International Expert Symposium in Fukushima: Radiation and Health Risks

Abstracts

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Abstract: Keynote Speech at the International Expert Symposium in Fukushima:
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Consequences of the Fukushima Nuclear Power Plant accident as combined disaster

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An earthquake named The Great East Japan Earthquake measuring 9.0 on the Richter scale struck the northeast coast of the Honshu Island in Japan at 14:46 on 11 March 2011, triggering a tsunami with over than 10 m-high waves hitting this area. The earthquake was followed by the sustained occurrence of numerous aftershocks. The earthquake and aftershocks left more than 15,700 people dead and almost 4,500 missing. The earthquake affected the Fukushima nuclear power plants (NPPs) of Tokyo Electric Power Co. (TEPCO) and caused serious damages to NPPs, resulting in a large amount of radioactive materials being released into the environment. The damages were caused to the cooling systems of NPPs, whereas they automatically shut down after the earthquake. The troubles in the cooling systems lead to core melting and hydrogen explosions. The major nuclides released were I-131, Cs-134 and Cs-137. The deposition of these radioactive materials on the land resulted in the high ambient dose of radiation around the NPPs, especially areas within 20 km radius or northwest of the NPPs. Therefore, almost 170,000 people had to evacuate or stay indoors. We dispatched the Radiation Emergency Medical Assistance Team (REMAT) to the local headquarters which was located 5 km from the NPPs almost 17 hours after the earthquake. However, this earthquake affected infrastructures such as the monitoring system for radiation as well as NPPs and the telecommunications system. Therefore, the local headquarters did not function, since community lifelines such as water supply and electricity were also severely damaged by the earthquake and tsunami. There were some people who were contaminated with radioactive materials at higher levels than screening. However, no decontamination could be performed without water supply. Moreover, it was impossible to change contaminated clothes because no other clothes were available. Thus, this accident was a combined disaster of earthquake, tsunami, and also radiation.

We have learned from this disaster that potential of damage to the radiation monitoring and the calculation system for radiation dose as well as lifelines should be taken into account in case of earthquake, and a scenario including an impaired monitoring system for radiation is important for the drill of nuclear disaster. There is urgent need for a "combined disaster" strategy, which should be emphasized for current disaster planning and response.

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The Recommendations of the International Commission on Radiological Protection *vis-à-vis* the Fukushima Dai-ichi NPP Accident Aftermath

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Following the nuclear accident at the Fukushima Dai-ichi NPP, the International Commission on Radiological Protection (ICRP) created a Task Group (TG84) on "*Initial Lessons Learned from the NPP Accident in Japan vis-à-vis the ICRP System of Radiological Protection*". The Task Group is expected to compile lessons learned related to the efforts carried out to protect people against radiation exposure during and after the emergency exposure situation caused by the accident and, in light of these lessons, to consider the suitability of ad hoc recommendations for the ICRP system of radiological protection for dealing with this type of emergency exposure. At the time of the present International Expert Symposium in Fukushima, the Task Group has not yet finished its work; however, the Author, who is the Chairman of the Task Group, intends to present at the Meeting his personal views on the main issues, which includes: the (mis)use of the concept of 'detriment-adjusted nominal risk coefficients'; the (mis)use of radiation protection quantities and units, issues on internal exposure; occupational protection during extreme events; utilization of the renewed concepts of dose limits, constraints and reference levels for protection of the public in the aftermath of an accident; and the crucial issue of levels of radioactivity in consumer products. Some topics related to these issues are discussed in the references cited.

References:

CAC, 2006. Codex Alimentarious Commission. Codex General Standard for Contaminants and Toxins in Foods. CODEX STAN 193-1995, Rev.2-2006. Codex Alimentarious Commission, Geneva, 2006. www.codexalimentarius.net/download/standards/17/CXS_193e.pdf.

IAEA, 1996. International Atomic Energy Agency. International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources. Safety Standards. Safety Series 115. International Atomic Energy Agency, Vienna.

IAEA, 2004a. International Atomic Energy Agency. Measures to Strengthen International Cooperation in Nuclear Radiation and Transport Safety and Waste Management. Resolution of the IAEA General Conference GC(48)/RES/10 under 805 A., 4., pt. 23; Radiological Criteria for Radionuclides in Commodities. International Atomic Energy Agency, Vienna.

IAEA, 2004b. International Atomic Energy Agency. Application of the Concepts of Exclusion, Exemption and Clearance. IAEA Safety Guide RS-G-1.7. International Atomic Energy Agency, Vienna. http://www-ns.iaea.org/downloads/drafts/ds161.pdf.

IAEA, 2002. International Atomic Energy Agency. Preparedness and response for a nuclear or radiological emergency : safety guide / jointly sponsored by the Food and Agriculture Organization of the United Nations … [et al.]. — Vienna : International Atomic Energy Agency, 2002.

ICRP, 1992. International Commission on Radiological Protection. Principles for Intervention for Protection of the Public in a Radiological Emergency; ICRP Publication 63; Ann. ICRP 22 (4), 1992

ICRP, 1999. International Commission on Radiological Protection. Protection of the Public in Situations of Prolonged Radiation Exposure; ICRP Publication 82; Ann. ICRP 29 (1-2), 1999

ICRP, 2005. International Commission on Radiological Protection. Protecting People against Radiation Exposure in the Event of a Radiological Attack; ICRP Publication 96; Ann. ICRP 35 (1), 2005

ICRP, 2007a. International Commission on Radiological Protection. The 2007 Recommendations of the International Commission on Radiological Protection; ICRP Publication 103; Ann. ICRP 37 (2-4), 2007

ICRP, 2007b. International Commission on Radiological Protection. Scope of Radiological Protection Control Measures; ICRP Publication 104; Ann. ICRP 37 (5), 2007

ICRP, 2009a. International Commission on Radiological Protection. Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations; ICRP Publication 109; Ann. ICRP 39 (1), 2009

ICRP,2009b. International Commission on Radiological Protection. Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas After a Nuclear Accident or a Radiation Emergency; ICRP Publication 111; Ann. ICRP 39 (3), 2009

RJG, 2011. Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety- The Accident at TEPCO's Fukushima Nuclear Power Stations; Nuclear Emergency Response Headquarters; Government of Japan; June 2011 [http://www.iaea.org/newscenter/focus/fukushima/japan-report.pdf]

WHO, 2004. World Health Organization. Guidelines for Drinking-water Quality, third ed. World Health Organization, Geneva. http://www.who.int/water_sanitation_health/dwq/gdwq3_9.pdf.

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Radioactive contamination of the environment and radiation doses to the public

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The accident at the Fukushima Dai-ichi nuclear power plant resulted in a substantial release of radionuclides to the atmosphere and marine environment and caused extensive contamination of the environment. Major atmospheric releases from unit 1 to 3 in operation occurred mainly on 12 to 22 March, and included radioactive gases and condensed aerosols. The main releases of radioactivity were about 1.6×10^{17} Bq of ^{131}I and about 1.5×10^{16} Bq of ^{137}Cs reported by the Japanese authority using a severe accident analysis code. As a result of successive atmospheric releases, some of the radionuclides released into the air are deposited on ground surface, resulting in surface contamination of plants, soil and urban environment, as well as contamination of surface water. The main deposition was strongly influenced by rain when the contaminated air masses passed during 15 March. Aerial monitoring conducted by the Ministry of Education, Culture, Sports, Science & Technology in Japan with the cooperation of the U.S. Department of Energy indicated high contamination in the northwest of the Fukushima site.

