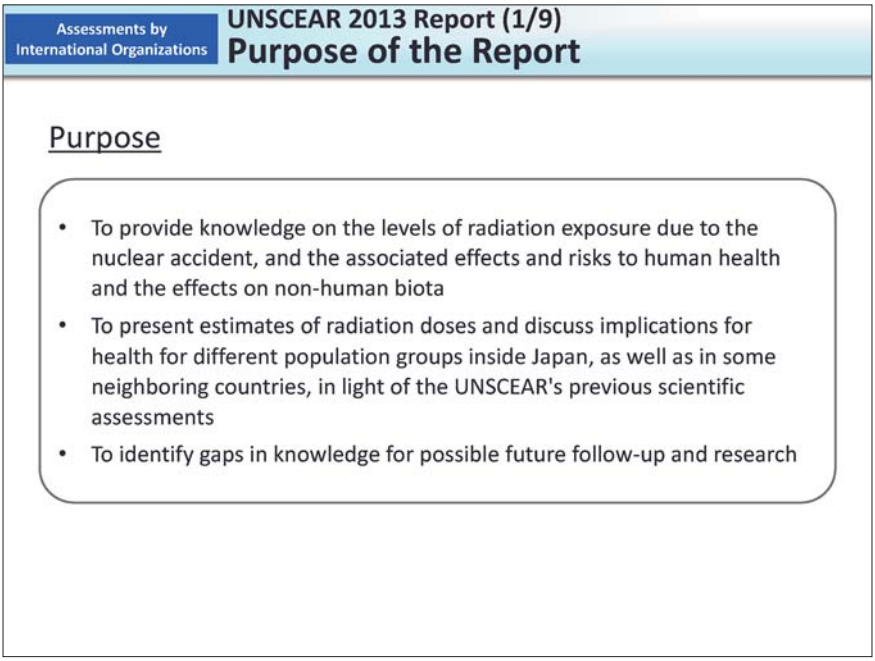


The UNSCEAR 2013 Report "Volume I, Scientific Annex A: Levels and Effects of Radiation Exposure due to the Nuclear Accident after the 2011 Great East-Japan Earthquake and Tsunami" was prepared for the following purposes.

・To evaluate information, mainly from 2011 and 2012, on the levels of radiation exposure due to the nuclear accident, and the associated effects and risks to human health and the effects on non-human biota

・To present estimates of radiation doses and discuss implications for health for different population groups inside Japan, and to a lesser degree in some neighboring countries, using data and information available to UNSCEAR, and against the backdrop of UNSCEAR's previous scientific assessments of effects of radiation on health and the environment from all sources, including accidents

・To identify gaps in knowledge for possible future follow-up and research

On the other hand, the following two are cited as what was not intended by this Report.

・To identify lessons or address policy issues with respect to human rights, public health protection, environmental protection, radiation protection, emergency preparedness and response, accident management, nuclear safety, and related issues

・To provide advice to local governments, the Government of Japan or to national and international bodies

[Relevant parts in the reports]

・UNSCEAR Report (prepared based on paragraph 8 on page 26, Scientific Annex A (Japanese-language version)) (Original English version: paragraph 8 on page 27)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (2/9)
Outline of Assessment of Public Exposure Doses

1. The assessment was based on measurement data as far as possible.
2. Doses that the public received for the first one year after the accident were assessed, targeting 20-year-old adults, 10-year-old children and 1-year-old infants.
3. Projections were also made of doses to be received over the first 10 years and up to age 80 years.
4. Models were used, with realistic assumptions, to provide an objective evaluation of the situation.
5. Protective actions taken during the first year were considered and the doses averted by them were estimated.

As indicated in the preface to the Report, at its fifty-eighth session in May 2011, the UNSCEAR decided to carry out, once sufficient information was available, an assessment of the levels of exposure and radiation risks attributable to the nuclear power plant accident following the Great East-Japan Earthquake and tsunami of March 2011. It was decided to mainly utilize prefectural data and government organizations' data released in Japan up to September 2012, and other data and documents provided by UN member countries other than Japan and by international organizations such as the International Atomic Energy Agency (IAEA) and the WHO. Additionally, new important information obtained by the end of 2013 was also taken into consideration to the extent possible.

"Chapter IV Assessment of doses to the public" of the UNSCEAR Report comprises the following.

