

A critical review of controversy over health effects of low dose radiation exposure by Fukushima Daiichi APP accident accompanied with East Japan Great Earthquake

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1 Introduction

After the accident of Fukushima Daiichi Atomic Power Plant in last March, there is a huge controversy over the potential for health effects of low dose radiation exposure, the ICRP's reference level of 20mSv/year which is employed for designating the evacuation areas.

Confusion among the general public arises because some experts have advocated that the low dose exposure has serious health risks, while mainstream experts explain that epidemiological studies are unlikely to detect any increase in risk of cancer or other serious diseases.

In reaction, the government of Japan established the “working group of experts for risk management of low dose radiation exposure” in the end of 2011, which includes 7 hearing sessions from 14 experts, 6 mainstream experts and 2 anti-mainstreamers, 2 international experts, 2 physiologists and 2 practitioners.

The confrontation between mainstream experts and anti-mainstreamers has continued for a long time, not only in Japan but also in the western world. However, no agreement has reached yet. This paper aims to analyze the argument of both side from three perspectives and try to find out proposals to make a contribution to the possible agreement.

2. Perspectives for Analysis

2.1. Difference of Discipline s in Each Specialty

The specialty of radioactive safety or radioactive protection, to which mainstream experts belong, has been a part of public health and employs epidemiological studies for its basement. On the contrary, anti-mainstreamers rarely belong to this specialty, and tend to use different approaches than epidemiology.

Since each specialty has its unique discipline for professional judgment, the argument between mainstreamers and anti-mainstreamers becomes an inter-specialty argument or inter-discipline argument. This paper analyzes the argument of both side from the perspective of discipline difference.

2.2. Cognitive Psychological Studies about Risk Perception

In cognitive psychology, a number of previous studies has made about risk perception of radioactive safety, in particular, risk acceptance of nuclear facilities. The psychological

studies imply that risk debate are not merely about risk statistics, some sociological and anthropological research implies that some of these debates may not even be about risk (Slovic 1987). The general public's basic conceptualization of risk is much richer than that of experts and reflects legitimate concerns that are typically omitted from expert risk assessments (Slovic, Flynn, Layman 1991). Previous studies proposed several factors, which affect risk perception of the general public, however, this paper employs two factors such as the importance of trust and identifiable information bias.

2.2.1 Importance of Trust for Risk Perception

Several psychological studies point to lack of trust as a critical factor underlying the divisive controversies that surround the management of radioactive hazard (Bella, Mosher and Calyo 1988, Slovic 1993). For instance, although x-rays and medicines pose significant risk, our relatively high degree of trust in the physicians who manage these devices makes them acceptable. Numerous polls have shown that the government and industry officials who oversee the management of nuclear power are not highly trusted (Flynn, Burns, Merts and Slovic 1992, Pijawka and Mushakatel 1992).

Trust is fragile. It is typically created rather slowly, but it can be destroyed in an instant by a single mishap or mistake. A study demonstrate that negative (trust-destroying) events are seen as far more likely to have a powerful effect on trust than are positive (trust-building) events (Slovic, Flynn, Johanson and Merts 1993).

Moreover, just as individuals give greater weight and attention to negative events, so do the news media. Much of what the media reports is bad (trust-destroying) news (Lichtenberg and MacLean 1992).

A single study demonstrating an association between exposure to radiation and some adverse health effect cannot easily be offset by numerous studies failing to find such an association (Macgregor, Slovic and Morgan 1992). The results of those studies match up closely with what had happened in the controversy about health effects by low level radiation exposure.

2.2.2 Identifiable Information Bias

Several studies demonstrate that sympathy for identifiable victims diminishes with deliberative thought, but remains consistently low for statistical victims. This pattern holds with various manipulations of deliberative thought, including explicit debiasing interventions, providing statistics and priming an analytic mindset (Small, Loewenstein and Slovic 2007). Such choices are made intuitively, based on spontaneous affective reactions (Schwarz and Clore 1983).

Some interventions to de-bias the identifiable victim effect have proposed and tested. A study employed an intervention designed to induce either a “calculation-based” or “feeling-based” mode of thought. In the calculation priming condition, participants are required to answer quantitative questions, on the contrary, in the feeling priming condition, participants are required to answer question which ask the feeling when participants hear the word such as “baby”. The results revealed that calculative thought lessens the appeal of an identifiable victim, but feeling-based thought does not improve the appeal of statistical victims. These results strongly support the notion that modes of processing, and specifically the distinction between feeling and calculation, play a crucial role in the identifiable victim effect (Small, Loewenstein and Slovic 2007).