Shortly after the high contamination in the northwest area occurred, radioiodine and radiocaesium were detected in the sampling of drinking water, vegetables and milk. ^{131}I activity concentrations in milk and leafy vegetables exceeded the provisional regulation values of 300 Bq/l and 2000 Bq/kg respectively. The Nuclear Emergency Response Headquarters has issued an instruction to Prefectures including Fukushima, Ibaraki, Tochigi, Gunma and Chiba, ordering the restriction of distribution of foods concerned produced in these prefectures. In May ^{137}Cs concentrations above the provisional regulation values have been detected in tea leaves harvested in Kanagawa Prefecture, which is about more than 300 km from the Fukushima site. Recently, beef containing radiocaesium in excess of the provisional regulation values has been found in the domestic meat distribution chain. It has been suspected that it is due to beef cattle fed rice straw that was left outdoors after the accident.

Following the nuclear accident the main exposure pathways are (a) external dose from cloud passage; (b) internal dose from inhalation during cloud passage and of resuspended material; (c) external dose from radionuclides deposited on ground surface; (d) internal dose from the consumption of contaminated food and water. In the Fukushima accident the government directed the evacuation of residents within the 20 km radius from the plant and the evacuation seemed to be completed during 15 March. Under the prevailing circumstances the most important pathway was the external dose from deposited radionuclides. External exposure from deposited radionuclides is highly dependent on the isotope composition of deposited radionuclides. Model estimates of the ambient gamma dose rates from the deposited radionuclides will contribute the establishment of conditions for both termination of protective actions and strategy of decontamination.

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Experience and Lesson from Fukushima Daiichi Nuclear Disaster

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The Great East Japan Earthquake occurred on March 11, 2011 has extended complex disaster by extensive earthquake, tsunami, and subsequent Fukushima Daiichi Nuclear Disaster. Released radioactive substances on March 15th, this accident was finally assessed Level 7, the maximum scale value by INES, ranked one of the largest nuclear accidents same level of Chernobyl.

Hiroshima University established Radiation Emergency Task Force on March 12th, since then, our Radiation Emergency Medical Team, 36 groups and total number of 1,053, have been sending to Fukushima to support the activities of radiation emergency medicine. Immediately after the accident, the Emergency Response Headquarter of Fukushima Prefecture were in the confusion, additionally, the Off-site Center(OFC) in Fukushima Prefecture Nuclear Disaster Prevention Center had to retreat from the restricted evacuation zone, which disrupted the OFC to play enough role in administrative chain of command in initial phase. In the kind of difficult situation, Hiroshima University established the Collaboration Council for Radiation Emergency Medicine with National Institute of Radiological Sciences in Fukushima, and then, rearranged decontamination teams, modified decontamination procedure guidelines and organized the confused screening of evacuee. We devoted ourselves to a variety of support activities.

We will report some issues recognized by our experience in support activities

1) Issue of urgent evacuation: The urgent evacuation of 1,500 patients in hospitals or nursing facilities inside restricted evacuation zone was enforced without enough preparation. Long hours waiting and transferring in the cold weather overstressed on vulnerable people. The result of surveying for external radiation contamination, all patients were under 130,000 cpm, it suggested that indoor evacuation was appropriate in that situation. This enforcement of urgent evacuation should be verified for our lesson. 2) Issue of Radiation Emergency Medicine Network System in the accident area: Three primary radiation emergency hospitals in 20-km restricted evacuation zone were immediately closed and the other two were also located near the damaged nuclear plant, so also couldn't work effectively. The location of primary radiation emergency hospitals and the range of EPZ-zone should be re-evaluated. 3) Issue of the screening of radiation contamination and the decontamination for residents: In the very low temperature and no enough water, we requested Fukushima Prefecture to alter the screening level and gained approvals, situational action should be required. 4) Issue of internal radiation exposure of nuclear disaster prevention workers: In cooperation with Nagasaki University medical teams, we evaluated internal radiation doses of more than 100 fire fighters working in 20-km restricted evacuation zone. The result, all were under 200 μSv. 5) Issue of risk communication: In delivering 31 lectures (audiences-8,278) and many meetings in Fukushima, learned that many residents, especially parents, were filled of doubts and fears. To reduce the sense of resident's uncertainty and fears, the risk communication based on scientific knowledge is significantly important.

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Internal Exposure Caused by the Fukushima Nuclear Accident

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Internal exposure as well as external exposure was caused by radionuclides released from the Fukushima Daiichi Nuclear Power Plant. For some plant workers, who were exposed to the released radioactivity at early stage of the accident, the contribution of internal exposure in the total exposure was considerable. On the other hand, for residents living in Fukushima, dose from internal exposure was limited. Radioactive contamination was detected in some food, including beef. In the case of the Chernobyl accident, it was reported that internal exposure was caused by consumption of contaminated food for a long period of time. To prevent further internal exposure through food, the transfer of radionuclides to food should be controlled.

Stable iodine medication was effective for workers. For the residents, timing to take stable iodine should be considered under the situation where the release of radioactive iodine is long-lasting.

In addition to actual effects, imaginary impact has been enormous. Often exaggerated stories regarding effects of internal exposure was provided to general public to lead misunderstanding that the effect from internal exposure is much severer than that from external exposure. In the current radiation protection system, a dose from internal exposure is expressed as a committed dose, an integral over 50 years for adult and years until 70 years of age for children. The committed dose is added up with an external dose to give an effective dose. Once expressed as the effective dose, from the viewpoint of radiation protection, the effect is supposed to be the same no matter whether the exposure is external or internal. The experts on biological effects of radiation and radiation protection should provide precise information on the concept of internal exposure to the public.

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Medical Effects and Risks of Exposure to Ionizing Radiation

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Effects and risk from exposure to ionizing radiation depend upon the absorbed dose, dose rate, quality of radiation, specifics of the tissue irradiated and other factors such as the age of the individual. Effects may be apparent almost immediately or may take decades to be manifest. Cancer is the most important stochastic effect at absorbed doses of less than 1 Gy. The risk of cancer induction varies widely across different tissues however the risk of fatal radiation induced cancer for a general population following chronic exposure is about 5% per Sv. Quantification of cancer risk at doses of less than 0.1 Gy remains problematic. Hereditary risks in humans appear to be much lower and risk can only be estimated from animal models. At high doses (over 1 Gy) cell killing and modification causes deterministic effects such as skin burns, bone marrow depression, immunosuppression become critical issues. Acute penetrating gamma irradiation at doses in excess of 2 Gy results in varying degrees of acute radiation sickness and doses over 10 Gy are usually lethal as a result of combined organ injury.

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Epidemiological investigations of aircrew –
an occupational group with low-level cosmic radiation exposure

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Primary cosmic radiation from the depth of the universe interacts with atmospheric molecules, leading to the generation of neutrons and other charged particles at flight altitudes. Several factors determine the exposure of aircrew and passengers, among them flight altitude and flight trajectory as well as solar cycle. Annual effective doses for flight crew have been estimated to be in the order of 2-5mSv, with maximum lifetime doses usually below 100mSv.

