The Asia-Pacific Journal: Japan Focus
In-depth critical analysis of the forces shaping the Asia-Pacific...and the world.

The Asia-Pacific Journal, Vol. 11, Issue 23, No. 2. June 10, 2013.

Scientists and Research on the Effects of Radiation Exposure: From Hiroshima to Fukushima 放射線影響の研究と科学者ー広島から福島へ

Sawada Shoji

Translated by Jason Buckley

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How should scientists fulfil their social role after 3-11?

Introduction

In March 2011 disaster struck the TEPCO Fukushima Daiichi Nuclear Power Plant. This incident compelled me to re-examine exactly how Japan became a nuclear energy giant, despite having suffered the consequences of nuclear weapons three times – the atomic bombings of Hiroshima and Nagasaki, and the Bikini Atoll hydrogen bomb test. I took a look back at the 1950s when nuclear power generation was first adopted and examined some of the records of the time.

From reading opinion pieces and documents written by physicist Dr Sakata Shoichi, it was apparent that conclusions reached in national debate among particle and nuclear physicists at the time had influenced the Special Committee for Nuclear Research and the Committee on Problems in Atomic Energy, both of which came under the Science Council of Japan. I also learned that a broad range of scientists at the Science Council of Japan had argued that nuclear energy was an unproven technology, that further research was required to assure completely safe nuclear energy for densely-populated and earthquake-prone Japan in particular, and that the practical application of nuclear power generation was premature. Through democratic debate, scientists from various specialist fields at the time exhibited a social role far greater than scientists of today.

The Japanese government and Diet, however, suppressed the influential voices of these scientists, and pursued policies to promote nuclear power through a political initiative linked to U.S. strategic maneuvering. In 1956 the Japanese government established the Science and Technology Agency and the Atomic Energy Commission to restrain the voices of scientists, weaken the power of the Science Council of Japan, and pursue politically-led science and technology policies, thus laying the foundations to promote future U.S.-dependent nuclear power policies.

Although these policies were at odds with their views, Dr Yukawa Hideki and Dr Sakata Shoichi tried to have the opinions of scientists heard by becoming members of the Atomic Energy Commission and the Nuclear Reactor Safety Inspection Committee, respectively. However, with the necessary inspection data never made available, their opinions completely ignored, and the pathway for scientists' opinions effectively closed, they soon resigned their memberships.

Yukawa Hideki with Einstein at Princeton, 1953

In the material that Dr Sakata left behind, I discovered he had come up with many new proposals which, even in their original form, would be applicable to the present day, such as one outlining the need for a safety regulatory committee to give top priority to safety, independent of pro-nuclear power government agencies.

I compiled this materiel with the idea that it had to be published. Right at that time, Saga University Professor Emeritus Kondo Hiroki, an alumnus of the Nagoya University research laboratory founded by Dr Sakata, suggested that Dr Sakata's academic works on nuclear power problems be made available on an internet archive site dedicated to him.[1] I also learned that the publisher Iwanami Shoten planned to publish Dr Sakata's thesis on the responsibility of scientists toward nuclear power.[2]

As a result of Dr Kondo's proposal, monthly meetings for a Sakata Shoichi research group were set up to delve into research areas such as the roles of scientists and their connection to society in the context of nuclear power issues. The Association for Citizens and Scientists Concerned about Internal Radiation Exposure was also established through the cooperation of citizens, scientists and doctors because of the need to research the effects of radiation exposure, including historical developments.

This paper examines the role of scientists researching the effects of radiation, the relationship between citizens and scientists, and the connection with government administration.

