資料２－２

The 2nd Symposium on Restoration Support for the Great East Japan Earthquake

Handout Material

'The Fukushima Nuclear Power Plant Accident and Radiation Health Risks'"

Dean of the Graduate School of Biomedical Sciences at Nagasaki University,
Adviser to Fukushima Prefecture on Health-risk Management from Nuclear Radiation

Shunichi Yamashita

From Nagasaki to Fukushima

-- How the World Copes with the Risk of Radiation --

Date and time: June 15 (Wed.) 14:00 – 16:00

Venue: Diamond Hall, Kita Aoyama, Minato-ku, Tokyo

The Fukushima Nuclear Power Plant Accident and Radiation Health Risks

Shunichi Yamashita
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I would like to start by first of all expressing my heartfelt condolences to all those who have suffered due to the calamity of the unparalleled Great East Japan Earthquake, which struck on March 11th this year.

The Fukushima No.1 and No.2 nuclear power plants that bore the brunt of the massive earthquake and tsunami followed two different paths of fate, a successful attempt and a failed attempt at shutdown, but with regard to the details and responses made to the accidents we will now have to wait for a future verification of the events. The results of the research into long-term health effects following the atomic bombings of Hiroshima and Nagasaki have become the standard criteria for worldwide radiation protection, and are the basis of the scientific and policy decisions of ~~both~~ the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the International Commission on Radiological Protection (ICRP), respectively. The lessons of Chernobyl have also taught us a great deal about the health effects of not only external exposure but also of internal exposure and chronic exposure to minute amounts of radiation. I would like now to consider the correct understanding of radiation from the perspective of the health risks that are the stochastic effects. Though we are still in a state of flux that still shows no signs of drawing to an end three months after the accident, I would like to explain just how health management and promotion can be attempted in the areas suffering from radioactive environmental contamination.

Types of radiation exposure, at first, include external exposure, internal exposure, whole body exposure, partial body exposure and contamination and so on, but it is the dose of all of these that decides the health effects. The 120,000 research and study results for the atomic bomb victims in Hiroshima and Nagasaki is external exposure data, but as a huge body of epidemiological research it is the criteria for radiation safety and protection regulations throughout the world. Specifically, there are two types of health effects caused by radiation. Acute Radiation Syndrome results from exposure to 1000mSv or more; anybody exposed to this level will exhibit vomiting, headaches, diarrhea, hair loss and other physical symptoms or features, for which there is a threshold, and these are called ‘deterministic effects.’ In the case of the form of exposure called ‘Late Radiation Effects, which raises the possibility of developing cancers in the future, and occurs following exposure to doses of between 100 and more than1000mSv, we can carry out comparative examinations of several groups of exposed and unexposed people. As a result, the way that the risk of cancer increases in a dose-dependent manner is called the ‘stochastic effect.’ So what happens in the case of exposure under 100mSv? The fact is that the results of large joint epidemiological studies have not been able

to prove the existence of any clear carcinogenic risks. However, emphasizing the stochastic effect, the recommendations for radiation safety and protection are made under the hypothesis that even with exposures to doses of under 100mSv the carcinogenic risk rises in proportion to the dose exactly as it does with doses of over 100mSv – in other words under the principle of the Linear No-Threshold (LNT) Hypothesis. It's a principle that seeks to reduce radiation as much as it is possible. In either the case of a single exposure or when repeated exposure to small amounts is undergone and the accumulative dose gradually reaches the same level, the protection criteria is for the same dose. Of course, biologically speaking it is easy to imagine that the gradual exposure to small amounts carries a much lower carcinogenic risk as the body's DNA repair function go to work, and this has been confirmed experimentally. The human race developed by continuously acquiring DNA repair abilities as it evolved, adapting to hostile environments, and spinning the 'threads of life.' The exposure limit for the general public in Japan is set at 1mSv per year. We are generally exposed around the world to an average accumulated dose of 2.4mSv, so I think you can appreciate just how minimal that 1mSv level is. Human beings have always, are now, and will in the future live together with minute amounts of radiation. In this sense, with regard to the emergency situation in Fukushima Prefecture it is important to compare the health risks from chronic exposure to minute amounts of radiation with the entities of the many other carcinogenic risks.