The recognition that aircrew is exposed to appreciable doses of cosmic ionizing radiation has motivated a fair number of epidemiological studies in this occupational group over the last 15 -20 years, usually with a focus on radiation-associated cancer. Aetiological studies have been rendered difficult by the fact that aircrew is a highly selected group with many specific characteristics and other exposures that also might influence cancer risk, among them disruption of the biological day-night rhythm.

Both cancer incidence and mortality have been evaluated in large cohorts of cockpit and cabin crew in North America, Europe and several other countries. Cohort data from 9 European countries with follow-up into the late 1990ies were jointly analysed in the ESCAPE project, and extended follow-up data are currently being analysed and published. Some results showed consistency across most relevant studies: overall cancer risk was not elevated, while malignant melanoma, other skin cancers and breast cancer in female aircrew have shown elevated incidence, with lesser risk elevations in terms of mortality. There are no risk elevations for leukaemia. In some studies including the large German cohort, brain cancer risk appears elevated. Cardiovascular mortality risks were generally very low.

Dose information in these studies was usually derived from reconstruction approaches based on routine licence information, types of aircraft and routes/hours flown, but not from direct measurements. However, dose estimates have shown high validity when compared with measured values. No clear cut dose-response patterns pointing to a higher risk for those with higher cumulative doses were found in statistical analyses. Overall, aircrew is exposed to low levels of ionizing radiation of cosmic origin, but radiation-associated health effects have not been clearly established in the studies available so far.

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Health Risks Associated With Environmental Radiation Exposures

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Ionizing radiation may be the most extensively studied human carcinogen. This is largely because it is often possible to obtain very exact measurements of radiation dose received, or to estimate it along with an estimate of uncertainty of the dose estimate. Numerous epidemiologic studies have been conducted of populations exposed to radiation under a variety of circumstances, and these are supported by a substantial body of literature from experimental studies. The greatest population exposure is from natural background sources. The greatest man-made exposure comes from medical uses, both diagnostic and therapeutic. Occupational exposures comprise a relatively minor component of population exposure, as do environmental sources. The latter include exposure from nuclear facilities as well as exposures from nuclear weapons manufacture, use and testing. Studies of persons exposed from the atomic bombings of Hiroshima and Nagasaki and their children have contributed a large amount of information regarding the effects of ionizing radiation in humans. Results from these studies are often characterized as the "gold standard" in providing the most comprehensive and strongest evidence for human radiation risk assessment. Increased incidence and mortality have been observed in a dose response manner for both hematopoietic and solid cancers (most notably leukemia, multiple myeloma, Breast, Thyroid, Lung cancer). Evidence is now emerging to suggest dose-dependent increases in risk for non-cancer diseases, most notably cardiovascular diseases. There is still much to be learned from the cohorts under study. Two major efforts have been made to study the effects of exposure to radioactive fallout from atmospheric testing of nuclear weapons: one of residents of the Marshall Islands and the other of residents of Utah and Nevada. Similarly, there have been at least three substantial efforts made to determine the risk associated with living in close proximity to a nuclear facility. These studies are very different from each other in design, although two focused on radioactive ^{131}I as the primary exposure. One is the Hanford Thyroid Disease Study; one is a study of residents living close to the comparable facility in the Russian Federation (Mayak); and the third is an ecologic study of cancer mortality around nuclear installations in the US. Finally, a few studies have been conducted of radiation exposures received due to accidents at nuclear facilities. By far the largest and most informative of these are a number of studies of the health consequences of the Chernobyl Power Station accident. Although studies of the health consequences of environmental radiation exposure are often exceedingly difficult to conduct relative to other modes of exposure (e.g., medical or occupational), and commonly are limited by an ecologic design, they can be informative in assessing risk. Indeed, two of the most extensively studied population groups (A-bomb survivors and persons exposed by Chernobyl) were exposed from environmental sources.

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Emergency Medical Preparedness for Radiological/Nuclear incidents
(*Note: The opinions are those of the author and not ASPR, NCI, NIH or DHHS)

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Given the potential enormity and complexity of a radiological or nuclear (rad/nuc) incident, advanced preparation is essential. In planning for a medical response, the ASPR uses an "all hazards" approach in that there are many similarities between natural and manmade disasters. The planning and response for rad/nuc incidents is built from a "systems-based" approach for largest sized incident- a nuclear detonation -that simultaneously addresses the various components. A radiological dispersal device can be explosive or non-explosive; a radiological exposure device would not involve released radiation. In the U.S., the planning for nuclear power plants (NPP) is the responsibility of the NPP operator along with the state and local regional planners under guidance from the Nuclear Regulatory Commission.

There are a number of general principles used in rad/nuc emergency preparedness:

- Just-in-time information: Few medical responders will have experience in dealing with a radiological incident and given their other day-to-day medical responsibilities preparation for a rad/nuc incident will not be high on their list.
- Algorithm-based response: Based on the concept of "Advanced Cardiac Life Support" by which complex medical conditions can be managed consistently, using expert-developed algorithms.
- Dual-utility medical countermeasures: To the extent possible, use drugs and medical supplies that are in routine use so that there will be medical countermeasures locally available and the medical responders will have familiarity with their use and side effects.
- Prompt situational awareness: this includes physical infrastructure damage, power supply, transportation, weather/plume modeling, hospital occupancy that must be rapidly available
- Initial response is local: the Federal response will take 12-24 hours to begin and then ramp up.
- Common operating principles: These would be based on collaborative planning involving government, academia and the private sector.
- International collaboration: Appropriate sharing of information and expertise, given the relatively small number of individuals with expertise in rad/nuc response.

The tools that have been developed include

- Radiation Emergency Medical Management (REMM) website (www.remm.nlm.gov)
- Playbooks- for Federal response and also a prototype for state and local planners (www.phe.gov)
- Planning Guidance for Response to a Nuclear Detonation (http://www.remm.nlm.gov/PlanningGuidanceNuclearDetonation.pdf)
- Radiation TRiage, TReatment and TRansport (RTR) system. (Hrdina, Prehosp and Disaster Med 24:167, 2009)
- Scarce Resources series (Disaster Med and Pub Health Preparedness Supplement Mar 2011).

The ready-access to just-in-time information along with the pre-established international collaborative networks including the Global Health Security Action Group facilitated the response to the Fukushima disaster. Sustained long-term scientific and medical collaborations are key to world preparation and response

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Radiation Epidemiology: a Perspective on Fukushima

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For nearly 100 years, epidemiologic studies of human populations exposed to ionizing radiation have provided quantitative information on health risks. High-dose deterministic (tissue reaction) effects result when sufficient numbers of functioning cells are killed such as bone marrow depression that can lead to death. Lower dose stochastic effects are probabilistic in nature and include increased risk of cancer later in life and heritable genetic defects, although genetic conditions in the children of irradiated parents have yet to be convincingly demonstrated. Radiation studies are of diverse populations and include not only the Japanese atomic bomb survivors, but also patients treated with radiation for malignant and nonmalignant disease; patients exposed for diagnostic purposes; persons with intakes of radionuclides; workers occupationally exposed; and communities exposed to environmental and accidentally released sources of radiation. Much is known about radiation and its risks. The major unanswered question in radiation epidemiology, however, is not whether radiation causes cancer, but what the level of risk is following low-dose-rate exposures. Paracelsus is credited with first articulating that the "poison is in the dose" which for radiation epidemiology translates as "the lower the dose the lower the risk" and, the important corollary, the lower the dose the greater the difficulty in detecting any increase in the number of cancers possibly attributable to radiation. In contrast to the Chernobyl reactor accident, the Fukushima reactor accident to date has resulted in no deterministic effects and no worker deaths. Estimates to date of population doses suggest very low uptakes of radioactive iodine which was a major determinant of the epidemic of thyroid cancer following childhood exposures around Chernobyl. The estimates to date of population doses are also much lower (and the distribution much narrower) than the doses for which cancer excesses have been detected among atomic bomb survivors after 60 years of follow-up. Studies of populations exposed to low doses are also limited in their ability to account for important lifestyle factors, such as cigarette smoking and medical x-ray exposures, which could distort finding. While studies of the Fukushima population should and are being considered for reassurance and health care reasons, apart from the extreme psychological stress caused by the horrific loss of life following the tsunami and the large-scale evacuation from homes and villages, such studies have limited to no chance in providing information on possible health risks following low-dose exposures received gradually over time --- the estimated doses (to date) are just too small.