3. Subject of Research

For easy analysis and comparison of arguments, the arguments should have a shared object and a standard format. Thus, this paper pick up the hearing/debate sessions of "Working Group on Risk Management of Low-dose Radiation Exposure (hereinafter "WG")", established by the Cabinet Secretariat of the Government of Japan in 2011.

3.1. Outline of the WG

The WG aims to develop scientific views and opinions regarding health effects from low-dose radiation exposure of 20 milli-sieverts (mSv), which is employed to map evacuation zone around TEPCO Fukushima Daiichi APP.

The Cabinet Secretary held 8 hearing sessions from experts in November to December in 2011. All sessions are open to public via internet video services, which are still on the web site of the Cabinet Secretary.

In the hearing sessions, all experts have 30 minutes for presentation, followed by 30 minutes discussion. The WG require all experts to submit the abstract of the presentation in a standardized format, whose items includes a) itemized conclusion of author's opinion about health effect by low-dose radiation exposure (within 6 bullets), b) a list of related literatures (no more than 10) and c) summary of authors opinion (no more than 400 letters in Japanese). All domestic experts except one submitted the format.

3.2. Selection of Experts to be Interviewed

Upon the selection of experts to be interviewed, the WG decided to invite leading anti-mainstream experts not only mainstreams, so as to the report of the WG persuasive to the general public.

The WG selected 14 experts, all domestic except two international experts, who explain the

basic concepts of ICRP recommendations and experience in the Chernobyl accidents and not to present their opinion about the effect of low-dose exposure. 4 experts do not specialize the effect of low-dose exposure, such as two psychologists, a practitioner of remediation work of contaminated environment, and a mayor of the affected area of accidents. 8 experts specialize health effect of radiation exposure, whose details are as follows;

KAI, Michiaki: Professor, Oita University of Nursing and Health Sciences

KIMURA, Shinzo: Director, Fukushima Office, International Epidemiology Research

Laboratory, Associate Professor, Radiation Hygiene, Dokkyo Medical University

KODAMA, Kazunori: Chief Scientist, Radiation Effects Research Foundation

KODAMA, Tatsuhiko: Professor, Research Center for Advanced Science and

Technology, The University of Tokyo

NIWA, Ohtsura: Emeritus Professor, Kyoto University

SAKAI, Kazuo: Director, Research Center for Radiation Protection, National Institute of Radiological Sciences

SHIBATA, Yoshisada: Professor, Nagasaki University Graduate School of Biomedical Sciences

SHIMADA, Yoshiya: Group Leader, Experimental Radiobiology for Children's Health Research Group, Research Center for Radiation Protection, National Institute of Radiological Sciences

Dr. Niwa and Dr. Kai are current members of Radiation Council, a governmental council which deliberate adequacy to introduce ICRP's recommendations into Japanese legislatures.

Dr. K. Kodama has been a researcher of Radiation Effects Research Foundation, a research institute which specialize health effect of the atomic bomb victims in Hiroshima and Nagasaki. He also serves as a specialist in international organizations such as UNSCEAR and WHO.

Dr. Sakai is a researcher who specialize health effect of low-dose exposure, a member of Atomic Safety Committee of Japan and a member of a special committee of ICRP. He had worked for the Central Research Institute for Electric Power Industry for a long time.

Dr. Shibata is an epidemiologist who committed researches about health effect of residents around Chernobyl. Dr. Shimada is a researcher who has engaged animal experimentation about health effect of radiation exposure. He has worked for governmental research institute for a long time.

Dr. T. Kodama, a leading anti-mainstreamer, is a molecule biologist and a physician, who specializes genome studies. He admits he is not an expert of health effect of radiation exposure, but has plenty experience on medical practice using radio isotope.

Dr. Kimura, a leading anti-mainstreamer, is a researcher of radiation hygiene. He had committed a survey of environmental radiometry around Chernobyl for a long time, and has been practicing radiometry survey around Fukushima Daiichi APP.

4 Analysis Based on Reasoning and Discipline

4.1. Reasoning of Mainstream Scientists

Opinions and reasoning of 6 mainstream scientists have a lot in common. All of them quoted epidemiological studies and reports of international organizations, in particular, half of them quoted UNSCEAR Report 2008, a review of related studies concerning Chernobyl and related ICRP publications. (Table 1)

Table 1 Type of study of mainstream scientists

Type of study	Subject of Research	# of Quotation
Epidemiology	ABS	12
Epidemiology	chornobyl	7
Epidemiology	others	4
Epidemiology	review	2
Ohters	Chornobyl	2
Ohters	standard	3
Recommendation	ICRP	8
Review	UNSCEAR	6
Report	WHO	1
Review	IAEA	1

