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**Lessons learned from radiation risk communication activities
regarding the Fukushima nuclear accident**Ichiro Yamaguchi¹⁾, Tsutomu Shimura¹⁾, Hiroshi Terada¹⁾, Erik R. Svendsen²⁾, Naoki Kunugita¹⁾¹⁾ Department of Environmental Health, National Institute of Public Health²⁾ Division of Environmental Health, Department of Public Health Sciences, Medical University of South Carolina**Abstract**

Introduction: The Fukushima nuclear disaster has brought numerous difficulties to the Japanese society, such as mental health issues, and secondary health issues during the recovery phase of the nuclear disaster. To promote a balanced public health policy, sound risk communication strategies are required.

Methods: Risk communication guidelines and public health activities regarding radiation risk communication after the Fukushima nuclear disaster were reviewed within the scientific literature by using the PubMed electronic database for medical journals to clarify the current perception of the risk communication issues.

Results: There was a consistent recognition of the applicability and importance of risk communication within the Fukushima accident, as was evident in each guideline and journal article which included both the MeSH Major Topics "radiation" and "communication" with the term "Fukushima" [All Fields]. Basic concepts of each Japanese risk communication guideline are consistent with guidelines issued by other international organizations.

Discussion: These risk communication principles indicated in the guidelines were useful for establishing good practices in local communities to empower residents and strengthen community function, potentially reducing the secondary health impacts induced by the Fukushima accident. However, the strengths within social sciences are thought to create new challenges because the ethical, legal, and social implications (ELSI) are newly recognized difficulties within local public health activities regarding radiation risk communication, and there is only a limited number of articles focused on these relationships and radiation risk communication within the social sciences. The collaborative problem-solving strategy should be strengthened to deal with the difficult issues in local communities since ELSI are all within local public health activities regarding radiation risk communication. Therefore, a collaborative problem-solving strategy within social sciences is a challenge issue to study.

Conclusions: Successful risk communication practices were helpful to the local community and supported by the local community. They were observable in local communities by employing the strategic approaches directed by a team organized with many experts in local issues, including local risk communicators. Established risk communication guidelines are helpful, especially regarding the ELSI of science and technology.

keywords: nuclear disaster, risk communication, public health, radiation

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Corresponding author: Ichiro Yamaguchi
2-3-6 Minami, Wako, Saitama 351-0197, Japan.
Tel. +81-48-458-6259; Fax +81-48-458-6270; Email: yamaguchi.iaa@niph.go.jp

I. Introduction

Released radioactive nuclides due to the Fukushima Daiichi nuclear power station accident caused by the tsunami of 11 March 2011 in Japan have a tremendous impact on Japanese society. Since that accident, there has been various countermeasures taken to protect the public from radiation. However, even though the radiation dose to each resident was successfully minimized, including internal radiation by the early evacuation and various related countermeasures in most cases, the nuclear disaster has brought numerous difficulties to the society, such as mental health issues [1,2], and secondary health issues [3] during the recovery phase of the nuclear disaster. Why is risk communication important for the recovery from the disaster? According to Reconstruction agency of Japan, the total number of disaster-related deaths from the Great East Japan Earthquake was 3,647 up to September 30, 2017 and among them 2,202 death cases occurred in Fukushima [4]. These deaths were caused by indirect effects of the disaster, showing the importance of a balanced public health policy.

How to get a balanced public health policy is important for the thyroid ultrasound examination survey that is a part of the Fukushima health management survey, since it is recognized that over-diagnosis issues are a concern in the thyroid ultrasound examination survey [5-6]. The primary purpose of the thyroid ultrasound examination survey is not research but to help residents by providing an opportunity for examination to each resident as a public health service. However, there is a common concern that the thyroid cancer screening program in Fukushima might be potentially problematic to public health [7].

However, each resident has a basic human right to know his/her health status caused by the accident and to choose to participate in scientific research even though it might impact her/his family by doing so. Also, the local government has the responsibility to protect the health of their community as best they can, and should provide the opportunity to examine his/her health concerns as a public health service. Had the Fukushima Government not providing thyroid screening then the public may have thought that the government did not care about their health, or that they did not understand the health risks. Therefore, although there are concerns about the overall public health benefits of the thyroid screening program, not doing the thyroid cancer screening program in Fukushima and doing nothing to inform the public about their current health might have been even more harmful to public health.