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Dosimetric Quantities in Radiological Protection and in Risk Assessment

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The quantification of human exposures to ionising radiation, and, setting limits for these exposures in radiological protection, requires the definition of appropriate quantities and specific units. The recent recommendations by ICRP in Publication 103 (2007) endorsed again the use of a set of quantities, the *mean absorbed dose* in an organ or tissue, D_T, the *equivalent dose* in an organ or tissue, H_T, and the *effective dose*, E, for all exposure situations

Because E is defined as the (weighted) sum of all H_T, effective dose and equivalent dose have the same name for the unit (sievert or Sv). This has caused confusions at times in communications with non-experts and will be addressed in the presentation..

Both, H_T and E enable the summation of doses from internal emitters and from external sources. Effective dose provides thus a single number for the quantification of exposure for comparison with dose limits, constraints and reference levels that relate to stochastic risks of whole-body radiation exposure.

Both, the equivalent and effective dose are not measurable but can be calculated if the exposure conditions are known. Measurable physical quantities such as fluence and surface contamination for external irradiation, and activity concentrations in air, water and food for exposure to incorporated radionuclides can be used to assess the protection quantities.

Effective dose is evaluated using reference anatomical data (ICRP Publications 89 and 110), sex and age averaged tissue weighting factors and organ equivalent doses, and standard biokinetic and dosimetric models. Hence, in a given exposure situation the value of effective dose applies to a reference person and it is not intended to provide an assessment of risk to individuals.

Estimates of risks to individuals and groups of individuals will always need to take account of all available specific exposure data and available scientific information. A promising approach – albeit still associated with considerable uncertainties - would be to base risk estimates on organ and tissue absorbed doses and to apply sex and age dependent incidence or detriment factors derived from the Japanese Lifespan Study data and other relevant epidemiological and radiobiological data.

The presentation will discuss the inherent complexity of effective dose, its limits of applicability outside its intended use in radiological protection. Approaches to radiation risk assessments for individuals and group of individuals will also be discussed.

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Estimation of Internal Radiation Dose from both Immediate Releases and Continued Exposures to Contaminated Materials

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A description is presented of radiation dose from radionuclides deposited within the human body, commonly referred to as 'internal dose', and how it differs from doses that result from radioactive materials and direct radiation outside of the body. The dose from radionuclides within the body depends upon which radionuclide is present (because this determines the energy of the particles emitted), how much is inhaled or ingested, where it is located within the body, and how long it stays there. Because of the complexities of the uptake and distribution of radioactive material in the body and the potentially extended time periods that may be involved, it is not possible to measure dose from internally-deposited radionuclides. All measurements are necessarily indirect and partial; thus models are used to complete the dose calculation. For people who have been exposed, this modeling is known as dose reconstruction. The basic elements of the dose-reconstruction process include five essential steps (definition of exposure scenarios, identification of exposure pathways, development and implementation of methods of estimating dose, evaluation of uncertainties in dose estimates, presentation and interpretation of analyses and results), and two essential foundation elements (data/information and quality assurance and quality control). Emergency remediation of the reactor site may result in large amounts of radioactive waste in the reactor buildings, in the immediate vicinity, and throughout the evacuated zone; more waste will be generated by future decommissioning activities. Some wastes will be highly radioactive and require sequestration from the environment. Others will be only slightly contaminated but of large volume; these will require some sort of near-surface disposal. Other areas will have minimal, but detectable, amounts of radioactivity. A process by which very low levels of contamination may be 'released' so that the land may be used will have to be developed. This will require a public consensus. A long and difficult public discussion is going to begin in Japan about all of these issues.

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Chernobyl accident and fallout from nuclear weapons tests: dosimetry, countermeasures, and epidemiology

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Large quantities of radioactive materials were released into the atmosphere as a result of the Chernobyl accident of 1986 and of the nuclear weapons tests conducted mainly in the 1950s and 1960s. The dosimetry concepts and methods used to estimate the external and internal doses received by the public from these events will be presented, as well as the principal results that were obtained in these studies. These dosimetry studies were conducted within the framework of epidemiologic studies or of the evaluation of risk estimates; therefore, the emphasis is on the estimation of absorbed doses to specific or representative individuals. The countermeasures that were used to reduce the doses will also be presented.

Radioactive fallout from nuclear weapons tests that occurred mainly in the 1950s and the 1960s caused the highest environmental radiation exposures among large population groups. For more than twenty years, the National Cancer Institute (NCI) has been involved in the estimation of radiation doses resulting from fallout at numerous locations worldwide. Most of the NCI fallout studies were mandated by Congress, including an assessment of the thyroid doses due to ^{131}I in fallout resulting from atmospheric tests conducted at the Nevada Test Site and a thorough evaluation of the doses to the inhabitants of the Marshall Islands. Current studies include the estimation of the individual thyroid doses in a cohort of 3,000 persons exposed to fallout from nuclear weapons tests carried out at the Semipalatinsk Nuclear Test Site and an assessment of the doses arising from the detonation of Trinity, which is the first nuclear weapons test ever conducted.

The explosions at the Chernobyl nuclear power plant in Ukraine early in the morning of April 26, 1986 led to a considerable release of radioactive materials during 10 days. As the major health effect of the accident is an elevated thyroid cancer incidence in children and adolescents, much attention has been paid to the thyroid doses resulting from intakes of ^{131}I, which were delivered within two months following the accident. The thyroid doses received by the inhabitants of the contaminated areas of Belarus, Russia, and Ukraine varied in a wide range, mainly according to age, level of ground contamination, milk consumption rate, and origin of the milk that was consumed. The NCI is involved in two epidemiological studies of thyroid diseases among populations who were affected by fallout from the accident and who were children at the time of the accident. In these studies, which are conducted in parallel in Ukraine and in Belarus, the estimation of individual doses and of their uncertainties is required for all of the approximately 25,000 cohort subjects.

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Implication of stem cells in radiation risks of in utero exposures and low dose rate

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Radiation risks for in utero exposures and low dose rate exposures are particular concerns of the general public under a long lasting radiation exposure situation taking place in Fukushima after March 11, 2011. Pregnant mothers are worried about a possibility of cancer in their oncoming children, while cumulative dose under low dose rate exposure scenario can be as high to the dose which is said to give statistically significant levels of risks when given acutely. Yet, the exact level of the risk stays enigmatic.