A. Exposure pathways, B. Data for dose assessment, C. Overview of methodology for assessing public exposures, D. Results of dose estimation, E. Uncertainties, and F. Comparison with direct measurements and other assessments

"D. Results of dose estimation" shows the estimation results for effective doses and absorbed doses in specific organs for general public in Japan. The section consists of (i) doses in the first year for members of the public not evacuated, (ii) evacuees' doses, (iii) estimation of doses in Japan for exposure over future years, and (iv) estimation of doses in other countries.

Details of the estimation of public exposure doses will be explained in the following pages.

[Relevant parts in the reports]

• UNSCEAR Report (prepared based on paragraphs 3 to 4 on page 25, and paragraph 12 on page 7, Scientific Annex A (Japanese-language version)) (Original English version: paragraphs 3 to 4 on page 25 and paragraph 12 on page 27)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (3/9) Data Used for Assessment of Public Exposure Doses

Used measurement values, etc.

1. Internal exposure through inhalation and external exposure

(i) Deposition densities of radioactive materials on the ground surface measured on earth and from aircraft

(ii) Radioactivity concentrations in the air and on the ground surface estimated based on types and estimated amount of radioactive materials released from the reactor and through diffusion simulation

2. Internal exposure through ingestion

- Radioactivity concentrations in foods and drinking water

(i) First year: Measurement data for concentrations of radionuclides in distributing foods and drinking water

(ii) Second year onward: Radioactivity concentrations in foods estimated through simulation based on soil contamination data; For marine products, radioactivity concentrations in seawater estimated based on measurement data in the sea area off Fukushima Prefecture and through diffusion simulation of radionuclides

- Japanese people's food intake (based on the National Health and Nutrition Survey)

Out of the radioactive materials released due to the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, Iodine-131, Cesium-134, and Cesium-137 are considered to have mainly contributed to people's exposure.

Doses can be assessed most reliably through the measurement using personal dosimeters in the case of external exposure and the measurement using whole-body counters in the case of internal exposure. Such data was partially available regarding the accident at the NPS but was not sufficient for calculating internal exposure doses for all people in Fukushima Prefecture as a whole and in other prefectures.

Therefore, the UNSCEAR conducted dose estimation based on the data indicated above and used other measurement data for verifying the calculation results.

[Relevant parts in the reports]

• UNSCEAR Report (prepared based on paragraphs 67 to 78 on pages 46 to 48, Scientific Annex A (Japanese-language version) (Original English version: paragraphs 67 to 78 on pages 48 to 50), Appendix A, and "IV. TRANSPORT AND DISPERSION IN THE OCEAN" of Appendix B)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (4/9) Estimation of Public Exposure Doses for Each of the Four Groups

Area classification for dose assessment

Group	Area	Spatial resolution for public dose assessment
1	Settlements in Fukushima Prefecture where people were evacuated in the days to months after the accident	Representative locations were used for each settlement identified in 18 evacuation scenarios
2	Districts of Fukushima Prefecture not evacuated	District level for external and inhalation pathways, based on the estimates for each of the 1-km-grid points, averaged over the district Prefecture level for ingestion pathway
3	Selected prefectures in eastern Japan that were neighboring (prefectures of Miyagi, Tochigi, Gunma and Ibaraki) or nearby (prefectures of Iwate and Chiba) to Fukushima Prefecture	District level for external and inhalation pathways, based on the estimates for each of the 1-km-grid points, averaged over the district Estimated dose due to ingestion for Iwate Prefecture same as for Group 4; for other five prefectures was based on average for the five prefectures
4	All remaining prefectures of Japan	Prefecture level for external and inhalation pathways Average for rest of Japan for ingestion pathway

Public exposure levels differ by location, and evacuees changed their locations as time passed.

Therefore, the UNSCEAR classified areas into four groups for assessing public exposure doses and further narrowed down the targets depending on the exposure pathways. The table above shows the four groups classified by the UNSCEAR.

- Group 1: Settlements in Fukushima Prefecture where people were evacuated in the days to months after the accident
- Group 2: Districts of Fukushima Prefecture not evacuated
- Group 3: Selected prefectures in eastern Japan that were neighboring (prefectures of Miyagi, Tochigi, Gunma and Ibaraki) or nearby (prefectures of Iwate and Chiba) to Fukushima Prefecture
- Group 4: All remaining prefectures of Japan

There are 12 administrative districts classified into Group 1 in Fukushima Prefecture and 18 evacuation scenarios were prepared covering all these 12 districts immediately after the accident, which means that some districts were covered under multiple scenarios at the same time. Therefore, the term "settlement" is used in Group 1 to represent specific zones in a single district that were subject to respective evacuation scenarios.

