological protection, illustrating the essential role of shared responsibility and collective learning in addressing complex risks.

Figure 2 illustrates the integrated approach to risk governance using dose measurements as an example.

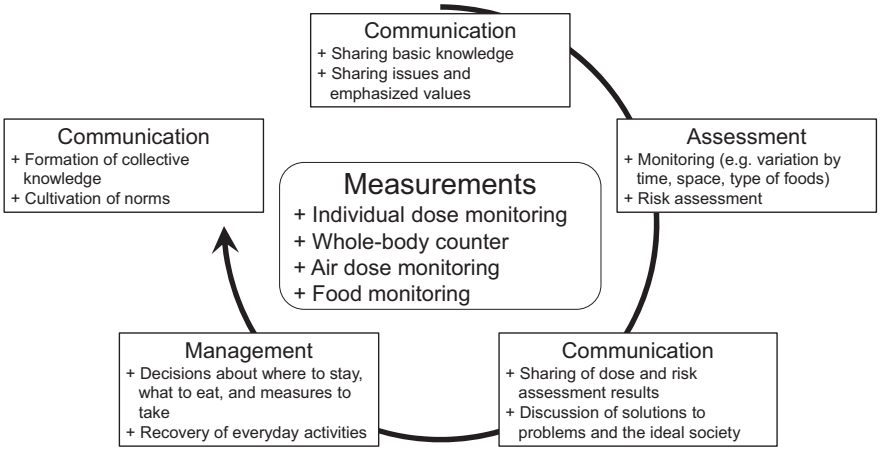

FIGURE 2. The integrated approach to risk governance using dose measurements as an example (© M. Murakami).

For residents, this approach means a process that allows their opinions to be reflected in decision-making and to restore their everyday lives. The measurement of radionuclides in foods and ambient dose rates at residences, and individual internal and external exposures, together with discussions of the results

among stakeholders including experts, are useful for the residents in facilitating their decision-making, such as what they can eat and where they can go (Ando, 2016). It should be noted here, however, that when measurements indicate a level perceived by residents as high risk, but additional protective measures (e.g., decontamination or relocation) are not possible or difficult to implement, such information may not effectively support decision-making for some actions. This highlights the importance of "integration of radiological protection into municipal systems," such as local public health, environmental monitoring, and community support frameworks, and "liaising officers" to bridge affected residents and radiological experts (Miyazaki, 2016). It was reported that after the Fukushima disaster, people who engaged in risk communication with their family, friends, and acquaintances were more likely to show improvements in self-efficacy and health-related behavioural changes. Furthermore, participation in everyday individual, social, interpersonal, and economic activities, such as hobbies, social participation, relationships, and work aided recovery (Kobayashi et al., 2021). This implies that it is important for affected residents to engage in routine communication with their families and friends that addresses the overall post-disaster situation, including radiation-related risks, in the aftermath of a nuclear disaster. The formation of collective knowledge about radiation within a community through a co-expertise process will be a cornerstone of such dialogue among affected residents.

Conclusion

The shift from risk assessment to risk governance reflects a profound transformation in the field of risk research. This transformation is also evident in radiation protection. While scientific data and information remain essential, on their own they are not sufficient. Psychological aspects, communication strategies, cultural aspects, ethical considerations, and stakeholder involvement are now recognized as indispensable components of effective management of exposure situations. This change underscores the growing awareness over recent decades that risk is not simply a technical variable to be quantified, but a multidimensional social construct influenced by trust, values and lived experience. In practical terms, this translates into the need for interdisciplinary collaboration, combining expertise from the natural sciences, social sciences, ethics, and the knowledges and wisdom of the public.

The co-expertise process represents one of the most advanced implementations of inclusive risk governance. It illustrates how scientific knowledge can be integrated with local experience, shared responsibility, and community-driven actions. By fostering dialogue, joint measurements, and collaborative problem-solving, the co-expertise approach helps empower affected populations, rebuild confidence and trust and bridge the gap between expert assessments and public concerns. These elements are particularly vital in post-accident contexts, where uncertainty, loss of control, and disruption of daily life challenge traditional communication and management strategies.

As future technological and environmental challenges emerge, this holistic approach will be crucial for sustaining resilience and social cohesion. Climate change, energy transitions, and evolving technological risks will likely intensify societal demands for transparency, participation, and fairness in decision-making. Radiological protection must therefore continue to expand beyond narrow regulatory frameworks and invest in inclusive, adaptive, and ethically grounded governance models. Such an evolution reinforces the idea that effective risk management is ultimately a shared endeavour—one that depends not only on scientific accuracy, but also on meaningful engagement, mutual respect, and the collective capacity to navigate uncertainty together.

References

Ando R. (2016) Measuring, discussing, and living together: lessons from 4 years in Suetsugi. Ann. ICRP. 45:75-83.

Ando R., Lochard J., Schneider T. (2026) The Suetsugi district co-expertise experience in Japan after the Fukushima accident. In: *The Co-Expertise Process*, Lochard J.,Schneider T. and Takamura N. (Eds), EDP Sciences, https://doi.org/10.1051/978-2-7598-3968-1.c006

Bernstein P.L. (1998) Against the Gods: The Remarkable Story of Risk. Wiley.

Bromet E.J. (2012) Mental health consequences of the Chernobyl disaster. J. Radiol. Prot. 32:N71-5.

Covello V.T., et al. (1988) Risk Communication, Risk Statistics, and Risk Comparisons: A Manual for Plant Managers. Chemical Manufacturers Association. https://www.psandman.com/articles/cma-0.htm (accessed January 5, 2026).