I myself have worked for a long time in Chernobyl, 'a land contaminated by radioactive fallout,' where I was involved in study and research with an international institution. Immediately after the accident, on April 26th 1986, a massive amount of radioactive iodine was released into the environment. Inaudible and odorless radioactive substances quietly fell on the people watching the May Day street marches. Initially exposure from inhaling, and later on internal exposure from food contamination were suspected of causing problems. By comparison with Japan, too, the people there continued living on land that was extensively contaminated with radioactive cesium, and they also continued ingesting contaminated food in no small measure. The annual doses of radiation that those millions of local residents were exposed to ranged from several mSv to tens of mSv, but no clear risk of cancer, which is to say a stochastic effect, has been confirmed to date. The ones who should be protected are infants, children, and pregnant women. At Chernobyl, however, thyroid exposure to internal radiation in children emerged as a major problem, particularly due to contamination of milk through the food chain by radioactive iodine that was released in large amounts immediately after the accident. Radioactive iodine has a half-life of eight days, so it had almost entirely disappeared after half a year. Following the accident, however, the area around Chernobyl experienced a sharp increase in cases of a childhood cancer of the thyroid after a certain period of latency. This was a rare cancer that affects one in a million, and there were nearly 6,000 cases in a 25-year period. People who were infants at the time of the accident are undergoing surgery for thyroid cancer even after they have grown up. The cancer has not occurred, however, in children born since the accident,

and today the incidence of childhood thyroid cancer is at normal levels. In other words, the health effect on the general population following the Chernobyl nuclear power plant accident is the sharp increase in thyroid cancer extending throughout the lifetimes of residents who were infants or small children at the time of the accident. This is why thyroid exposure to internal radioactive iodine was also raised as a problem with the recent Fukushima nuclear power plant accident, and why regulations for food safety were promptly upheld. Although Fukushima and neighboring prefectures not only had restrictions placed on the distribution of agriculture, forestry, and fishery products, but also paid a heavy price in the form of harmful rumors as a result, it can very fortunately be inferred that the risk of thyroid exposure to radioactive iodine was drastically reduced. It will be necessary, however, to continue verifying this by reevaluating thyroid exposure doses among those who are expected to have been exposed.

Japan has been experiencing the reverberations of shock from the earthquake since March 11, and everything at this point is undergoing a period of upheaval. The Chernobyl nuclear power plant accident was a remote contributing factor in the breakdown of the East-West cold war structure and the dissolution of the Soviet Union, so Japan must make good use of the lessons of Chernobyl and explore the ways leading to new life rather than destruction. I would like to take this perspective in considering the course of the Fukushima nuclear power plant accident and the question of whether the levels of radiation in the environment will have any health effects.

After the occurrence of the tsunami that followed the earthquake, the residents of communities within a three-kilometer radius of the nuclear power plant were instructed to evacuate, and residents within a 10-kilometer radius were instructed to take refuge. Then further instructions were issued to residents within a 20-kilometer radius to seek refuge in safer locations. Even after that, concerns about the health effects of radioactive fallout due to hydrogen explosions led to residents within 30 kilometers being instructed to take refuge indoors, and their continuation in that state indicates the seriousness of the situation. The offsite centers that should have served as headquarters for local countermeasures to the nuclear power plant disaster were dysfunctional, and in this and other ways, matters were initially in a state of extreme confusion. On March 15, radioactive fallout drifting through the environment on winds blowing to the northwest fell mixed with snow in the city of Fukushima, 60 km away. Concerns have been expressed over environmental contamination and the impact on human health over a rather extensive area. The government expressed its view that there were no immediate health effects and has continued to repeat this view. Finally, however, orders for systematic evacuation were issued to parts of Katsurao-mura, Namie-machi, Iidate-mura, and Kawamata-machi as well as to parts of Minami Soma City on April 11. The area at a radius of 20 to 30 kilometers that had been designated for indoor refuge was then further defined as an Emergency Evacuation Readiness Zone. It is essential that the radiation doses of these disaster victims be

reevaluated, and it is considered desirable that medium to long-term health management be carried out.