The beginning of nuclear weapons policy and the cover-up of radiation damage

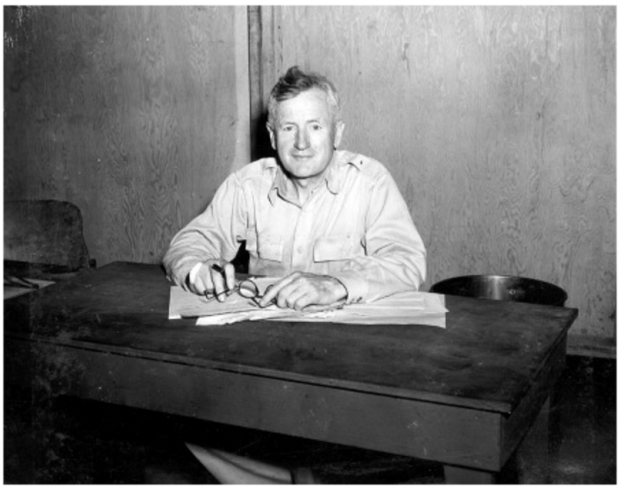
Research into the effects of radiation exposure from the nuclear fallout of the Hiroshima and Nagasaki atomic bombs has been greatly distorted by U.S. nuclear policy and policies to promote nuclear power. Agencies such as the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have also failed to fulfilled their original role due to their subordination to nuclear policy, with the result that the social responsibility of scientists to bring to light the truth about the effects of radiation has not been fulfilled.

The reason for 'dropping the atomic bombs on Hiroshima and Nagasaki to end the war early and save a million lives including young

Americans who would have been lost to war', a claim devised by chemist and Harvard University President James Conant, was a myth invented after the war. As some U.S. and Japanese historians have explained based on records at the time, an important factor in the decision to use the atomic bombs was the desire to preempt Soviet entry into the war. It was also the first use of the strategy to threaten the Soviets with nuclear weapons with an eye to the postwar order.

In September 1945 at the beginning of the occupation, foreign journalists came to Japan to investigate the situation. On 5 September 1945, the *Daily Express* printed a dispatch from journalist Wilfred Burchett which said, "In Hiroshima, 30 days after the first atomic bomb destroyed the city and shook the world, people are still dying, mysteriously and horribly – people who were uninjured in the cataclysm – from an unknown something which I can only describe as the atomic plague." On the same day William H. Lawrence of the *New York Times* reported, "The atomic bomb still is killing Japanese at a rate of 100 daily."

Fearing that such reports would raise criticisms of the inhumanity of the bomb, General Thomas Farrell, Deputy Commander of the Manhattan Project and head of the medical section, told a press conference in Tokyo on 6 September, "In Hiroshima and Nagasaki, here at the beginning of September, anyone liable to die has already died and no one is suffering from atomic radiation. (Takahashi, 2012)"



Gen Thomas Farrell

The U.S. authorities made such statements because of fears that acknowledgment of the effects of radiation would constitute admission that the damage from the bomb was far reaching and the effects long lasting, that it would become evident that the use of nuclear weapons violated international humanitarian law, and that international criticism of the use of the bomb would grow. On 19 September occupation forces imposed press censorship on the atomic bombings. This U.S. government policy was one of the contexts behind the delay in a complete investigation into the harmful effects of radiation.

ABCC – issues concerning the research of the U.S. agency investigating the effects of radiation

While the U.S. government took steps to conceal the harmful effects of atomic bomb radiation, it actively sought to understand the effects of radiation from nuclear weapons. The Atomic Bomb Casualty Commission (ABCC) was established in Hiroshima and Nagasaki in 1947 at the direction of President Truman. The Japanese government subsequently drew up a list of *hibakusha*, survivors of the atomic bomb, from a supplementary questionnaire of the 1950 national census, giving it to the ABCC without using it to provide any assistance to the survivors. From this list, the ABCC began an epidemiological study into the causes of death, with residents of Hiroshima and Nagasaki as study subjects. However, many *hibakusha* shunned it because of the coercive nature of the occupation forces, as well as the fact that it only involved medical examination, with no actual medical treatment provided even to those who were suffering.[3]

ABCC screening of atomic victims

The ABCC research focused on external exposure from radiation released during the first minute after the atomic blast. Radiation released after the first minute of the blast is known as residual radiation. Residual radiation includes radiation released from matter that has undergone neutron activation through the absorption of neutrons from initial radiation, and radiation released from radioactive fallout. At the time there was much debate over the destructive power of initial radiation from a nuclear weapon. So the fact that the ABCC was keen to focus primarily on initial radiation and reluctant to examine the longer-term effects of residual radiation indicates that the driving force behind the ABCC study was to better understand nuclear war, not the science of radiation.