Recent advances in stem cell research have revealed a dynamic nature of stem cell turnover in the tissue stem cell niche. One characteristics of this turnover is the competitive evolution of the stem cells leading to the selection and the domination of the fittest in the stem cell niche while unfit stem cells are eliminated by commitment to the progenitor . This dynamism is developmentally regulated and tissue specific, but operate in general to eliminate non-fit stem cells whose expression profiles are transiently and/or semi-permanently modified after radiation exposures. The competition and elimination of un-fit cells is particularly strong during neonatal stages when adult tissue stem cell niche is established for first time in the ontogeny. Indeed, fetal exposure is known to give no chromosome aberration in the lymphocytes after birth. This indicates elimination of the damaged stem cells. In accordance with this data, fetal exposure does not give leukemia in mice, nor does it gives solid tumors in a variety of tissues after birth. In Oxford survey, a mail based epidemiological analyses conducted as early as in 1950s indicated fetal stages are extremely sensitive for the induction of cancer with the relative risk as high as 50/Gy. In contrast, in utero exposed cohort of atomic bomb survivors indicated a moderate or even a low risk or childhood cancer when conducted compared with childhood exposures. Further advance in stem cell radiobiology is expected to give answer to this long lasting debate.

As for the low dose radiation, especially the dose below a few mGy, cells are exposed to a single track of electron at a time. When this dose is given in a year, each cell is separated by a few months for receiving a track of electron. This means stem cells in a tissue stem cell niche are composed by a mixture of the exposed and non-exposed in which the former is always a minority. Under this scenario, the cells traversed by a single track may not have advantage over non-traversed ones, and eventually eliminated to move into the progenitor compartment rather than staying in the stem cell compartment of the tissue stem cell niche. Human epidemiology of constant low dose rate radiation areas was conducted in Kerala India for the past 20 years which does not indicate elevation of cancer risk. Again, further analyses of low dose rate whole body stem cell kinetics and human epidemiology of high background natural radiation areas such as Kerala are likely to give answers to this enigmatic issue.

Abstract: Presentation at the International Expert Symposium in Fukushima:
Radiation and Health Risks
September 11-12, 2011, Fukushima, Japan

**Radiation and Cancer Risk in Atomic Bomb Survivors:
Radiation Effects Research Foundation, Hiroshima and Nagasaki, Japan**

Kazunori Kodama
Radiation Effects Research Foundation
with Kotaro Ozasa and Toshiteru Okubo

To determine health effects of radiation in A-bomb survivors, the Radiation Effects Research Foundation has been conducting studies on the Life Span Study (LSS) population which consists of 93,000 A-bomb survivors and 27,000 controls.

Solid cancer: The most important result of the LSS is elevation of cancer risk with increase of radiation dose. In the recent report on the incidence of solid cancers, it is estimated that, at age 70 following exposure at age 30, solid-cancer rates increase by about 35% per Gy (90% CI: 28%; 43%) for men and 58% per Gy (90% CI: 43%; 69%) for women. The age-at-exposure is an important risk modifier. For lung cancer, cigarette smoking has been found to be an important risk modifier. Radiation has similar effects upon first-primary and second-primary cancer risks. Finally, it appears that radiation-associated increases in cancer rates persist throughout life.

The in utero group exhibited statistically significant dose-related increase in incidence rate for solid cancers. The lifetime risk, however, may be considerably lower than for early childhood exposure.

Leukemia: In the most recent decade of observation (1991-2000) on mortality, the estimated attributable fraction of leukemia deaths among those survivors exposed to >0.005 Gy was 34%, suggesting that the effect of the atomic bombings on leukemia mortality has persisted for more than five decades. In addition, the significant dose-response for myelodysplastic syndrome (MDS) was found in Nagasaki LSS members 40 to 60 years after radiation exposure.

Future perspective: In view of the nature of the continuing increase in solid cancer risks, the LSS should continue to provide important new information on radiation exposure and solid cancer risks for another 15 to 20 years.

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Radiation and Health Risks
September 11-12, 2011, Fukushima, Japan

Lessons of Chernobyl and prognosis for Fukushima: radiological consequences

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In the presentation the following three main questions are considered:

- Results of large-scale studies of the National Radiation Epidemiological Registry for 25 years of follow-up after the accident at the Chernobyl NPP; summarized data on radiation risks for emergency accident workers and the population of the most contaminated with radionuclides territories of Russia;
- Verification of ICRP prognostic models (Publication 103) for estimating radiation risk with an allowance for data on the Chernobyl accident
- Prognostic estimates of potential radiological consequences of the disaster at the Fukushima Dai-ichi NPP with the use of the ICRP prognostic models

Conclusion

Information on health effects of the Chernobyl accident is very important for prognostic estimates of health effects of the Fukushima Dai-ichi disaster. It is determined by the fact that doses from the Chernobyl are many times less than doses after the A-bombing. We have demonstrated that the main estimates of radiation risks after the Chernobyl accident are in close agreement with the ICRP models (Publication 103).

Prognostic estimates of radiological effects of the Fukushima Dai-ichi disaster based on the ICRP models are preliminary, because of the lack of dosimetry and demographic data. At the same time we consider it necessary to determine groups of potential risk on the basis of conclusions drawn from radiation epidemiological studies.

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September 11-12, 2011, Fukushima, Japan

Chernobyl Experience in the Area of Retrospective Dosimetry

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Chernobyl accident, which occurred on April 26, 1986 at NPP located less than 150 km north of Kiev, is the largest nuclear accident ever. Unprecedented scale of the accident was determined not only by the amount of released activity, but also by a number of population and workers involved and, therefore, exposed to enhanced doses of ionizing radiation.

Population of the 30-km exclusion zone numbering about 116,000 persons of all ages and both genders was evacuated within days and weeks after the accident, emergency workers called 'liquidators of the accident' (males age 20-50) were involved into clean-up and recovery for 5 years and their number is estimated as 600,000, about 300,000 are Ukrainian citizens.

Due to unexpected and excessively large scale accident, none of residents had personal dosimeters, personal dosimetry of liquidators was not total, dosimetry techniques and practices were far from the optimum.

As a result, an acute need for retrospective dose assessment was dictated by radiation protection and research considerations. This need was responded by implementation of wide scale dose reconstruction efforts, which covered main exposed cohorts and encompassed broad variety of newly developed methods: analytical (time-and-motion), modeling, biological and physical (EPR spectroscopy of teeth, TL of quartz).

The presentation will summarize vast experience accumulated by RCRM in the field of retrospective dosimetry of large cohorts of exposed population and professionals. These dose reconstruction projects were implemented, in particular, in the framework of epidemiological studies, designed to follow-up medical consequences of Chernobyl accident and study health effects of ionizing radiation, in particular, Ukrainian-American studies of cataracts and leukemia among liquidators.

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THYROID CANCER IN UKRAINE AFTER THE CHORNOBYL ACCIDENT (IN THE FRAMEWORK OF UKRAINE-U.S. THYROID PROJECT)

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Background and aims – As a result of the accident at the Chernobyl Nuclear Power Plant, millions of residents of Belarus, Russia and Ukraine were exposed to significant doses of radioactive iodine isotopes, mainly I-131. The purpose of the Ukraine-American Project is to quantify thyroid cancer risk in the framework of a classical cohort study, comprising subjects who were aged up to 18 years at the moment of the accident, had direct measurements of thyroid I-131 activity taken within two months after the accident, and were resident in three heavily contaminated northern regions of Ukraine (Zhytomyr, Kyiv, and Chernihiv regions).