Meanwhile, the people working at the Fukushima nuclear power plant accident sites are at greater risk of direct exposure to radiation. This necessitates radiation emergency medical care in the form of constant readiness to take measures in response to industrial accidents. However, for the vast majority of Fukushima Prefecture residents, including evacuees, there is no risk of exposure to dosages exceeding 100mSv. Even less is there any need at all for concern regarding the deterministic effects of exposure to 1000mSv or more. The only increase of radiation in the environment and in the earth due to the effects of radioactive fallout is from the radioisotopes of iodine (half-life of eight days) and cesium (half-life of 30 years). These are of concern as causes of external and internal exposure of our bodies to radiation. However, given the diversity in individual people's patterns of activity and dose distribution as well as the particular half-lives that are characteristic of radioactive substances, it can easily be inferred that their doses, if actually measured, would likely be lower than the theoretical integrated dose values. The environmental monitoring data from different areas of Fukushima Prefecture are continuing to show a diminishing trend at every measurement site to date. I hope that this trend will continue unchanged.

Finally, I would observe that along with evaluation and analysis of risk by scientific means, correct risk communication is also necessary. Risk management to mitigate and preclude risk makes use of regulatory science. In other words, overall judgments are made of the benefits and drawbacks in grey zones, where matters are not clearly defined in black and white, and policy decisions regarding risk taking are made. The matter of how the public will perceive these decisions, however, and how they will understand and judge the risks, will differ from person to person. This is risk perception. On April 12, a provisional report was made to the International Atomic Energy Agency (IAEA) that the accident was rated at Level 7 on the International Nuclear Event Scale. This came about because the total amount of radioactivity released into the atmosphere was rated the equivalent of approximately one-tenth, and currently one-fifth, that from the Chernobyl accident. Given the severity of the incident, it is essential that additional new sites for local environmental and health monitoring be established.

One lesson indicated by this recent experience appears to be the development of a new framework for radiation emergency medical care. This should monitor the validity of information on the health risks of radioactivity from the point of information scarcity to overflow and intermixture. It should evaluate government positions and instructions objectively, neutrally, and dispassionately. And it should be able to speak to the people of Japan with credibility. It is precisely when emergencies occur that it is necessary to respond in ways that surpass existing frameworks with extraordinary thinking. We published the titles Philosophy and Technology of Risk Communication and Risk Perception and Risk Communication even before this accident, while our most recent publication is

Atomic Bomb Victims of the 21st Century, so we are together with everyone in considering radiation health risks.

It is particularly important to reevaluate the exposure doses of individual people when dealing with problems of uncertain and indeterminate radiation health risks. To that end, the people concerned should act without delay to collect solid information on their own activities from the point immediately after the earthquake on March 11 up to the end of March, relying on their own memories to do so. There is also a need for health management that will forestall the damage caused by rumor and keep the psychological impact of events to a minimum. A health effects management group for Fukushima Prefecture residents has been established for that purpose. I intend to do everything I can to enable Japan-wide support for the "United We Stand Fukushima" movement.