To study the effects of radiation, the U.S. constructed replicas of Japanese houses in the Nevada Desert nuclear testing ground to investigate the effect of shielding from initial radiation. It also measured initial radiation exposure doses at designated distances from the hypocentre to draw up the tentative 1957 (T57D) and 1965 (T65D) dosimetry systems. Using these systems, the ABCC classified atomic bomb survivors into groups based on different degrees of initial radiation exposure doses, furthering research into areas such as rates of death by cancer.

The ABCC was dissolved in 1975 and the joint U.S.-Japan Radiation Effects Research Foundation (RERF) was established, taking over research which had focussed primarily on the effects of initial radiation.

A study into the effects of radiation should have compared a control group of people who were never exposed to radiation from the atomic bomb blast with *hibakusha*. However, the ABCC and RERF studies used as a control group survivors who were exposed at long distances and received negligible initial radiation exposure, as well as those exposed to radiation by entering highly radiated areas after the bombs exploded.[4]

In 1983 Dr Inge Schmitz-Feuerhake of the University of Bremen compared incidence of, and death and various disorders from, the RERF's group of distally exposed or entrant *hibakusha*, against the average Japanese. The results made clear the fact that people from both groups were exposed to considerable residual radiation. Her research, published as a letter in Health Physics journal, was important in that it demonstrated scientifically for the first time the effects of radiation exposure from residual radiation.

DS86's residual radiation dosimetry system

Powerful computers soon allowed for the calculation of radiation released by an atomic blast, leading to the development of the Dosimetry System 1986 to calculate radiation exposure. Accordingly, the RERF published a report titled *US-Japan Joint Reassessment*

of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki (DS86) [5] which provided a more accurate assessment of the effects of the atomic blasts.

DS86 gave dose assessments of gamma and neutron radiation from initial radiation at designated distances from the hypocentres of Hiroshima and Nagasaki. The report also included a chapter on radiation doses from residual radioactivity which provided physical measurements of radiation released from radioactive material caused by fallout rain that entered the soil and was not washed away in the black rain or heavy downpours that followed the blast, as well as measurements of radiation released from material affected by induced radioactivity. Based on the calculations, it considered maximum exposure doses from radioactive fallout to be 6-20 mSv in the Koi-Takasu district of Hiroshima, three to four kilometres west of the hypocentre, and 200 mSv in the Nishiyama district of Nagasaki, approximately three kilometres east of the hypocentre, with other areas receiving negligible doses. The report, however, does concede the possibility that radioactive matter washed away in the rain afterwards. Nevertheless, both the RERF and the Japanese government used these figures from DS86 as a basis for disregarding radioactive effects from radioactive fallout.

Soil collected in Hiroshima by a team led by Dr Nishina Yoshio three days after the blast was preserved. Dr Shizuma Kiyoshi and his colleagues ran some tests[6] and discovered that the soil collected from the eastern foot of the Nishi-Ohashi Bridge, which later experienced heavy rain, measured radioactivity levels more than twenty times those in the Koi-Takasu district, considered by DS86 to have received the highest amount of radioactive fallout material in Hiroshima. This fact indicates that the washing away of radioactive matter, stated as a mere possibility in DS86, did indeed occur.

DS86 also measured gamma radiation from cesium-137 in the Nishiyama district of Nagasaki in 1969 and 1981 using the whole-body counter on the *hibakusha*, a system which measures radioactivity within the body. From these measured values, the cumulative exposure dose from 1945 to 1985 was estimated to be 0.1 mSv among males and 0.08 mSv among females. The half-life of cesium-137 is around 30 years, but cesium which has been absorbed into the body is excreted, so the biological half-life is approximately 80 days. Consequently, the internal exposure dose from the direct absorption of radioactive fallout cannot be measured after 24 years due to the exponential decay. The whole-body counter measures the amount of cesium-137 absorbed from agricultural products throughout the previous year; it does not indicate the dose received from radioactive fallout absorbed immediately after the atomic blast. The Ministry of Health, Labour and Welfare, however, continues to use data that ignores the effects of radiation exposure from radioactive fallout.