For any public health screening program, informing not only the benefits but also the risks should be an essential procedure, and transparency of such a public health program

is also important. In the case of radiation effects from insoluble radioactive particles [8], how can public health officials inform the biological risks including subclinical changes in the respiratory system properly to residents? To assess such health effects due to a disaster good disaster epidemiological studies should be carried out involving and supported by affected people [9].

Therefore, how to communicate with the public regarding radiation and its risk has been become a serious social issue. To facilitate recovery activities in affected areas, continuous public health risk communication in the long-term perspective is needed by collaborating with the relevant stakeholders [10].

After the Fukushima nuclear disaster, the basic strategies of risk communication were issued from the Ministry of Education, Culture, Sports, Science and Technology, Japan by adding existing guidelines issued from each ministry. After considering the specific problems regarding the nuclear disaster many lessons to be learnt are mentioned as a useful resource in the next section.

To facilitate more effective and practical risk communication activities including the long recovery phase after the nuclear disaster, the local practices used during the existing exposure situation after the nuclear disaster were reviewed in this paper to inform the development and improvement of current guidelines.

II. Domestic guidelines on risk communication issued by each Ministry to facilitate good risk communication

According to the National Research Council, USA, 'Risk communication' is a component of risk management, which is the selection of risk control options. It is the process that provides the information on which government, industry, or individual decision makers base their choices. Successful risk communication does not guarantee that risk management decisions will maximize general welfare; it only ensures that decision makers will understand what is known about the implications for welfare of the available options (National Research Council, 1989) [11]. By utilizing this definition, domestic guidelines on risk communication have been established such as risk communication on food safety by Ministry of Health, Labour and Welfare (MHLW) [12], how to promote risk communication on chemical substances by Ministry of Environment (MOE) [13], the website on consumers' opinions and risk communication including the text book on risk communication regarding health issues explaining the principle and practice by the Ministry of Agriculture, Forestry and Fisheries (MAFF) [14], the website on risk communication including the

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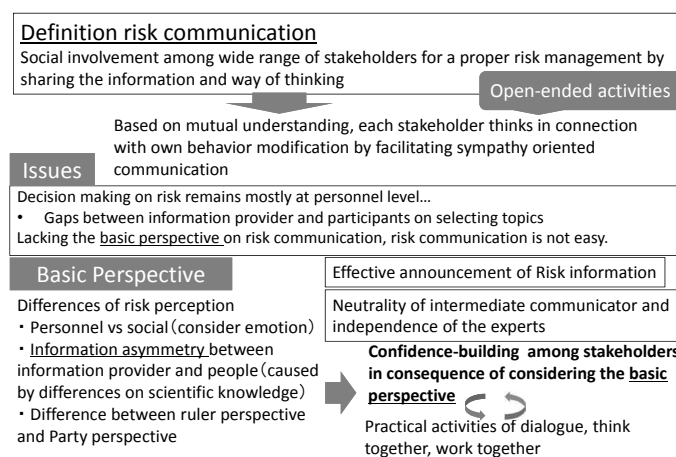
explanation of the typical misunderstanding of risk communication by the Ministry of Economy, Trade and Industry (METI) [15]. National Institute of Technology and Evaluation (NITE) also provides the basic guidelines for risk communication by introducing good examples and a tool for risk assessment that is able to be easily understood [16]. Those guidelines were issued before the nuclear disaster.

In addition to these guidelines, several new guidelines were issued after the Fukushima nuclear accident. One of them was "Risk Communication Promotion Measures" that was issued by the Safety and Security Science Technology and Social Collaboration Committee of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in March, 2014 [17]. The basic concept of this guideline is shown at Fig.1. Related to this guideline, "Risk Communication Case Study Report" was issued by the Science Communication Center of the Japan Science and Technology Agency Science Committee in March, 2014 including various attempts at including radiation issues. This guideline discussed the issue of subjectivity of risk perception by indicating the factors that influence risk perception such as fairness and spontaneity [18]. Furthermore, it is described that the importance of the aspect of social justice issues since fairness is related to social inequality and spontaneity is related to the human rights matter of self-determination. In other words, risk perception and related emotions to them reflect social issues rather than individual psychological issues. Similarly, artificiality relates to risk perception since artificiality means that the risk is caused by human activity. Therefore, this risk would be recognized as a matter of "responsibility" since the stakeholders are responsible for these risks and trust is also an important factor in the society. That is the basic concept of the ethical, legal, and social implications

(ELSI) of science and technology [19].