[Relevant parts in the reports]

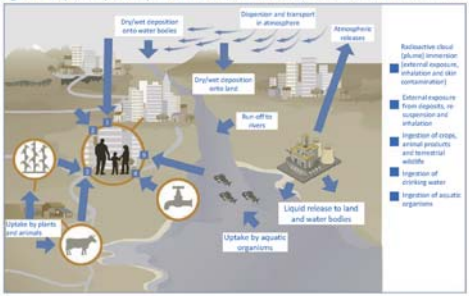
- UNSCEAR Report (prepared based on paragraphs 79 to 80 on pages 48 to 49, Scientific Annex A (Japanese-language version) (Original English version; paragraphs 79 to 80 on pages 50 to 51), and paragraphs 30 to 32 on pages 155 to 156, Appendix C)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (5/9)
Assessment of Public Exposure Doses: Exposure Pathways

Figure V. Exposure pathways from releases of radioactive material to the environment



1. Move of radioactive plumes in the air
   - ✓ External exposure
   - ✓ Internal exposure (inhalation)
2. Deposition on the ground surface
   - ✓ External exposure
   - ✓ Internal exposure (re-suspension, inhalation)
3. Deposition on the ground surface, etc.
   - ✓ Internal exposure (transfer to foods and drinks)

Major exposure pathways to be assessed

(i) External exposure from radioactive materials in plumes and internal exposure through inhalation thereof
(ii) External exposure from radioactive materials deposited on the ground surface and internal exposure through ingestion of radionuclides that have transferred into foods and drinks
(iii) Internal exposure through ingestion of radioactive materials that have transferred into marine products

In order to estimate exposure doses from radioactive materials released into the environment due to the accident, exposure modes are analyzed in the first place.

The figure above roughly shows exposure pathways in which radioactive materials move in the air in the form of a radioactive plume and reach people's residential areas. In this case, exposure occurs in the following two pathways: external exposure directly from a radioactive plume passing by and internal exposure through inhalation of radioactive materials in a plume.

Furthermore, when radioactive materials in a plume were deposited on the ground surface due to rain, etc., exposure occurs in the following two pathways. The first is external exposure due to radiation from radioactive materials deposited on the ground surface. The second is internal exposure through ingestion of agricultural products with deposited radioactive materials or ingestion of meat of livestock that ate such contaminated agricultural products. As exposure through ingestion of foods and drinks, the following two pathways are considered: internal exposure through ingestion of tap water or other drinking water containing radioactive materials and internal exposure through ingestion of fish into which radioactive materials that had moved into the ocean transferred.

There is also the possibility that radioactive materials deposited on the ground surface become re-suspended in the air and cause internal exposure through inhalation, but radiation effects through this exposure pathway are considered to be minor.

Given these, the major exposure pathways due to radioactive materials released into the air are as follows.

(i) External exposure from radionuclides in the radioactive plumes
(ii) Internal exposure from inhalation of radionuclides in the radioactive plumes
(iii) External exposure from radionuclides deposited on the ground
(iv) Internal exposure from ingestion of radionuclides in foods and water

[Relevant parts in the reports]

• UNSCEAR Report (prepared from paragraphs 65 to 66 on pages 45 to 46, Scientific Annex A (Japanese-language version) (Original English version: paragraphs 65 to 66 on pages 47 to 48), and paragraphs C3 to C7 on pages 148 to 149, Appendix C)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (6/9)
Assessment of Public Exposure Doses: Results

Table 1. Estimated average effective doses and absorbed doses to the thyroid by area for the first one year after the accident*1

Group		Effective dose (mSv)		Absorbed dose to the thyroid (mGv)	
		20-year-old (Adults)*2	1-year old (Infants)	20-year-old (Adults)*2	1-year old (Infants)
Evacuated settlements					
1[a]	Precautionary Evacuation Areas[b]	1.1-5.7	1.6-9.3	7.2-34	15-82
	Deliberate Evacuation Areas[c]	4.8-9.3	7.1-13	16-35	47-83
Non-evacuated areas					
2	Fukushima Prefecture (other than evacuated settlements)	1.0-4.3	2.0-7.5	7.8-17	33-52
3	Neighboring prefectures[d]	0.2-1.4	0.3-2.5	0.6-5.1	2.7-15
4	Rest of Japan	0.1-0.3	0.2-0.5	0.5-0.9	2.6-3.3