Methods - Four two-year screening cycles have been implemented: 13,243 subjects were screened in cycle 1 (1998-2000); 12,419 (93.8%) in cycle 2 (2001-2002); 11,745 (88.7%) in cycle 3 (2003-2004); and 10,186 (76.9%) in cycle 4 of screening. A standardized procedure of clinical examinations included: thyroid palpation, ultrasound examination, blood collection followed by a determination of thyroid hormone levels, urinary iodine content test, and, if indicated, fine needle aspiration. Individual I-131 doses on cohort member's thyroid were assessed from I-131 activity measurement in the subject's thyroid and extended dosimetry interview data (mean dose = 0,79 Gy; dose range - 0 to 40 Gy).

Results - 45 prevalent cases of thyroid carcinoma have been detected in cycle 1 of screening. Thyroid cancer risk based on the first cycle of screening demonstrated a strong approximately linear relationship with the individual thyroid exposure dose ($p < 0.01$); the ERR was estimated to be 5.25 (95% CI: 1.70, 27.5) per Gy. Also, an analysis has been completed, of 65 incident cases of thyroid cancer diagnosed during the screening cycles 2 - 4, and about 73,000 persons/years of observation. The dose dependence was consistent with both linear model of excessive absolute risk (EAR), and that of excessive relative risk (ERR). EAR per 10^4 PY per Gy was estimated to be 2.21 (95% CI: 0.04 - 5.78) and ERR 1.91 per Gy (95% CI: 0.43 - 6.34).

Among 110 cases of thyroid cancer diagnosed in 1998-2008, papillary carcinomas were prevalent - 104 cases (94.5%); in addition, 5 cases (4.6%) of follicular adenoma and one case (4.6%) of medullary carcinoma were diagnosed.

Conclusions - The data obtained demonstrate that for a period of 20 years after the Chernobyl accident thyroid cancer risk still remains reliably significant, which is a weighty argument in favor of a further follow-up of cohort members of the Ukrainian-American Thyroid Project in order to ascertain the dose-effect relationship and determine the time pattern of risk.

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Mental health consequences of the Chernobyl disaster

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The psychological consequences of human-made and natural disasters have been studied worldwide for more than 100 years. The mental health consequences typically involve depression, anxiety, post-traumatic stress disorder, and medically unexplained somatic symptoms, with excess morbidity rates in the order of 20% in the first year. In human-made disasters, these symptoms and mental health conditions often become chronic and persistent. Events involving radiation are particularly pernicious because the exposure is invisible and universally feared, and causes long-term threats to health. During the 25 years since the Chernobyl accident, studies of the mental health of community populations exposed to radiation showed an approximately two-fold increase in post-traumatic stress disorder and other clinical conditions, and poorer subjective ratings of health. These morbidity patterns are consistent with impairments documented after other toxic events, including the atomic bombings of Hiroshima and Nagasaki and the Three Mile Island accident. Research on first-responders and clean-up workers also found elevated rates of anxiety and depressive disorders, including suicide, as long as 20 years later, with odds ratios between 2.5-3.5 for post-traumatic stress disorder and 16.6 for current severe headaches. Psychobiological studies in Kiev suggest potential EEG changes in highly exposed liquidators. In contrast, findings on the long-term mental health of children who were *in utero* or under age 2 at the time of the accident and were evacuated, moved away, or remained in contaminated villages are not consistent. Some studies found no psychological or cognitive differences between exposed children and controls, including the World Health Organization Study of children *in utero* examined at age 7 and a systematic, multidisciplinary study of evacuee children in Kiev assessed at ages 11 and 19. Other studies in the former Soviet Union and northern Europe reported significant impairments in aspects of cognitive functioning in exposed children compared to controls, with one study reporting a dose-response association with radiation exposure.

Taken as a whole, the evidence about mental health has led experts to suggest that mental health is the largest public health problem unleashed by the accident. Although the web of causality is complex, depressive and anxiety disorders are clinically important outcomes because of their well established relationships with disability, poor quality of life, physical morbidity, greater use of medical services, and even mortality. Thus, the current body of research indicates a large unmet need for mental health interventions to reduce the psychological morbidity of affected populations. It would be parsimonious to include mental health screenings in population-based monitoring studies to clarify the long-term psychological consequences in various risk groups, particular the cohort born or raised in high exposure regions, and to understand its link to changes in physical health.

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The Chernobyl Tissue Bank – integrating research on radiation-induced thyroid cancer.

Geraldine A. Thomas
Chernobyl Tissue Bank
on behalf of the Steering Group, Scientific Advisory Board and the Pathology Panel of the CTB

The Chernobyl Tissue Bank (CTB) was established in 1998 to collect, store and distribute biological samples from patients born on or after 26th April 1967, and resident in the regions of Ukraine and Russia contaminated by fallout from the Chernobyl accident and who developed thyroid cancer. The project is supported financially by the European Commission, the National Cancer Institute of the USA and the Sasakawa Memorial Foundation, and has the political support of the Governments of Ukraine and Russia. Patients attending thyroid clinics in the Institute of Endocrinology in Kiev, Ukraine and the Medical Radiological Research Centre in Obninsk, Russia are asked to consent to the use of samples left over from their operation for suspected thyroid cancer for research. The study cohort includes any patient with a pre-operative diagnosis of suspected thyroid cancer, who was resident in the most heavily contaminated regions of Ukraine and Russia at the time of the accident and aged under 19 at the time of the accident (i.e. born on or after 26th April 1967). The CTB database also includes a dose estimation for each patient. A sample of blood for extraction of DNA, serum and samples of both frozen (where the tumour is large enough) and formalin fixed paraffin embedded (FFPE) tumour and normal thyroid tissue are provided by each patient.

The current collection includes 3861 cases of thyroid cancer and adenoma. The pathology of every case submitted to the CTB is reviewed by an international panel of pathologists. Molecular biology quality assurance (QA) is carried out on each sample prior to release to researchers. In order to maximise the use of the resource, nucleic acids are extracted from the same frozen tissue block, aliquotted and are distributed to multiple researchers. Individual sections from FFPE blocks from individual cases are also issued to multiple researchers. This permits integration of results from a number of studies on single cases and facilitates an integrated biology approach to thyroid cancer post Chernobyl.

Researchers apply for material through an online portal (https://cisbic.bioinformatics.ic.ac.uk/ctb/html_ctb_public/). Applications are reviewed by an independent external review panel, thus ensuring that the material is used appropriately in first class scientific research. Researchers agree to provide data from their studies back to the project in order that these can be integrated into future studies. So far, 2397 aliquots of RNA and 1237 of DNA from tissue, 541 aliquots of DNA from blood and 6300 sections from FFPE blocks have been issued to researchers worldwide. A key finding so far is that the molecular biology of thyroid cancer is different in young patients from that in adults. The most recent studies, which are currently being validated, have indicated that there may be subtle differences in particular regions of individual chromosomes, that may be a marker for radiation-induced cancer.

The CTB provides a unique resource for studies on radiation induced thyroid cancer and serves as a paradigm for cancer research in general in this era of integrative biology.