These discussions in this guideline are basically consistent with guidelines issued by international organizations [20-27] and the other guidelines issued by each member state or the European Union [28-32].

How to consider the specific characteristics of the nuclear accident in risk communication? This guideline is reflected lessons learnt from the nuclear disaster response. Therefore, this guideline deals with risk communication carefully by emphasizing the importance of dealing with public concerns and social and normative issues not by just thinking simply about scientific literacy only, but recognizing that public concerns are "emotional" and could be "wrong" risk recognition in terms of science without thinking about hidden motivation. Especially in the situation of confusion, people become sensitive to social and normative problems, and if a communicator ignores the social / normative aspects and tries to provide risk comparison unilaterally from the probabilistic viewpoints, it would lead to dissatisfaction and anger of people. Due to the difficult situations after the nuclear disaster, it became needed to have the basic principle and philosophy of risk communication and this guideline is reliable and a useful tool for risk communication and previous study also supports this view [33]. As a good example, the training course provided by the NIPH have lectures made by a social scientist and the feedback from the class participants is very positive. Although the number of scientific papers is limited, there are many real activities collaborating with good social scientists. Focusing on food safety, "Report on the risk communication regarding food safety" issued by Food Safety Commission in Japan in May, 2015. This report is more focused on food safety and consensus building in the society.



MEXT: promotion policy of risk communication (2014)

Original version is made by MEXT and it is modified and translated by the authors.

Fig.1 Outline of Risk Communication Strategy

III. The example of risk communication activities regarding the Fukushima accident

According to the PubMed electronic database for medical journals, six articles were identified by "radiation"[MeSH Major Topic] AND "communication"[MeSH Major Topic] AND Fukushima [All Fields]. These are papers described with unique approaches utilizing personal [34] and local [35] measurement, general reviews [36-37], a review focusing on radio phobia [38] and media analysis among European countries providing a practical guideline for sound public communication about radiation risks [39].

Risk perception is subjective and depends on the background situation as well. Murakami summarized major risk communication activities in Fukushima (Murakami 2017) [33]. Adding this comprehensive review, the unique activities provided by Date city, Fukushima would be worth mentioning. Since risk communication is still not an easy task and the majority of residents do not show their demand for radiation risk communication events during the survey conducted by each municipality and the Government of Japan such as 9.4% in Tomioka [40]. Although presentation and explanation of radiation risks to affected people is recognized as a difficult task, it was observed that showing quantitative risks information using loss of life expectancy by answering questions is acceptable with participants by considering and emphasizing the importance of environment justice and fairness as the basic concept to think about with these difficult issues. Emphasizing again, risk comparison is not indicated as a in one-way method. Instead of this, comparisons were demonstrated by answering questions from each participant in a frank atmosphere coordinated by clinical psychologists since subjective risk comparison is a good way to recognize the size of the risk although a pressed risk comparison by someone else is not acceptable [18]. This method is implemented by referring to various guidelines indicated in the previous section. Therefore, common recognition of these guidelines among relevant organizations should be promoted to deal with these difficult tasks.

Case study 1: Date city case, collaborative activities with NPO and residents

For the public health service regarding radiation issues, a specific nonprofit organization (NPO) plays an important role. This NPO is named "Warm- heart" and it fosters the long-term supporters who live together in the affected area so that children and their families in Fukushima can overcome the difficulties burdened by the nuclear accident and fosters a healthy and bright future both mentally and

physically. This NPO is consisted by clinical psychologist, nursery teacher, pediatrician, health fitness programmer etc. By gathering these experts' efforts together and participating in municipal affairs activities, they are working on community activities with local governments. The significance of this task was described below by looking back on the activities of this work.