Most of the mainstreamers quoted overlapped epidemiological studies, in particular, all 6 of them quoted same epidemiological study of the atomic bomb victims in 2007. Since the WG focused on thyroid cancer in children, 3 of them quoted the epidemiological studies in 1995 and 2005 about thyroid cancer around Chernobyl. Some of them quoted the epidemiological studies of residents who live in high-level natural radiation areas. The journals of quoted literatures are concentrated in a few journals and report of international organization. (Table 2)

Table 2 Journals quoted by mainstream scientists

Journal or report	# of quotation
Radiation Research	11
Journal of National Cancer Institute	7
Health Physics	2
Other journals	7

ICRP Publication	8
UNSCEAR Report	6
IAEA Report	1
WHO Report	1

4.2. Discipline of Mainstream Experts

The academic area concerning health effect by radiation exposure is a part of public health. Public health has wide scope, whose subject of research is not individual but population. Epidemiology and toxicology are most used methodology in this field, which has three disciplines, such as a) confounding control and statistical significance, b) concept of risk, and c) cost benefit analysis.

4.2.1. Concept of Confounding Control and Statistical Significance

Concept of confounding control and statistical significance can resolve a question as follows. It is well known that percentage of cancer patient increase by age and has regional differences. For evaluation of potential cancer causing chemical substance, if the association between exposure of the chemical and incident rate of cancer is observed in statistically significant, the association does not happen by chance. However, the association may be caused by age or regional differences, which is called as "confounding factors". Confounding control is a statistical methodology to remove the effect of such confounding factors, and can specify the association between cancer incident ratio and a targeted substance.

4.2.2. Concept of Risk

Concept of risk is crucial to understand the meaning of the observed association. The statistically significant association between a chemical substance and cancer incident rate, controlled confounding factors, is assumed that the chemical accelerates an incident rate of cancer. However, all persons who are exposed to the substance do not cause cancer, and only a part of them does. Risk by exposure only increase the possibility of cancer incident, and thus does not cause cancer determinately.

4.2.3. Concept of Cost Benefit Analysis

Cost benefit analysis is a methodology for judgment of means of regulation. A competent authority tries to prohibit the use and production of the chemical which has judged as cancer causing substance, if possible. However, absolute prohibition is not feasible if the substance is vitally necessary for industries. In this case, the authority have to issue specific permission of its use under a certain exposure limit, which increase the risk of cancer of workers. The residents around a plant have also potential risk of cancer, because 100% enclosure of the

substance is technically impossible. The cost benefit analysis decides to what extent the risk of workers is acceptable, in consideration of social and economical condition and practice.

4.3. Reasoning of Anti-mainstreamers

The paper analyzes the reasoning of anti-mainstreamers in the hearing sessions of the WG. Dr. Kimura admitted that his opinion was not based on peer reviewed literatures but the results of radiometry surveys by himself and interviews from local experts of Chernobyl. He also could not present solid reasoning why Chernobyl experts employed 5 mSv per year as a limit for evacuation.

On the contrary, Dr. T. Kodama is a molecular biologist who specialize carcinogenic pathology and also a clinician, whose article was published in leading academic journals such as Science. Thus, he quoted 8 articles not from epidemiological studies but carcinogenesis field or clinical studies. In particular, he stressed a clinical data as an evidence of health effects by low-dose exposure, which is a pathology report of patients of prostatic hyperplasia around Chernobyl. He insisted that the report reveals the association between low-level exposure such as 10 Bq/l and increase of urinary bladder cancer, and also presented 7 pathology studies to reinforce his argument.

4.4. Discipline of Leading Anti-mainstreamers

The subject of clinicians is patients, who is an identifiable human being with personality. So they make their best even if the patients has scarce or unexpected illness. They try to find out a cause and pathology of diseases, such as by molecular biological studies.

4.5. Analysis of Difference of Discipline

The argument between Dr. T. Kodama and mainstream scientists is worth to be analyzed. This argument can be said as interdisciplinary debate between experts of epidemiology focused on population and experts of clinical study focused on individual patients.

The argument of Dr. T. Kodama did not fit any of disciplines of population based analysis and epidemiology. In precise, the clinical report of urinary bladder cancer does not show statistical significance and not mention confounding control. Also, the pathology studies as "reinforcement" does not fit the concept of risk. Even if, the molecular-biological markers indicated the damage of the tissues by low-dose exposure, it does not necessarily cause cancer, because cancer has stochastically-processed pathology. Moreover, his quoted data cannot resolve the question why the increase of urinary bladder cancer incidents are not observed around Chernobyl after 25 years of its accident, which is more than standard incubation period for cancer.

Lastly, cost benefit analysis cannot accept a preventative regulation of low-dose exposure, which cannot provide statistical significant benefit in population, in spite of its economic benefit of radioactive use.