Abstract: Presentation at the International Expert Symposium in Fukushima:
Radiation and Health Risks
September 11-12, 2011, Fukushima, Japan

Radiation Protection Principles

John R Cooper
Health Protection Agency

After several years of consultation, at the end of 2007 the International Commission on Radiological Protection (ICRP) published its new Recommendations for a system of radiological protection (Publication 103). These new Recommendations are a logical development of the previous Recommendations issued in 1991 as Publication 60, representing a consolidation of Publication 60 and the subsequent derivative publications.

The basic principles of radiation protection, Justification, Optimisation of Protection, and Application of Dose Limits, are unchanged from the 1990 Recommendations. ICRP continues to distinguish between three categories of exposure, occupational exposures, public exposures, and medical exposures of patients (and comforters, careers, and volunteers in research). ICRP now recognises, however, three types of exposure situations which replace the previous categorisation into practices and interventions. These three exposure situations are intended to cover the entire range of exposure situations, making the system of protection generally applicable to all circumstances of radiation exposure.

The 2007 Recommendations emphasise the key role of the principle of optimisation, which should be applied in the same manner in all exposure situations. Restrictions are applied to effective doses to individuals, namely dose constraints for planned exposure situations and reference levels for emergency and existing exposure situations. Radiological protection options resulting in doses greater in magnitude than such restrictions should be rejected at the planning stage. Importantly, these restrictions on doses are applied prospectively, as with optimisation as a whole. If, following the implementation of an optimised protection strategy, it is subsequently shown that the value of the constraint or reference level is exceeded, the reasons should be investigated but this fact alone should not necessarily prompt regulatory action. ICRP expects that such an emphasis on a common approach to radiological protection across all circumstances of exposure, will aid application of the Commission's recommendations.

One of the main implications of the change from practices and interventions to the three types of exposure situation occurs in the area of emergency exposure situations. In the 1990 Recommendations these situations are regarded as interventions with optimisation considering mainly the magnitude in the reduction in projected doses. In the 2007 Recommendations application of optimisation with reference levels places additional emphasis on the level of dose remaining after action has been taken; the intention of emergency planning should be to select protective options that will result in a residual dose below the value of the reference level.

This presentation will describe ICRP's 2007 Recommendations, making comparison with the previous 1990 Recommendations as appropriate. Emphasis will be placed on application to emergencies and the further guidance issued in Publication 109 on this topic will also be discussed. Finally, the role of the Health Protection Agency in implementing ICRP Recommendations in the UK will be briefly described.

Abstract: Presentation at the International Expert Symposium in Fukushima:
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September 11-12, 2011, Fukushima, Japan

Cancer Risk Modeling and Radiological Protection

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Estimates of the excess risk of cancer following exposure to ionizing radiation are obtained from the epidemiological study of exposed groups of people, guided by the results of experimental studies (for example, of laboratory animals). Cancer risk models are derived principally from the experience of the Japanese survivors of the atomic bombings of Hiroshima and Nagasaki, who have been studied in considerable detail and who were exposed to a range of doses during a brief period (i.e. at a high dose-rate); but the results obtained from the analysis of this dataset are supported by many other epidemiological studies, such as those of groups exposed for medical reasons. These cancer risk models describe the variation of the radiation-related risk of different types of cancers with the tissue-specific dose of radiation received – the dose-response relationship – and include, where appropriate, the influence of certain important risk modifying factors such as age-at-exposure and time-since-exposure. Since much of the information used in the generation of these risk models is obtained from individuals receiving moderate and high doses (>100 mSv), a crucial aspect of the models is the extension of the predicted excess risk to low doses (<100 mSv). It is assumed for the purposes of radiological protection that for low doses and low dose-rates the dose-response is linear (and for sparsely ionizing radiations, e.g. γ-rays, with a slope half of that at moderate doses delivered at high dose-rates) with no threshold dose – the linear no-threshold (LNT) cancer risk model predicting, overall, an average lifetime excess risk of the development of a serious cancer of ~5% per Sv effective dose received. The LNT model is controversial because it is difficult to test definitively at low doses, the predicted excess risk being small relative to the variation in total cancer risk arising from background risk factors. Nonetheless, for some cancers at least, evidence does exist to indicate that a small excess risk is consequent upon the receipt of low doses, and that its magnitude is at about the level predicted by risk models – this evidence is likely to grow in the near future, for example from large studies of workers in the nuclear industry and those exposed to relatively high dose medical diagnostic procedures such as CT scans. For α-particle exposure, groups exist for epidemiological study, particularly those exposed to radon in mines or homes, and appropriate risk models have been derived from these groups. Those exposed to radiation from intakes of radioactive material other than radon are not extensive, but studies of internal exposures such as to releases from the Chernobyl nuclear reactor accident or radionuclides from atmospheric nuclear weapons testing do not suggest a serious underestimation of the predicted risk of cancer from such exposures. In summary, the assumption that some small risk of cancer arises from low-level exposure to radiation, made for the purposes of radiological protection, is difficult to confirm because of relatively large fluctuations in background risk factors, but the currently available evidence suggests that the assumption is likely to be correct and that the degree of risk is around that predicted by the LNT risk model for cancer based largely upon those exposed to moderate and high doses at high dose-rates.

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Protection of people living in long term contaminated areas after a nuclear accident: the Recommendations of ICRP Publication 111

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The objective of the ICRP system of radiological protection is to manage and control exposures to ionising radiation so that deterministic effects are prevented, and the risks of stochastic effects are reduced to the extent reasonably achievable. The Commission defines prolonged exposures resulting from nuclear accidents or radiation emergencies as existing exposure situations and provides guidance for the protection of people living in long-term contaminated areas after such events in its Publication 111 (2009). The principle of optimization of protection i.e. maintaining or reducing all doses to levels that are as low as reasonably achievable, economic and societal factors being taken into account, is the driving principle for managing such exposure situation. The Commission recommends the use a dose reference level to restrict individual doses to be selected in the lower part of a 1 to 20 mSv/year dose band depending on the circumstances. In the long term the objective of protection is to reduce exposures to levels that are close or similar to situations considered as normal i.e. below 1 mSv/year.

To be effective, protection strategies to maintain and reduce exposure as low as reasonably achievable should include actions implemented by public authorities, and private businesses (particularly to improve the radiological quality of food production systems) but also by the affected population itself. The process through which inhabitants living in a contaminated environment identify problems and apply their own protective actions has been named “self-help protection” by the Commission. Such a process supposes that affected individuals are fully aware of the situation and are well informed. It is the responsibility of authorities to establish programmes for continuous radiation monitoring, information and education of the population. The involvement of local professionals and inhabitants in the definition and implementation of protection strategies is a key factor for the sustainability of long term rehabilitation programs.

The paper addresses first the issue of the transition from the emergency exposure situation to the existing exposure situation and, next, the key characteristics of living in long term contaminated areas. The last part presents the Commission’s recommendations concerning radiation monitoring, health surveillance and the management of contaminated foodstuffs and other commodities to be implemented to protect people and to favour the redeployment of social and economic activities in the affected areas.