An analysis was done of the progress of supportive activities of the public health center after the nuclear accident and tried to analyze the problems and their efforts to solve their emergence in the development of activities as a case of external support in community health activities after the nuclear disaster. Then various investigations have revealed that nuclear disaster not only brings radiation risk to people but also brings a psychological burden. In that situation, community health activities carried out by municipalities in consideration of psychological care are also accepted and supported by participants in each region. During fiscal years 2011-2015, 224 local events were held in each region in the city and total participants number was 2,434 including some duplication. Date city provides personal consultation service regarding radiation and total participants number was 344 including duplication during fiscal years 2012-2015. They had accumulated experience in activities in these areas collaborating with local community leaders.

It seemed that by employing the clinical psychologists and involving them in the local municipal activities in the community, it made meaningful opportunities to draw out the power of the area and each event was filled with fun. Even in the case of taking up the difficult radiation issue, clinical psychologists consulted on the atmosphere and focusing on the needs of residents. Clinical psychologists also considered the diversity of risk perception among the participants. It was shown in the feedback sheets that the satisfaction of participants was high (data not shown).

Case study 2: Kawauchi village case

Kawauchi Village was the first evacuated municipality which allowed residents to return to their homes. It is within Futaba County, Fukushima Prefecture, the region most affected by the accident of the Fukushima Nuclear Power Station (FNPS). Immediately after the FNPS accident, all residents were required to evacuate on 16 March 2011. The evacuation order was lifted for the east part in October, 2014 and the entire area on 14 June, 2016. It has been shown that a marked bipolarization of the risk perception among the residents in Kawauchi village about the health effects of radiation and among the residents. This could have a major impact on social well-being after the accident at FNPS [41]. Bipolarization of the risk perception

is still observable between the returned residents and the still evacuated residents partially due to the discontinuance of the temporary emergency housing after March 2017 [42]. Kawauchi Village is a beautiful mountain village with a wealth of nature, but it is without a public water supply service like neighboring Katsurao village. Previously, their daily lives were blessed with nature, and they are now trying to get back their own rich natural life style by implementing techniques to ensure radiation safety for their products. However, it has become difficult to restore the traditional charcoal industry due to the radioactive waste issue. Since their traditional lifestyle is important, current radiation risk reduction behaviors should also be considered [43-45].

Food monitoring stations in Kawauchi village have the unique characteristic of involving local residents in the operation of each food monitoring station. Kawauchi village has 8 districts. After the nuclear disaster, each district had a food radiation monitoring station except the 8th district which was closest to the Fukushima Dai-ichi nuclear power station. Since April 2014, these food radiation monitoring stations have been consolidated into 4 stations. Participating residents are paid and they study radiation extensively through a variety of opportunities; they are well-motivated to contribute to their village recovery. These food radiation monitoring stations are operated by a commerce and industry association that is consigned by the Kawauchi village office to promote cooperation between the residents and village office.

IV. Guidelines on risk communication emphasizing stakeholder involvement

The public considers nuclear accidents as severe events. If the public health community is not prepared, it is difficult to deal with these situations. For this nuclear event, the public health community was not prepared well for such a huge nuclear disaster. In order to improve public health preparedness, the Communications Workshop was organized to start planning effective communications together to explore how related organizations would work together in the event of a nuclear accident and to raise awareness of the pitfalls and best practices from Fukushima through the assessment of planned procedures. The experience of drill on a nuclear disaster was published as the report of the NRPB [46]. According to their exercise, it was realized that without adequate stakeholders consensus could not be formed among the experts. Then stakeholder involvement was studied experimentally. They found that the discussions on waste management regarding the affected farm industry, especially issue of the disposal of

contaminated dairy milk, was similar with the experiences of the Fukushima nuclear accident [47-50].

Stakeholder involvement for post-nuclear disaster is a key to resolving this problem. For the local public health activities dealing with difficult conflict issues, the collaborative problem-solving model shown by US EPA [51] is adaptable and effective since this model has been developed by gathering many real case studies and its philosophy of collaboration is easy to observe empathy by stakeholders with different positions.