Legal claims for the recognition of illness caused by atomic-bomb radiation

A *hibakusha* may apply to the Japanese government for recognition that his or her illness was caused by exposure to radiation from the atomic bomb.[7] In the 1990s, legal challenges confronted government attempts to reject applications for recognition as *hibakusha.*

In 1997 I participated in a study group to measure traces of initial radiation that was absorbed by above ground matter. The results led us to conclude that there was a systematic underestimation in the DS86 findings for the area beyond 1.2 km from the hypocentre.[8] My involvement in the trials began with my submission of these findings to the courts on behalf of those applying for *hibakusha* status and appearance as a witness.

The courts ruled in favour of the *hibakusha*. Having lost at the Supreme Court, the Japanese government was forced to revise the criteria for recognition of illness caused by atomic-bomb radiation. However, the Ministry of Health, Labour and Welfare adopted a "probability of causation" criterion to calculate the likelihood that the cause of illness in a *hibakusha* was attributable to exposure to atomic bomb radiation. The criteria for recognition became even more stringent; so much so that even some who had won legal cases for recognition as *hibakusha* had their applications rejected. Given the fact that the severity of illnesses from radiation varies greatly among individuals, the "probability of causation" criteria misapplied the science of statistics by disregarding individual differences, and merely judged based on average value. Furthermore, as this system in practice took into account initial radiation exposure only, distally exposed and entrant *hibakusha* ended up with a probability of zero, so their applications for recognition continued to be rejected. Thus, in 2003, at the encouragement of the Japan Confederation of A-and H-Bomb Sufferers Organizations (Hidankyo), *hibakusha* began filing class action lawsuits for the recognition of illnesses caused by exposure to atomic bomb radiation,[9] with the number of plaintiffs eventually totalling 306 in 17 district courts from Sapporo to Kagoshima.

Evaluation of the effects of radioactive fallout from the Hiroshima and Nagasaki atomic bombs relied upon physical methods of measurement. Radioactive fallout results in internal exposure via the release of radioactive particles into the body through inhalation and ingestion. There are limits to the conclusions that can be drawn based on physical methods of measurement for radiation exposure, including internal exposure, so it is necessary to assess biological effects such as rates of acute symptoms, incidences and rates of death from late-onset disorders such as cancer, and frequency of chromosome abnormality occurring among *hibakusha*. Although studies were conducted on incidences of various acute radiation sicknesses immediately after the blast, there has been hardly any follow-up research on the consequences of radiation exposure based on these studies.

In their court testimonies, *hibakusha* plaintiffs painfully recalled their experiences of the bombings, talked about their continued suffering in the sixty years since the blasts, and pleaded anew that the use of nuclear weapons be considered a crime against humanity. Scientists and doctors set up a nation-wide legal team to criticise the limitations of the "probability of causation" criteria and to ensure that research findings on atomic bomb radiation and radiation damage informed the courts' decisions. Organisations to support elderly *hibakusha* have also been formed for each lawsuit, and so far 29 judgements have upheld their lawsuits in district and high courts.

In March 2007 the government scrapped the "probability of causation" system, and amended the criteria to recognize distally exposed and entrant *hibakusha*. In my 2005 testimony at the Osaka District Court during the initial stages of these class action law suits, I emphasised that initial radiation at distances further out had been underestimated, and indicated that research on the effects of radiation exposure from radioactive fallout was still in the rudimentary stages. I was able to incorporate findings in relation to fallout during later testimonies.

Although the government suffered successive defeats in class action lawsuits over the recognition of illness caused by atomic bomb radiation, the Ministry of Health, Labour and Welfare, government witnesses, and scientists who have written opinion papers continue to be swayed by DS86, and to underestimate the effects of internal radiation exposure from radioactive fallout and induced radioactivity.

Exposure from fallout

The 1950 ABCC group study investigated in detail the shielding effect and physical position a person was in at the moment of the atomic bomb blast, as well as incidences of acute hair loss. This study on acute hair loss showed, like many others, that outbreaks had occurred beyond 2km from the hypocentre where initial radiation had hardly reached. However, the RERF, the Ministry of Health,

Labour and Welfare, and many scientists associated with the Japan Radiation Research Society (JRRS) assert even now that acute hair loss for people at further distances was caused by psychological shock and that diarrhoea was the result of poor hygiene. However, it is difficult to conclude that such systematic outbreak of these acute symptoms at distances greater than 2km from the hypocentre was caused by factors other than the effect of radiation exposure from fallout.