[a] Estimate evacuees' doses using 18 evacuation scenarios

[b] Settlements where evacuation was ordered from March 12 to 15, 2011, as emergency protective measures to prevent high-level exposure

[c] Settlements where evacuation was ordered from the end of March to June 2011

[d] Iwate, Miyagi, Ibaraki, Tochigi, Gunma and Chiba Prefectures

*1: Estimation of doses for typical residents of evacuated settlements and other areas in Japan

*2: Estimated doses for 10-year-old children are omitted here.

mSv: millisieverts mGy: milligrays

Reference: Estimation of the public doses in neighboring countries and the rest of the world: The UNSCEAR concluded that the average effective dose for people residing outside Japan for the first one year after the accident was lower than 0.01 mSv.

This table shows estimated effective doses and absorbed doses to the thyroid for the first one year after the accident for typical residents in evacuated settlements and residents in administrative districts other than evacuated settlements in Fukushima Prefecture and in other prefectures in Japan.

Doses in the table show doses added to background doses due to natural radiation, that is, estimated exposure doses from the radionuclides released into the environment due to the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS.

Ranges of doses show those of the representative values for each municipality in areas or for each evacuation scenario among targeted groups.

[Relevant parts in the reports]

・UNSCEAR Report (prepared based on paragraphs 209 to 214 on pages 80 to 81, Scientific Annex A (Japanese-language version)) (Original English version: paragraphs 209 to 214 on pages 86 to 87)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (7/9)

Assessment of Health Effects on General Public

- It is not likely that any significant changes attributable to radiation exposure due to the accident would arise in future cancer statistics.
- There is the possibility that thyroid cancer risks may theoretically increase among the group of children whose estimated exposure doses were at the highest level. Therefore, their situations need to be closely followed up and assessed.
- Congenital abnormalities and heritable effects are not detected.

Source: Prepared based on the UN document, "UNSCEAR: Fukushima-Daiichi NPS Accident (Evaluating Radiation Science for Informed Decision-Making)"

The UNSCEAR assessed public health effects as indicated above based on its exposure dose assessment.

Assessment concerning risks of specific types of cancer and other diseases is as follows.

• Thyroid cancer: Most of the doses were in a range for which an excess incidence of thyroid cancer due to radiation exposure has not been confirmed. However, absorbed doses to the thyroid towards the upper bounds could lead to a discernible increase in the incidence of thyroid cancer among sufficiently large population groups. Nevertheless, the occurrence of a large number of radiation induced thyroid cancers in Fukushima Prefecture—such as occurred after the Chernobyl NPS Accident—can be discounted, because absorbed doses to the thyroid after the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS were substantially lower than those after the Chernobyl NPS Accident.
• Leukemia: The UNSCEAR considered the risk to those exposed as foetuses during pregnancy, and during infancy and childhood, and concluded that no discernible increases in the incidence of leukemia among those groups are expected.
• Breast cancer: The UNSCEAR considered the risk to those exposed at the stage of youth, and concluded that no discernible increases in the incidence of breast cancer among those groups are expected.
• Exposure during pregnancy: The UNSCEAR does not expect any increases in spontaneous abortion, miscarriages, perinatal mortality, congenital effects or cognitive impairment resulting from exposure during pregnancy, nor does it expect any discernible increases in heritable diseases among the descendants of those exposed from the accident at TEPCO's Fukushima Daiichi NPS.

[Relevant parts in the reports]
• UNSCEAR Report (prepared based on paragraphs 220 and 222 to 224 on pages 82 to 83, Scientific Annex A (Japanese-language version)) (Original English version: paragraphs 220 and 222 to 224 on page 89)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (8/9)
Assessment of Public Exposure Doses: Uncertainties

1. Measurement levels of short-half-life radionuclides deposited on the ground surface and their spatial distribution by area
2. Changes in release rates of radionuclides over time and weather information at the time of their release
3. Particle sizes and chemical forms of radioactive iodine
4. Assumption of radioactivity concentrations in foods
5. Japanese people's thyroid iodine uptake rate

The UNSCEAR estimated public exposure doses from radioactive materials released due to the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS under certain assumptions based on insufficient knowledge and information, and therefore, it considers that the results contain certain uncertainties.

1. Uncertainties concerning measurements of radionuclides deposited on the ground surface
   - Uncertainties in measurement values of Cs-134 and Cs-137 are relatively small.
   - Regarding I-131, whose half-life is approx. 8 days, uncertainties are significant due to the fact that its radioactive decay had progressed before the measurement.