V. Risk communication and social media

The European Food Safety Authority (EFSA) issued Risk Communication Guidelines indicating 4 guiding principles; Openness, Transparency, Independence and Responsiveness/timeliness [52]. From this point, it was shown that the importance of "attitude" when releasing a message, not just "how to technologically put out a message". Also, this has shown the importance of grasping the mutual relationship within dialogue so that the structure of distrust among the audience is found. In the EFSA guidelines, various tools and channels are picked up, and it explains in what situations it is suitable and what kind of scene it is not suitable for. The unique characteristics of the list it contains, not only websites but also, social networking, twitter and blogging. Although utilizing social media has challenges for administrative organizations, "A structured plan for social media improved the visibility of EFSA's content".

The social media issues in risk communication were also indicated and discussed at the 32nd meeting of RASSC, IAEA as review of the IAEA safety standards based on experience following the Fukushima accident saying Radiation Safety Standards Committee (RASSC) agreed that the best means of communicating with the public in the aftermath of an emergency is to be already established as a credible source on social media. There is a need to develop guidance for Member States on how to establish a presence on social media and how to develop and maintain credibility".

Furthermore, utilization of natural language processing technology would be bigger challenge of risk communication by social listening from now on. What is the easy way to know what people want to know? To examine the discourse on the net, reputation analysis tools using natural language processing are being developed. The significance and advantages of a reputation analysis tool is that it is inexpensive compared to a standard social survey, and quick. Newly developed techniques using natural language processing are making it possible to improve and

support people's thinking [53]. These techniques would be useful to obtain frank opinions from the public and these tools would be good regarding community engagement and responsiveness.

Other usages of reputation analysis tool are rumor survey. A case example that "You can discover food poisoning that has not been reported to the administration from the word-of-mouth" has been published [54].

VI. Role of a risk communicator

The role of the risk communicator is to build bridges between the risk manager, risk assessors and other interested scientists, and other key stakeholders, such as residents and consumers. Of utmost importance is the translation of risk assessment information into objective, understandable information which can be provided to the public while considering their health literacy. In addition, the risk communicator needs to collect feedback and assess the opinions regarding changes in values and priorities of the public, and feed this back to risk managers and assessors (Fig.2). It was confirmed that gaming is an effective way for the development of the communication tool intended for the public to become familiar with technical terms [55].

VII. Challenges of communication with affected residents in terms of thyroid cancer screening tests

The psychosocial impact of thyroid cancer on young people who were exposed to I-131 following the Dai-ichi power plant explosion is important. Clearly, the experience

in Belarus following the Chernobyl accident underscores the significance of psychosocial studies. One companion study might be to survey the parent's concerns about their children having thyroid cancer and how that has affected the family situation. If they have more than one child are they worried about their other children developing thyroid cancer? It may be that siblings who are not affected represent a psychologically high-risk group among their friends. Surveying them may be important as well. The results of these studies would be helpful in designing appropriate psychosocial interventions to help the affected child, unaffected siblings, and the parents cope with their situation. Following a cohort of these individuals over an extended period would be informative about the long-term consequences on their psychological and social development. A comparison set of studies would be doing the same surveys in children and their families who have normal ultrasonography and those who have nodules or cysts. Depending on the findings, these groups may be helped by psycho-educational interventions.

One other potential population to survey would be the children and parents, who lived in Futaba County at the time of the power plant meltdown and explosions. These towns were the exceptional ones that administered potassium iodide to their inhabitants. It would be useful to understand whether taking the potassium iodide not only protected them from the thyroid cancer risk but whether it also protected them from the adverse psychological effects of radiation exposure. If this could be demonstrated, it would be another strong reason for every town near nuclear power stations to have a protocol in place to administer KI following a nuclear accident.