Dr. T. Kodama, however, never succumb to his opponents. He kept insisting that he is not epidemiologist but molecular-biologist and have conviction that low-dose exposure cause damage of tissues in observance with molecular markers. He also argued that urinary bladder cancer may increase in the future, and epidemiologically confirm the association between cancer and low-dose exposure, because cancer pathology is not well understood yet.

5. Analysis of Risk Perception

The paper scrutinizes the reason of such a large gap between anti-mainstreamers and mainstreamers by some psychological analysis of risk perception.

5.1. Analysis of Trust Building

As mentioned above, lack of trust is a critical factor in the divisive controversies in technological hazards and induce the risk perception such as high in risk, low in benefit, and unacceptable.

Mainstreamers has been members of inner-circle of judgment of radiation protection standard in Japan. Dr. Niwa and Dr. Kai have been members of governmental council, which deliberate ICRP recommendations, while Dr. K. Kodama has been a member of a special committee of UNSCEAR and ICRP. Dr Sakai has worked with the research institute funded by electrical companies, while Dr. Shimada has long worked with a governmental research institute. They, therefore, have strong trust toward current radiation protection standard.

On the other hand, both Dr. Kimura and Dr. T. Kodama are not epidemiologist, therefore, has not committed the decision making process of radiation protection. As results, their trust to the current standard has limits.

5.2. Analysis of Identifiable Victim Effect

The paper also deliberates effects of identifiable victim in the argument of the WG. As mentioned earlier, calculation practice may reduce the bias of identifiable victims. According to specialty of Dr. Kimura and Dr. T. Kodama, they seem to be not well trained in statistical methodology including epidemiology. Moreover, Dr. T. Kodama has a lot of clinical experience including cancer patients, while Dr. Kimura has research experience of thyroid cancer patients around Chernobyl. It is, therefore, a reasonable estimate that such continuous exposure to the identifiable victims may increase distrust to statistical data and standards based on them.

6. Discussion

Controversy between anti-mainstreamers and mainstreamers has a long history not only in domestic but also international. However, it could not fill the gap between them. The paper analyze the difference from three proposed perspectives, and aims to propose an approach to be tried.

6.1. Consensus Building in Interdisciplinary Communication

Epidemiological studies has been functioned as the means for formulating regulations of harmful substance under the opponent pressure from industries. Study of cancer and tobacco in 1970's is the typical one. Three disciplines of epidemiology have developed to defense the study results from attack of industries such as; there are other causes of cancer; there are many smokers who did not cause cancer, and economical influence should be considered in formulating regulations.

Unfortunately, the disciplines are effective to the attack such that no harm even if statistically significant, however, are not persuasive to the argument such that hazardous even if not statistically significant. Instead, the argument in the WG focused on the reason why we cannot observe the increase of cancer after standard incubation period of cancer, which is so called "epical proof" argument. This is not a standard discipline of epidemiology, whose methodology has not been established.

On the contrary, molecular-biology approach has remarkable progress recently, however, still have a lot of unknown process of carcinogenesis. This approach, therefore, can say "there is a possibility to cause cancer in the future", at maximum, and cannot refute the attack such as "no cancer increase after an incubation period" effectively.

Incident rate of cancer of epidemiology should have identical results of pathology of molecular biology in theory, however, due to the unknown process of cancer development, we could not find out universal discipline for judgment which is plausible for both side. As results, the argument between both side becomes a selection of discipline and cannot reach consensus.

As a proposed alternative discipline, the author would like to pick up the argument such "no cancer increase after an incubation period". If experts succeed to promote research about incubation period of cancer epidemiologically and molecular biologically, it can be a new discipline of epidemiology which is effective to refute the argument such "hazardous even if not statistically significant".

6.2. Consensus Building by Trust Building

According to the previous studies, building trust is far harder than destroying it, however, "local board authority to close plant" appears as the most effective way for rebuilding trust (Slovic 1993). Practicing this proposal is relatively easy, such that invitation of anti-mainstreamers into the inner-circle of decision making process of radiation protection standard. As a member of the governmental committee, they have a responsibility to make a reasonable judgment, which is feasible to practice, and be bind their decision. This practice may increase trust of the governmental decision from anti-mainstream scientists.

6.3. Consensus Building by De-bias of Identifiable Victim Effect

The problem setting of this effect itself has the basis on the dichotomy between identifiable victim and statistics victim, which have implication that the latter is right. The way to resolve, therefore, have to enlighten the people affected by the bias. In precise, experts, in any field of study, have to be trained statistical methodologies and disciplines as minimum academic training, because statistical approach prevails not only natural science but also social science and even in psychology and linguistics.

However, the opposite is also true. Epidemiologist should know other disciplines of other field such as molecular biology and psychology. Promotion of awareness of disciplines each other possibly become the first step of consensus building between different academic subject.

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