Abstract: Presentation at the International Expert Symposium in Fukushima:
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Some lessons on radiological protection learned from the accident of the Fukushima Daiichi nuclear power plant

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In the early stage, a large quantity of radioactive iodine accidentally released from the plant mainly contributed to the total effective dose to the public and was focused in radiological protection. The evacuation and food restriction that timely adopted by the authorities effectively reduced the dose received by people living in the affected area. After March 24, the atmospheric release of radioactive iodine declined since the damaged reactors became stable. As a result of stable contamination in the environment, the transition from emergencies to existing exposure situation was gradually being in progress. In general, a reference level of the magnitude used in emergency exposure situations is not acceptable as a long-term benchmark and the process of selecting the value of the reference level should also be carefully balanced to appropriately include the views of all relevant stakeholders. However, the emergency policy continued and confused the living people in the contaminated area since the policy decided by the authorities would be affected by the reactor conditions. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) decided the use of the tentative reference level of 3.8 μ Sv/hr at the playgrounds until summer vacation. In deriving the criteria, the MEXT selected 20mSv/y of the dose band for existing exposure situation recommended by the ICRP. The mothers in the affected area became recognized that the dose of 20 mSv/y was unacceptably higher in children since 1 mSv/y is the dose limit for the public. Much concern was increasing about the internal exposure to children, since little information on internal exposure is a critical issue in emergency since the public tries to obtain practically measured data. Current Internet information accelerated the concern about the internal exposure to children and the related health effects. From these social situations the following lessons have been learned. The selection of reference doses in emergency and existing exposure situations after the accident is needed to link with the corresponding risk using a risk-informed approach that can consider internal exposure. The accountability of the reference doses is being required particularly in existing exposure situation. The ICRP and the related authorities have thus far had no effective risk communication with the public.

Abstract: Comments at the International Expert Symposium in Fukushima:
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New Perspective of Severe Nuclear Accidents

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The public reactions in Korea to the nuclear accidents in the Fukushima Daiichi plants, particularly with respect to over-reactions, were reviewed to draw a conclusion that a significant radioactive contamination of a country with small territory could lead a severe national crisis. Here 'significant' does not necessarily mean harmful to the public health but means simply detectable. The most affecting factor is the socio-economical damage caused by stigma. Escape of foreign capital also can be a blow. In addition, difficulty in food supply, shortage of electricity due to forced shutdown of operating nuclear power plants, and social disruption also put oil on fire. It should be noted that most of such over-reactions are originated form misunderstanding of radiation risk. Such unjustifiable damages from a nuclear accident due to propagation of undue fear should be prevented. Given nuclear power is an unavoidable choice, the status of public perception should be reformed at any cost, not only in the countries operating nuclear power plants but in the global society as a whole.

Abstract: Comments at the International Expert Symposium in Fukushima:
Radiation and Health Risks
September 11-12, 2011, Fukushima, Japan

Preparing a scientific report to the General Assembly on "Exposures due to the nuclear accident following the Great East-Japan earthquake and tsunami" – the current status of UNSCEAR activities

Wolfgang Weiss
UNSCEAR

At its 58th session in May 2011, the Scientific Committee considered the implications of the nuclear power plant accident of March 2011, as far as radiation levels and effects were concerned. The Committee expressed its sympathy and solidarity to the Japanese people and wishes for a prompt recovery from the aftermath of these devastating natural events. It also conveyed to the Japanese scientists that were currently assessing the radiation consequences its availability to support their efforts. The Committee has extensive experience in the appropriate scientific methodologies for exposure assessment of accidental releases. It has recently published reports on the current scientific knowledge of radiation-related heath effects (including those at low doses and dose rates). These could serve as a basis for assessment of the radiation levels and effects attributable to the accident. The Committee recognized that the emergency situation in Japan was still in progress and thus a Committee report based on current information and possible effects attributable to the accident would be incomplete. In addition, there was a vast amount of environmental data that had been and would continue to be collected. It is likely that the data from the accident would take many months to analyze. Notwithstanding this, the Committee recommended to start with the compilation of all relevant data and information as soon as possible.

The report will only assess the levels of exposure and effects scientifically. It will not address policy matters or identify lessons to be learned with respect to nuclear safety, radiation protection, environmental protection, emergency preparedness and response, or public health actions. It will be critical to maintain close coordination with activities being undertaken by the Japanese government, in order to avoid confusion and misinterpretation. The Committee decided to carry out, once sufficient information was available, a full assessment of the levels of exposure and radiation risks attributable to the accident. It envisages a preliminary document for consideration at its 59th session in May of 2012 and a more complete report for the sixtieth session of the Committee in 2013. The report will define or adopt methodologies to estimate doses for different population groups inside and outside of Japan, and assess those doses using available data and information, obtained through official channels, published in the open literature, or from other sources where the quality of the information can be assured. The work will heavily rely on contributions of key organizations who are willing and able to work intensively to produce the report in a short period of time. The interim report will discuss issues which the Committee can be sure of at that point (beginning 2012). On the other hand, the main scientific report for the 60th session of UNSCEAR in 2013 has to be extremely well written and supported by evidence documented with full rigour. The typical target audience beside politicians would be science journalists. The report's annexes will contain more detailed information for scientists. It would be likely that another more complete and definitive report would be needed several years after the accident had ended.

The Chernobyl experience tells us to expect public distress and anxiety, and concerns about the long-term implications of the accident. The work of UNSCEAR will be very important to provide an independent authoritative assessment of the long-term implications of radiation exposure from the radionuclides in the environment. UNSCEAR can contribute much to providing better background information to help improve understanding of the public and decision-makers about radiation and its effects. The effects of long-lived radioactive material in the environment will likely continue to be of concern long after the physical recovery from the tsunami is complete. It will be important for the global community to respond in a coordinated and thoughtful manner in coming years.

Provision of quality-assured data will be important in the context of conducting the UNSCEAR assessment. The active cooperation of all organizations in Japan as well as with international organizations within the UN family, in particular the IAEA, the CTBTO, the WMO, and the WHO in this matter, particularly regarding the monitoring results and the assessment methodologies of their own which will provide significant input in characterizing the situation in Japan, the Pacific Ocean, and world wide.

A kick-off meeting has been organized on 30 June / 1 July 2011 to conduct preliminary planning of the UNSCEAR assessment. 34 participants from 10 States member of UNSCEAR and 3 observer countries as well as from 4 international organizations attended the meeting. The main objectives of the meeting were to agree on the work plan which had been developed in close co-operation with the Japanese counterparts (NIRS, NSC, Permanent Mission of Japan in Vienna) and to find ways in moving forward to getting relevant data for the assessment. The work will be organized in four groups:
Group A: Data compilation, screening, QA, documentation ;
Group B: Radionuclide releases and dispersion;
Group C: Dose and risk assessment: (a) humans and (b) biota;
Group D: Worker doses and health effects.

Japan has already nominated an expert for each group. Other countries expressed their interest by nominating persons for one of the envisaged expert groups. The management of the work will be performed by Wolfgang Weiss (BfS) and Yoshiharu Yonekura (NIRS) together with the UNSCEAR secretariat.

A draft list of data requirements prepared by BfS has been discussed during the kick-off meeting and an updated version has been made available by the end of July 2011. The Japanese delegation was asked to respond on the availability of data or assessments for the parameters included in the updated list by September 2011. According to the Japanese delegation different data sources are available in Japan. The main official sources for data are the three following:
1. the Government of Japan;
2. the Fukushima prefecture;
3. University network (only after passing a pre-reviewing).
In addition, there is a large number of measurements conducted by TEPCO and other industrial partners, which also could be taken into account if they pass the pre-review process.

The UNSCEAR assessment work might only start properly by the end of the year 2011 after obtaining high quality data as well as published assessments from different sources. It is important to reduce the burden for the Japanese colleagues by requesting only information needed for the assessment and to avoid any duplication of work.