It is known from experiments on animals that the rate of outbreak of acute illnesses is normally distributed with exposure dose. Past studies have calculated the exposure dose from initial radiation of the two blasts (taking into account the shielding effect) and the exposure dose from fallout by applying normal probability distribution to the rate of hair loss in the ABCC study. The results showed that beyond 1.2km from the Hiroshima hypocentre, the exposure dose from fallout exceeded that of initial radiation, and beyond 2km initial radiation was virtually zero. They also showed that 4 to 5km from the Hiroshima hypocentre, the average exposure dose from radioactive fallout has a constant value of around 800 mSv. This is 40 to 130 times what the Ministry of Health, Labour and Welfare asserts that the exposure dose from fallout was in the Koi-Takasu district.[10]

Past studies also calculated that the average exposure dose from fallout 5 to 12km from the hypocentre of the Nagasaki blast had a constant value of 1200 mSv. Again this was done using normal distribution, based on the rate of hair loss recorded in surveys by Nagasaki City and Nagasaki Prefecture of people who experienced the atomic bombing within 12km of the hypocentre in areas that were not supplied *hibakusha* health books. This value, 1.5 times greater than the exposure dose from fallout 4 to 5km from the hypocentre in Hiroshima, corresponds to the power of the Nagasaki blast, which was 1.4 times greater than Hiroshima's; the amount of induced radiation in the bombshell, which was greater in the Nagasaki bomb[11]; and the fact that radiation from the unfissioned leftover plutonium-239 of the Nagasaki bomb was stronger than the uranium-235 from the Hiroshima bomb.

Being able to estimate the exposure dose from fallout using the ABCC's hair-loss survey enabled me to understand the extent to which the RERF, which disregarded calculations based on rate of hair loss, underestimated the risk of late onset disorders such as cancer. The Hiroshima University Research Institute for Radiation Biology and Medicine undertook a study entitled *Mortality Statistics among Atomic Bomb Survivors in Hiroshima Prefecture, 1968-1972,*[12] which compared death rates from malignant neoplasms in *hibakusha* who lived in Hiroshima Prefecture with those of Hiroshima Prefecture residents. Using this study, I managed to calculate the excess relative risk of cancer per Sv of radiation based on the relationship between exposure dose and rate of death from malignant neoplasms in one year for directly exposed *hibakusha*. With non-*hibakusha* residents of Hiroshima Prefecture as the control group, the excess relative risk per Sv of radiation is 0.53. However, if, like RERF studies, the control group consists of distally exposed *hibakusha* who were beyond 2km, the excess relative risk per Sv falls by half to 0.23. [13] So it is glaringly obvious that we should consider the effects of exposure from radioactive fallout in risk estimation. Internal exposure is the main form of exposure in nuclear accidents, so it stands to reason that doubts will be raised about the application of the ICRP's radiation protection standards which rely on the RERF's research that that is limited to exposure from initial radiation and disregards the effects exposure from radioactive fallout.[14]

Scientists and citizens working together for a nuclear-free world

The main form of radiation exposure at the recent Fukushima nuclear incident was internal exposure through inhalation and ingestion. However, by following the ICRP standards and ignoring the properties of internal exposure, the government and its advisors wilfully underestimated the related health effects. We therefore demand that lives be protected from radiation damage through rigorous scientific understanding of internal exposure.

On 19 March 2011, immediately after the Fukushima nuclear incident, the governor of Fukushima appointed Nagasaki University Atomic Bomb Disease Institute Professor Dr Yamashita Shunichi as the radiation risk management advisor to Fukushima Prefecture. He was also made special professor and vice-president of Fukushima Medical University.

Insisting that it was important to avoid frightening Fukushima residents over radiation exposure, Dr Yamashita gave speeches saying, "there is no data that shows that the risk of cancer increases with exposure of less than 100 mSv per year", "radiation doesn't affect people who smile", and "this is a state of emergency…as responsible citizens we should rest assured in following the government's line." These comments had the unintended effect of greatly increasing distrust and unease.