The 2nd Tokyo Symposium on Restoration Support for Fukushima
By NASHIM, June 15, 2011 Tokyo

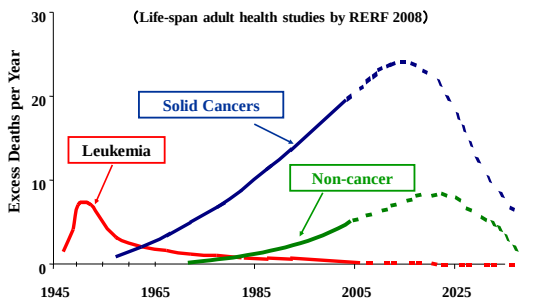
Quake-damaged Fukushima No1 Nuclear Power Plants and Radiation Health Risk

Shunichi Yamashita, Nagasaki University

長崎医科大学壊滅の日(1945年8月9日)

Change of cancer risk after A-bombing

Follow-up studies in Hiroshima and Nagasaki, and future prospects

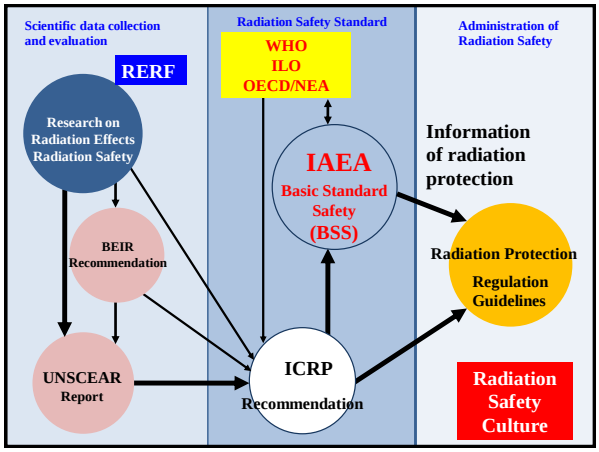


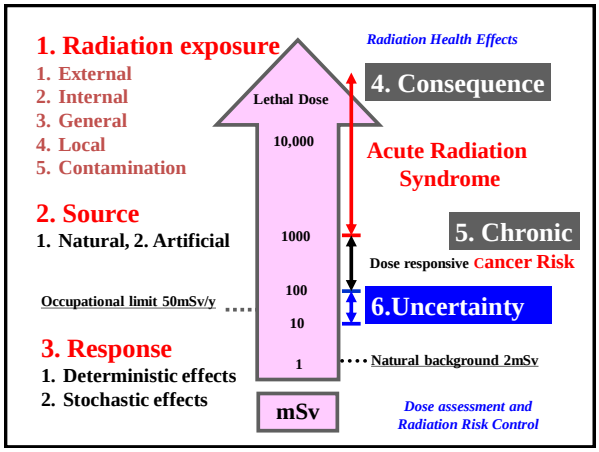
International Standards in Radiation Risk Evaluation

Based on a large-scale radiation epidemiology research completed using an evaluation of the radiation-induced health effects on the survivors of the 1945 Atomic bombing of Hiroshima and Nagasaki, the UNSCAER report dated on 2006 contained the final formulae for radiation risk evaluation, taking into account of the uncertainty factors.

Epidemiological Data from Humans

- **Atomic Bomb survivors' data and radiation risk analysis with other exposure groups have proved the *dose- and age- dependent* thyroid cancer risk after *external* irradiation for all their life with unlimited latency.**
- **Chernobyl data suggest that a dramatic increase of childhood thyroid cancers can be induced by short-lived radioactive iodines by its *internal* exposure just after the accident.**
- **Radiation-induced thyroid cancers are all histologically *papillary thyroid carcinoma*.**





Recent Development in Radiation *Health and Life* Sciences

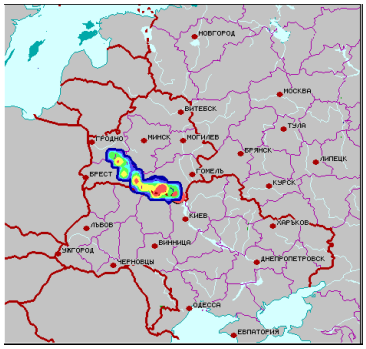
- **Dose-effect relationship**
- **Age-dependent effect**
- **Causality**
- **Genetic susceptibility**
- **Combined effects**