Finkel A.M. (2011) "Solution-focused risk assessment": A proposal for the fusion of environmental analysis and action. Hum. Ecol. Risk Assess. 17:754-787.

ICRP (1959) Recommendations of the International Commission on Radiological Protection. ICRP Publications 1.

ICRP (1977a) Problems Involved in Developing an Index of Harm. ICRP. 27. Ann. ICRP. 1.

ICRP (1977b) Recommendations of the ICRP. ICRP. 26. Ann. ICRP. 1.

ICRP (1991) 1990 Recommendations of the International Commission on Radiological Protection. ICRP. 60. Ann. ICRP. 21.

ICRP (2007) The 2007 Recommendations of the International Commission on Radiological Protection. ICRP. 103. Ann. ICRP. 37.

ICRP (2009) Application of the commission's recommendations to the protection of people living in long-term contaminated areas after a nuclear accident or a radiation emergency. ICRP. 111. Ann. ICRP. 39.

ICRP (2018) Ethical Foundations of the System of Radiological Protection. ICRP. 138. Ann. ICRP. 47:1-65.

ICRP (2020) Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident: Update of ICRP Publications 109 and 111. ICRP. 146. Ann. ICRP. 49:11-135.

Ito S., et al. (2018) Depressive symptoms and associated factors in female students in Fukushima four years after the Fukushima nuclear power plant disaster. Int. J. Environ. Res. Public Health. 15:2411.

Kahneman D. (2011) Thinking, Fast and Slow. New York: Farrar, Straus and Giroux.

Kennedy J.F. (1962) Special message to the Congress on protecting the consumer interest. https://www.presidency.ucsb.edu/node/237009 (accessed December 24, 2024).

Kleinhesselink R.R., Rosa E.A. (1991) Cognitive representation of risk perceptions: A comparison of Japan and the United States. J. Cross-Cult. Psychol. 22:11-28.

Kobayashi T., et al. (2021) May risk communication with non-experts contribute to post-disaster restoration of normalcy? A survey on the disaster-struck prefectures after the Great East Japan Earthquake. Int. J. Disaster Risk Reduction. 65:102564.

Lochard J. (2016) The Ethics of Radiological Protection. First Thomas S. Tenforde Topical Lecture, 51st NCRP Annual Meeting, Bethesda, MA, USA, 17 March 2015. Health Physics 110(2):201-210.

Lochard J., Schneider T., Ando R., Niwa O., Clement C., Lecomte JF., Tada J. (2019). An overview of the dialogue meetings initiated by ICRP in Japan after the Fukushima accident. Radioprotection 54(2):87-101.

Miyazaki M. (2016) Four and a half years of experience of a clinician born and raised in Fukushima: discrepancy found through dialogues and practices. Ann. ICRP. 45:23-32.

Murakami M. (2016) Risk analysis as regulatory science: Toward the establishment of standards. Radiat. Prot. Dosim. 171:156-162.

Murakami M., et al. (2016) Evaluation of risk perception and risk-comparison information regarding dietary radionuclides after the 2011 Fukushima nuclear power plant accident. PLoS ONE. 11(11):e0165594.

Murakami M., et al. (2022) Radiation risk perception after the Fukushima disaster. In: Health Effects of the Fukushima Nuclear Disaster (K. Kamiya, et al., Eds.), pp. 247-263. Academic Press.

National Research Council Committee on the Institutional Means for Assessment of Risks to Public Health (1983) Risk Assessment in the Federal Government: Managing the Process. National Academies Press (US), Washington (DC).

National Research Council (1989) Improving Risk Communication. National Academy Press.

National Research Council (2009) Science and Decisions: Advancing Risk Assessment. Washington, DC: National Academies Press.

Renn O. (2008) White paper on risk governance: Toward an integrative framework. In: Global Risk Governance: Concept and Practice Using the IRGC Framework (O. Renn, K.D. Walker, Eds.), pp. 3-73. Springer Netherlands, Dordrecht.

Select Committee on Science and Technology (2000) Science and Technology, Third Report. House of Lords.

Siegrist M., et al. (2010) Trust in Risk Management: Uncertainty and Scepticism in the Public Mind. Earthscan.

Slovic P. (1987) Perception of risk. Science. 236:280-285.

Slovic P., et al. (1979) Rating the risks. Environment. 21:14-39.

Starr C. (1969) Social benefit versus technological risk. Science. 165:1232-8.

Suzuki Y., et al. (2015) Psychological distress and the perception of radiation risks: the Fukushima Health Management Survey. Bull. World Health Organ. 93:598-605.

Takada M., et al. (2022) Important factors for public acceptance of the final disposal of contaminated soil and wastes resulting from the Fukushima Daiichi nuclear power station accident. PLOS ONE. 17:e0269702.

Takahashi M., Schneider T., Lecomte J.-F., Gariel J.-C. (2026). The ethical dimensions of the co-expertise process after a nuclear accident. In: *The Co-Expertise Process*, Lochard J.,Schneider T. and Takamura N. (Eds), EDP Sciences, https://doi.org/10.1051/978-2-7598-3968-1.c013

The Royal Society (1983) Risk Assessment: Reports of a Royal Society Study Group. Royal Society, London.

United Nations Scientific Committee on the Effects of Atomic Radiation (2011) UNSCEAR 2008 Report Volume II. United Nations, New York.

Visschers V.H.M., Siegrist M. (2013) How a nuclear power plant accident influences acceptance of nuclear power: Results of a longitudinal study before and after the Fukushima disaster. Risk Anal. 33:333-347.