Dr Yamashita's comments are consistent with the position of the Japanese government, which had previously forced the "duty of endurance" onto its citizens in a state of emergency during the Asia-Pacific War. In 1980 at the Conference on Basic Problems Regarding Measures for A-bomb Victims following demands from *hibakusha* groups for compensation, the then Ministry of Welfare determined that, "In war, a state of emergency into which the nation enters over its very fate, it is the duty of the citizen to sacrifice life, person and property; this means that all citizens must endure war time sacrifices equally."[15] The Japanese government has merely replaced "war damage" with "radiation exposure" as the duty of endurance this time.

The Japanese government is keen to restart nuclear power plants. Its haste to restart makes it difficult to believe that it will prioritise protecting its citizens from radiation exposure. In September 2011, Dr Yamashita organised an international expert symposium at Fukushima Medical University titled *Radiation and Health Risks, the World's Wisdom Collected to Deliberate on the Future of Fukushima.* The aim of this symposium was to report the cancer rate of the RERF's study, which used distally exposed *hibakusha* as the control group, and to restore trust by winning the praise of researchers from global organisations such as the IAEA for the RERF's *hibakusha* research whose legitimacy had been questioned.

I have been to Fukushima three times to explain the fundamental approach to radiation exposure, and stressed the importance of conveying correct information to people so that they may make their own judgement about the effects of radiation exposure. Exposure to 1 mSv of radiation will cause damage to around 500 biomolecules per cell over the entire body from ionisation. Most will repair, while approximately one of the biomolecules will repair incorrectly or will be unable to repair. Thanks to base pairs in a double helix, if a portion of DNA, the key to life, is damaged, it will be almost completely repaired to its former state. Because of this, life on earth has evolved into its current state despite the varying degrees of damage caused by natural radiation. However, in addition to excessive radioactive exposure, if radioactive isotopes that resemble elements essential to the living body are introduced into human bodies, they will concentrate in specific organs and cause exposure effects. Even a dose of 10 mSv will cause a near proportionate increase in the rate of late-onset disorders from chromosomal abnormality such as cancer. The first thing we must do to give peace of mind to care providers worried about the effects of radiation on children is to explain the known facts clearly.

Given this situation, citizens and scientists came together to grasp the problem of internal exposure objectively and through scientific facts, and launched the Association for Citizens and Scientists Concerned about Internal Radiation Exposures (ACSIR), with the aim of conveying this message to wider society. This association, in cooperation with other organisations, invited scientists from overseas who had researched the exposure effects of the Chernobyl disaster to exchange research in a series of lecture meetings.

As of mid-2012, the Sakata Shoichi research group had met six times since October 2011 to discuss the preconditions for societal

application of advanced scientific and technological achievements in such areas as nuclear power and medicine, insofar as their relationship to experts (industry and academia), government (politicians and public servants), business (management and unions), and the media. In particular, we discussed how to make up for the lack of specialist knowledge relating to the effects of low dose internal exposure on health, which became evident throughout the Fukushima nuclear disaster, and also how to convey scientific facts to society and citizens.

When U.S. and Russian scientists first tried to inform their respective governments of the details discussed regarding the abolition of nuclear weapons at the Pugwash Conferences, which were established based on the Russell-Einstein Manifesto of 1955 calling for the end of nuclear weapons and war, they were ignored. When they invited influential scientists to participate in the conferences, discussions changed from abolition of nuclear weapons to such topics as "the role of scientists is to explore ways of living with nuclear weapons," since the abolition of nuclear weapons was considered too difficult. From that time on, nuclear deterrence theory dominated the Pugwash Conferences. Japan's counterpart to the Pugwash Conferences, the Kyoto Conference of Scientists focused on appealing to the public rather than to the government. This experience offers a suggestion as to the appropriate relationship between scientists and citizens.[16]

At a recent Sakata Shoichi research meeting, Niigata University Professor Emeritus Kobayashi Shozo gave a report concerning the Ministry of Education, Culture, Sports, Science and Technology's (MEXT) supplementary reading material on radiation. Prof. Kobayashi reported that the Atomic Energy Society of Japan had studied the contents of energy education in primary and middle school, and that the Japan Atomic Energy Relations Organization was commissioned to create the supplementary readers. Currently, MEXT-led courses are being held using supplementary readers that contain the claims of the Atomic Energy Society of Japan, which emphasise that there is nothing to fear from natural radiation and that radiation has important applications. However, they fail to provide any basis for children to take into account the effects of radiation exposure on humans and consider scientifically through their own reasoning the effects of radiation exposure.