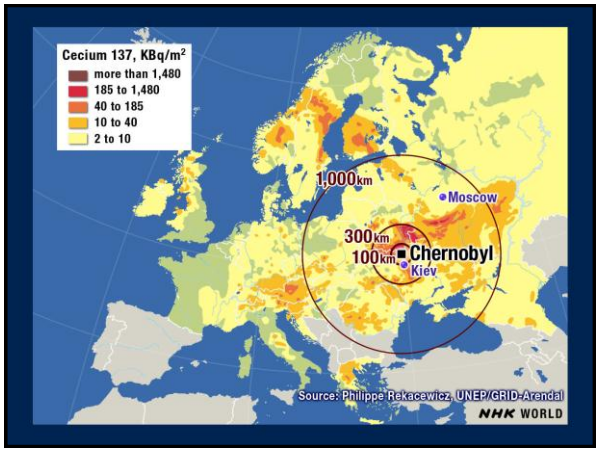
Cancer risks attributable to low doses of ionizing radiation: assessing what we really know and understand and what we can contribute to Fukushima using lessons from Chernobyl.

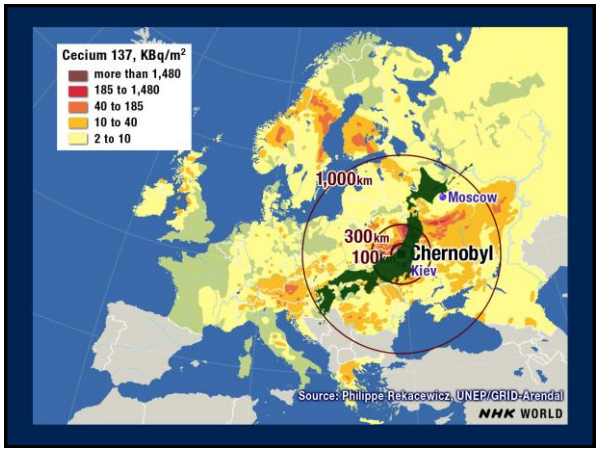
Chernobyl Nuclear Power Plant Accident

NRER

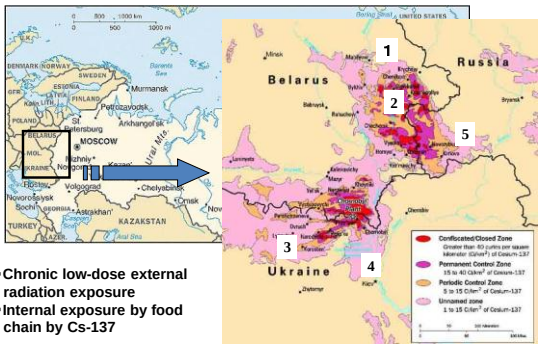
April 26, 1986





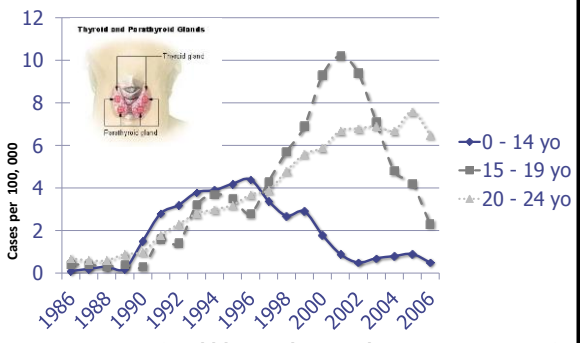


Radio-contaminated Soil Map of Cs-137



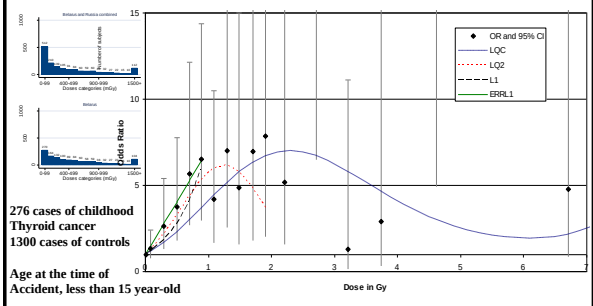
- Chronic low-dose external radiation exposure
- Internal exposure by food chain by Cs-137