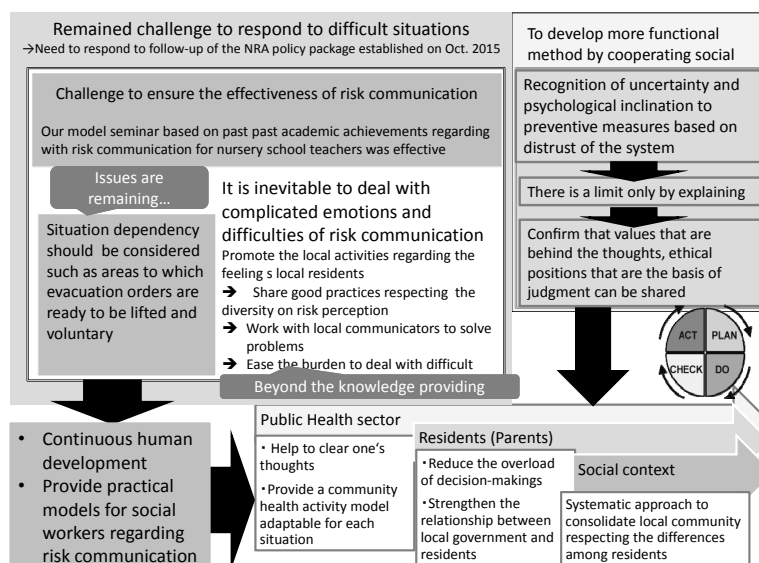


Fig.2 Challenge to ensure the effectiveness of risk communication

VIII. Long-term collaborative work with public employees who engaged in recovery work in Fukushima by caring for their stress

Maeda mentioned that mental health issues are prioritized among relevant stakeholders including public employees: "In addition to other stressors, such as exposure to residents' anger, role conflicts among the employees were one of the etiological factors that caused such a high prevalence rate of depression among our study participants"[56]. To reduce the stress among stakeholders, environmental justice collaborative problem-solving model is promising tool supported by social scientists.

IX. Conclusions

Successful good practices are those helpful to the local community, supported by the local community, and are observable in local communities. They use strategic approaches with a team organized by many experts in local areas, including local risk communicators. Established risk communication guidelines are helpful for their approach especially in the ethical, legal, and social implications (ELSI) of science and technology.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

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福島第一原子力発電所事故後の放射線リスクコミュニケーション活動の教訓

山口一郎¹⁾, 志村勉¹⁾, 寺田宙¹⁾, エリック・スベンソン²⁾, 櫻田尚樹¹⁾

¹⁾ 国立保健医療科学院生活環境研究部

²⁾ サウスカロライナ医科大学公衆衛生科学部環境保健分野

抄録

導入：東電福島第一原子力発電所事故からの回復期において、精神保健対策や二次的な健康影響への対応が容易ではない課題となっている。バランスの取れた公衆衛生施策を展開するには、リスク・コミュニケーションに関する健全な取り組みが求められる。

方法：放射線リスクコミュニケーションに関するガイドラインや公衆衛生活動に関してPubMedを用いた文献レビューを行い、リスクコミュニケーション課題に関する今日の捉え方を調べた。

結果：それぞれのガイドラインの内容や「放射線」、「コミュニケーション」をMeSHの主要トピックスとして選択し、「福島」で検索し得られた文献からは福島での原発事故でのリスク・コミュニケーションの適用可能性やその重要性について一致した認識があった。日本の各省庁で発行しているリスク・コミュニケーションに関するガイドラインは、国際機関が発行しているガイドラインとも考え方が一致していた。

考察：これらのガイドラインで提示されていたリスク・コミュニケーションの基本的な考え方は、地域住民と地域社会機能を高める地域保健の良好活動事例でもその展開を支える役立つものとなっており、原発事故によりもたらされた二次的な健康被害の低減に役立っている可能性がある。しかしながら、倫理的、法的、社会的議論を検討する活動(ELSI)は、放射線リスクコミュニケーションに関する地域保健活動において新しく認識されてきた概念であり、まだ、この観点で社会学と地域保健活動の連携について書かれた論文が限られていることから、社会科学とより連携を深めることが挑戦的な課題となっていた。ELSIは、地域保健活動での放射線リスクコミュニケーションにおいて避けては通れない概念であり、このような地域での容易ではない課題に対して、関係者で連携した課題解決戦略が強化される必要がある。このように社会科学も活用した関係者で連携した課題解決戦略は、研究上も挑戦的な課題となっていると考えられる。

結論：リスクコミュニケーションのよい取り組みは、地域社会にとって役立つものであり、その展開が地域社会からも支持されていた。地域社会において地域のコミュニケータを含む複数の専門職からなるチームとして組織された戦略的な取り組みが観察された。確立されたリスクコミュニケーションのガイドラインは、特に科学技術でのELSIの観点から特に役立つものである。

キーワード：原子力災害, リスク・コミュニケーション, 公衆衛生, 放射線