At present, the Japanese government, which is subordinate to the U.S. government and Japan's nuclear lobby,[17] is trying desperately to restart nuclear power plants while the truth about the full effects of the Fukushima disaster remains unclear. Therefore, we must break away from politics which ignores the safety of citizens, and through the cooperation of citizens and scientists, design a citizen-centered safety system that protects our children from the effects of radiation exposure.

Internationally, the Preparatory Committee for the 2015 Nuclear Non-Proliferation Treaty (NPT) Review Conference has been established and work has begun toward the formation of a nuclear weapons convention. If such a convention were to materialise, it would open a vista for an equitable world without nuclear weapons or nuclear power, away from the inequitable Non-Proliferation Treaty system which preserves the right of some countries but not others to have nuclear weapons, and which operates as part of an international policy for the promotion of nuclear power.

The moral challenge for humanity in the 21st Century is for citizens and scientists to jointly prepare for future generations to be able to enjoy peaceful and rich lives, without dependence on limited fossil fuels or nuclear fuel, without the threat of radioactive damage from non-disposable, high-level radioactive waste, and with reliance on renewable and natural energy.

This article was originally published in Japanese in *Sekai* (World) July 2012.

Professor Emeritus Sawada Shoji is a physicist at Nagoya University. He was born in 1931. At 13 he experienced the atomic bombing in Hiroshima. In 1999 he co-authored The Truth about Radiation Damage from the Hiroshima and Nagasaki Blasts (Kyodo Kenkyu Hiroshima Nagasaki Genbaku Higai No Jisso), published by Shin-Nihon Publishing.

Jason Buckley is a Japanese linguist and holds an MA with Distinction in Advanced Japanese Studies from the University of Sheffield. Following three years of work and study in Japan he took up a two-year research position at the London office of the Jichitai Kokusaika Kyokai (CLAIR). His areas of interest include military history and international relations.

Recommended Citation: Sawada Shoji, "Scientists and Research on the Effects of Radiation Exposure: From Hiroshima to Fukushima," The Asia-Pacific Journal, Vol. 11, Issue 23, No. 2. June 10, 2013.

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Takahashi, H., *Fūinsareta Hiroshima, Nagasaki: Bei kaku jikken to minkan bōei keikaku*.2012, Shinatei Zōhoban.

Translator's Notes

[1] Sakata Memorial Archival Library Documents available at this site.

[2] Dr Sakata's thesis is available in Japanese here. Other recently published works include *Sakata Shoichi no Shogai* (the life of Sakata Shoichi) by Nishitani Tadashi, available here and Dr Sakata's own *Kopenhaagen Nikki* (Copenhagen Journal), available here.

[3] M. Susan Lindee, Suffering Made Real: American Science and the Survivors at Hiroshima, University of Chicago Press, 1994, p.117, deals with this issue, stating, "although there was a 'no-treatment' policy which provoked resentment in the two cities, there was in fact a degree of discontinuity between policy and practice with some ABCC physicians, both American and Japanese, providing medical care."

[4] Referred to hereafter as 'distally exposed' and 'entrant' *hibakusha*. 'Distally exposed' is defined by the RERF here. 'Entrant' hibakusha are sometimes divided into two categories, 'early entrants' (those who entered the cities within 30 days after the bombings), and 'late entrants' (those who entered the cities more than 30 days after the bombings). This difference is discussed further here.

[5] Further information on DS86 can be found here. The final report is available in full here.

[6] Shizuma K. et al., 137Cs Concentration in Soil Samples from an Early Survey of Hiroshima Atomic Bomb and Cumulative Dose Estimation from the Fallout, Health Physics, 1996 Sep, vol 71, issue 3, pp. 340-6. The full report is available by searching the Health Physics website: here.

[7] Further information on the trials can be found on the Japan Association of Lawyers Against Nuclear Arms website: here

[8] Dr Sawada's findings can be found in full in 'Estimation of Residual Radiation Effects on Survivors of the Hiroshima Atomic Bombing, from Incidence of the Acute Radiation Disease', Fukushima and Health: What to Expect: Proceedings of the 3rd International Conference for the European Committee on Radiation Risk, May 5-6th, 2009, Lesvos, Greece, Green Audit Books, 2011, pp. 118-143, available here.