Increase of Thyroid Cancers in Belarus



(Demidchik Yu, Saenko V, Yamashita S. ABEM 2007 51:748-62)

Risk of Thyroid Cancer around Chernobyl

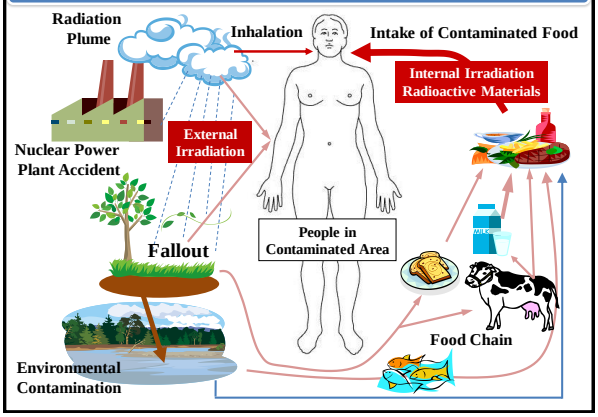


276 cases of childhood Thyroid cancer
1300 cases of controls

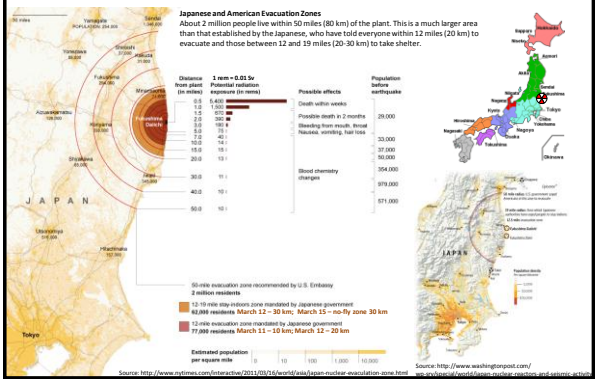
Age at the time of Accident, less than 15 year-old

(Cardis E et al; Risk of thyroid cancer following I-131 exposure in childhood, 2005)

Biological Reaction & Cancer Risk After Nuclear Disaster



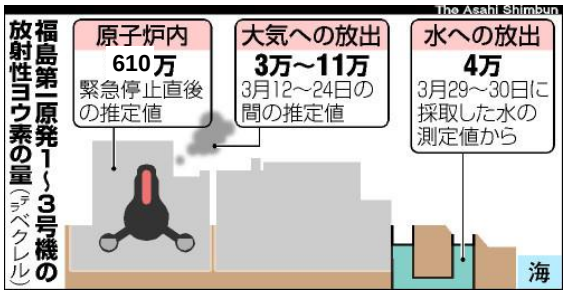
The Evacuation Zones Around the Fukushima Daiichi Nuclear Plant






福島原発で炉心溶融 放射性物質漏れ、事態深刻2011.3.12 14:18 福島第1原発の避難指示が半径10キロに拡大、浪江町役場の避難所から更に離れた双葉郡浪江丁立湾野小学校に避難した浪江町の住民ら＝12日午後、福島県双葉郡浪江町

放射性ヨウ素は約2%、放射性セシウムは1%が放出（アサヒコム4月15日より）



IAEAの発表によれば、チェルノブイリ原発事故では、放射性ヨウ素320万テラベクレル、放射性セシウム28万テラベクレル、全体で520万テラベクレルが環境中に放出、福島は全体で37万テラベクレル。