2. Uncertainties concerning changes in release rates of radionuclides over time and weather information at the time of their release
   - Estimation of doses for people who evacuated in March 2011 is based on the results of the Atmospheric Transport and Dispersion Model (ATDM) simulations.
   - As a result, the estimation results may be overestimated or underestimated by a factor of up to typically four to five.

3. Uncertainties affecting assessment of absorbed doses to the thyroid
   - There was no data on relative amounts of particulate and gaseous forms of I-131 in the air and the estimation was made under the assumption that equal amounts of iodine were released in particulate and gaseous forms. This resulted in an uncertainty of up to about a factor of two over the periods of the principal exposures.

4. Uncertainties concerning the assumption of radioactivity concentrations in foods
   - Foodstuffs were not sampled randomly, because the authorities gave priority to identifying foods with the highest concentrations. It was therefore likely that the values of average concentrations used for the assessment led to overestimation.
   - Assumptions concerning the pattern of food distribution and consumption (overestimation of the intake of foods produced in Fukushima Prefecture) were another source of uncertainty.
   - Measured radioactivity concentrations in foods below the detection limits were all assumed as 10 Bq/kg, and this led to overestimation of internal exposure through ingestion of foods for the first one year.

5. Uncertainties concerning Japanese people's thyroid iodine uptake rate
   - Japanese people's thyroid iodine uptake rate may be different from the standard model adopted by the ICRP (the level of uncertainties is smaller than those concerning the aforementioned four items and a possible reduction in exposure doses due to this factor is less than 30%).

[Relevant parts in the reports]
•UNSCEAR Report (prepared based on paragraphs 110 to 115 on pages 57 to 58, Scientific Annex A (Japanese-language version) (Original English version: paragraphs 110 to 115 on pages 60 to 61), and C113 to C131 of "IV. Uncertainties" on pages 188 to 192, Appendix C)

Included in this reference material on March 31, 2015

Assessments by International Organizations

UNSCEAR 2013 Report (9/9)

Comparison with Direct Measurements

Two sets of measurement information of radionuclides served as information sources for assessing public exposure doses.

(i) Measured values of I-131 in the thyroid, especially in the thyroid of children

(ii) Results of the whole-body monitoring of Cs-134 and Cs-137

1. The UNSCEAR's estimates of settlement-average absorbed doses to the thyroid from internal exposure were up to about five times higher than the corresponding values derived from direct monitoring of this group.
2. The results of the whole-body counting of more than 106,000 residents of Fukushima Prefecture were substantially lower than the UNSCEAR's estimates of average effective doses through inhalation and ingestion of Cs-134 and Cs-137.

The UNSCEAR Report suggests the possibility of certain overestimation in assumptions on protective measures and factors concerning dose measurements due to lack of information when estimating public exposure doses. This possibility was also confirmed in the comparison with the results of the measurement of absorbed I-131 to the thyroid conducted in Fukushima Prefecture after the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS and the whole-body counting of Cs-134 and Cs-137.

Data used for the comparison was as follows.

(i) Absorbed doses to the thyroid due to internal exposure: Data for the thyroid monitoring carried out targeting 1,080 children aged between 1 and 15 years in Iwaki City, Kawamata Town and Iitate Village over the period from March 26 to 30, 2011, using hand-held dose-rate instruments

(ii) Effective doses through internal exposure: Data for the whole-body counting targeting more than 106,000 residents of Fukushima Prefecture conducted as part of the Fukushima Health Management Survey, and data for the whole-body counting targeting 33,000 residents of Fukushima Prefecture and neighboring prefectures conducted by researchers from October 2011 to February 2012

As shown in the slide above, the UNSCEAR Report concludes as follows with regard to the comparison between its estimation and these direct measurements.

・Regarding (i) above, the UNSCEAR's estimates were up to about five times higher than the settlement-average absorbed doses obtained through direct measurements.

・Regarding (ii) above, the UNSCEAR's estimates were substantially higher than the results of direct measurements (direct measurement data is substantially lower than the UNSCEAR's estimates).

[Relevant parts in the reports]

・UNSCEAR Report (prepared based on paragraphs 116 to 118 on page59, Scientific Annex A (Japanese-language version)) (Original English version: paragraphs 116 to 118 on page 62)

Included in this reference material on March 31, 2015