[9] Further reading on the trials: here and here.

[10] Dr Sawada discussed this in his papers 'Estimation of Residual Nuclear Radiation Effects on Survivors of Hiroshima Atomic Bombing, from Incidence of Acute Radiation Disease', Bulletin of Social Medicine, 2011, vol 29, issue 1, pp. 47-62, available here and 'Cover-up of the effects of internal exposure by residual radiation from the atomic bombing of Hiroshima and Nagasaki', Medicine, Conflict and Survival, 2007, vol 23, issue 1, pp. 58-74, available here.

[11] Further information from Dr Sawada: Most of the neutrons produced by the chain reaction of uranium-235 or plutonium-239 were absorbed by the nuclei of the bombshell. Most of the neutron-absorbed nuclei of the bombshell became radioactive through the induction of neutron absorption. These were contained into the fireball. The Nagasaki bomb was an implosion-type, so the fission nuclei of the plutonium were surrounded by bombshell, thus more neutrons were absorbed than in the case of the Hiroshima bomb which was a gun-barrel type. The amount of neutrons emitted from the Nagasaki bomb was about half that of the Hiroshima bomb (on the contrary, the amount of the gamma rays from the Nagasaki bomb was twice that of Hiroshima bomb) which was clarified by measurements.

[12] Kurihara M. et al., Mortality Statistics among Atomic Bomb Survivors in Hiroshima Prefecture, 1968-1972, Journal of Radiation Research, 1981, vol 22, no. 4, pp. 456-471. Full report available from the Journal of Radiation Research website here.

[13] The below tables were extracted from Dr Sawada's paper that compares RERF and Hiroshima University data. Available in Japanese here.

Annual death rate from malignant neoplasms

	Directly exposed *hibakusha*					**All *hibakusha***	**Non-*hibakusha***
	Within 1km	1-1.5km	1.5-2km	Within 2km (TOTAL)	Beyond 2km		
Person-years 1968-1972	38,605	103,247	133,424	275,276	192,960	791,609	7,421,760
Deaths by malignant neoplasm	157	361	363	881	560	2,766	12,151
Annual death rate from malignant neoplasms	0.407	0.350	0.272	0.32	0.29	0.349	0.164

Risk of death from malignant neoplasm for Hiroshima Prefecture *hibakusha* according to the Hiroshima University Research Institute for Radiation Biology and Medicine study

* ERR = ((Annual Death Rate from Malignant Neoplasm) / (0.164 or Non-*hibakusha* Annual Death Rate From Malignant Neoplasm Control Group)) – 1
** RERF method uses the 'beyond 2km' malignant neoplasm death rate of 0.29 as the control group

	Directly exposed *hibakusha*				**Non-*hibakusha***
	Within 1km	1-1.5km	1.5-2km	Beyond 2km	

[14] In December 2012 the RERF issued a statement outlining their views on residual radiation as a result of numerous media

Dose from initial radiation	1.614	0.77	0.1	0	0
Dose from fallout	2.27	1.469	1.458	0.85	0
Total dose	3.884	2.239	1.558	0.85	0
Excess relative risk (ERR)*	1.4817	1.1341	0.6585	0.7683	0
ERR using RERF method**	0.4034	0.2069	?0.0621	0	?
Excess relative risk per Sv	RIRBM method = 0.53; RERF method = 0.23				

reports allegedly confused over residual radiation exposure and implying doubts over RERF risk data. Although it states, "there is reason to believe that the effects of residual radiation were low enough to be considered virtually negligible," there is no mention of the aforementioned hair loss surveys, Hiroshima University mortality study, or Dr Sawada's risk estimates. See here.

[15] Further reading: here and here.

[16] Further reading on this can be found in Dr Sawada's article *The Influence of Hiroshima and Nagasaki on Scientists in Japan* on the International Network of Engineers and Scientists Against Proliferation website: INESAP website

[17] Also known as the 'nuclear village', it refers to the institutional and individual pro-nuclear advocates who comprise the utilities, nuclear vendors, bureaucracy, Diet (Japan's parliament), financial sector, media and academia. Further reading here.