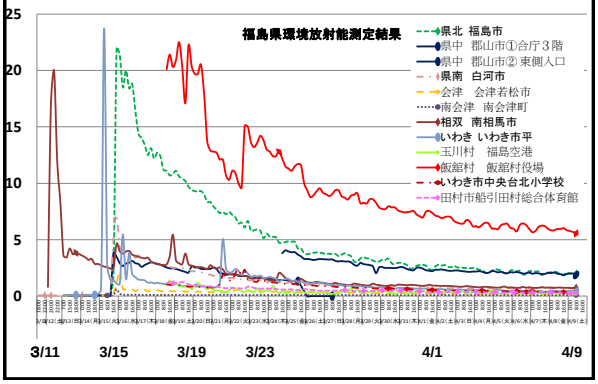
What is the effect of radiation fallout just after the accident？

Primary screening cut-off level; 100,000 cpm by γ-counter

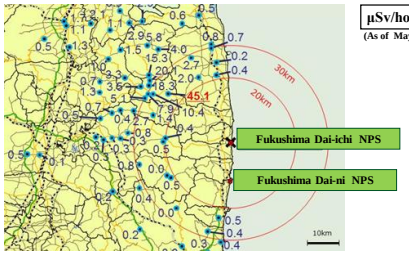
Crisis Communication
3月20日いわき市、21日福島市を皮切りに各市町村講演と対話5月初旬まで

Radiation Health Risk Communication
4月連休から文部科学省判断に従い積算線量の基準値遵守、ラジオ福島等

Environmental Radiation Level in Fukushima

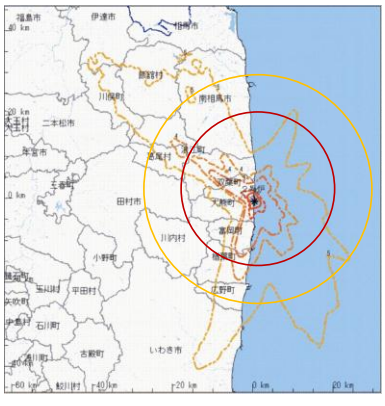


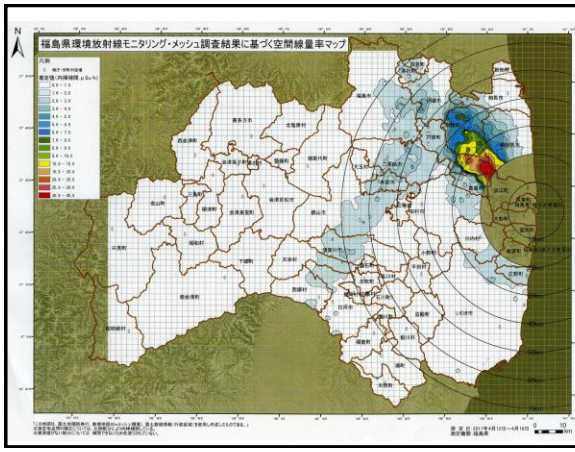
Dose-Rates at the Site of Fukushima Dai-ichi NPPs

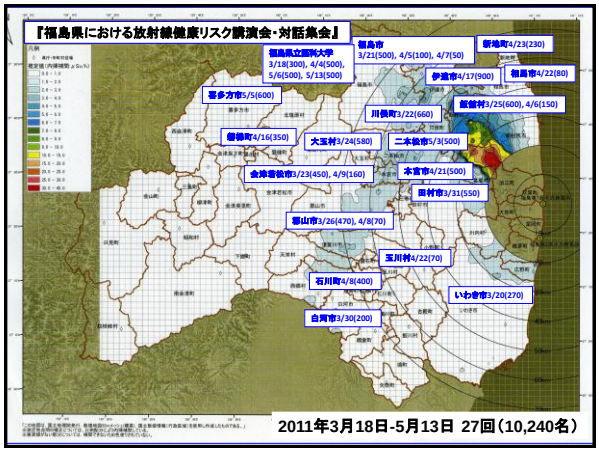


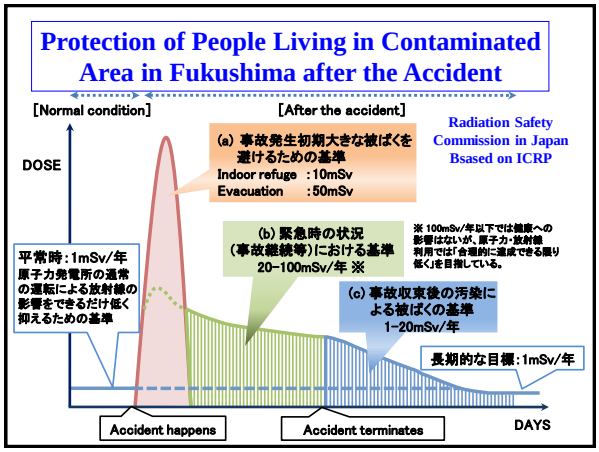
20 km radius of the plant and other designated areas
→ no-entry zone, planned evacuation zone

Some areas between 20 and 30 km radius of the plant (as a general rule)
→ emergency evacuation preparation area



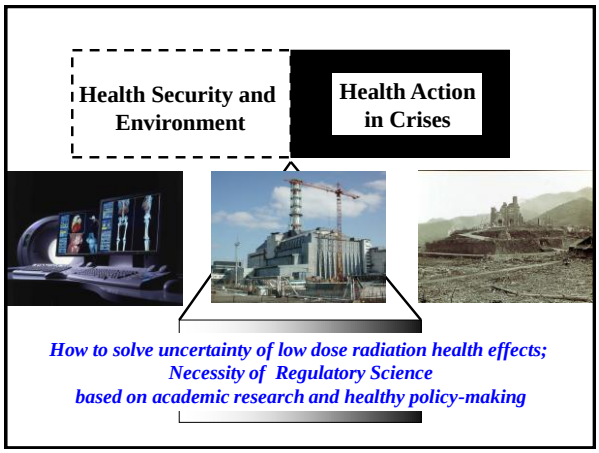


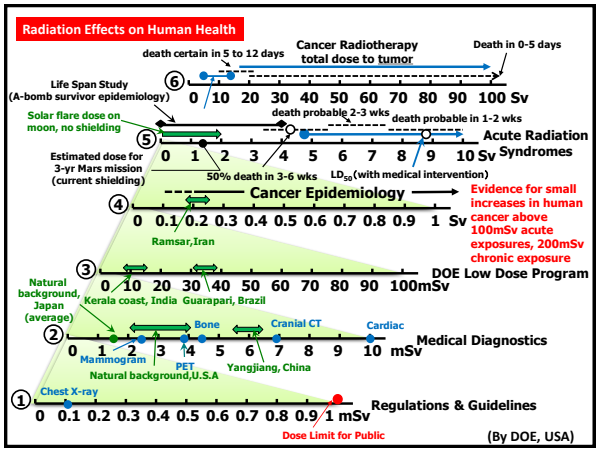




Further radiation health-related activities

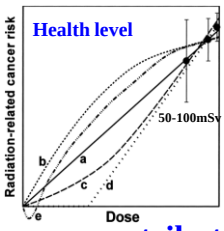
- Determination of accumulated doses (maximally individually-oriented), including type of exposure (external, internal) and major affecting radioisotope
- Calculation of radiation risk
- Identification of groups with risk exceeding socially-acceptable values
- Long-term health monitoring of the groups with elevated risk if necessary





Japan-wide support for the "United We Stand Fukushima" movement

Limitation of low-dose epidemiological studies related to Atomic bomb survivors data because of various type of heterogeneity in population and non-specificity of radiogenic cancer



Limitation of science for contribution to risk assessment and uncertainty because of no direct evidence between radiation and human cancers

What can we contribute to ?

1. Understanding molecular and cellular mechanism of low dose radiation-associated cancer induction may alter the concept of risk assessment by an identification of vulnerable group and radiation susceptible or resistant individual .

2. The advancement of radiation biology/oncology may improve the concept of risk management by an active prophylaxis or prevention before/during/after medical radiological exposure.