ATTACHMENT A-20

ESTIMATES OF COLLECTIVE DOSE FOR THE JAPANESE POPULATION RESULTING FROM THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION

UNSCEAR 2020/2021 Report, Annex B, Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi Nuclear Power Station: implications of information published since the UNSCEAR 2013 Report

Contents

This attachment describes the approaches that the Committee has used to estimate collective doses to the population of Japan following the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS). Collective effective and thyroid doses have been estimated and are summarized for each pathway of exposure, for different age groups in the population, and for different geographical areas of Japan.

Notes

For consistency, doses in this attachment are quoted, in general, to two significant figures. This should not be interpreted as an indication of their precision that is often much less.

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CONTENTS

ESTIMATES OF COLLECTIVE DOSE

1. Collective doses[1] have been assessed on the basis of a Japanese population of 128 million people as determined in the 2010 census [MIC, 2011]. The distribution of this population among different age groups was: 7.4 million (5.8%) were aged 0–5 years; 11.7 million (9.1%) were aged 6–15 years; and the remainder, 108.9 million (85.1%) were above 16 years old and considered to be adults. The total population and its age distribution were assumed to remain constant over the periods for which collective doses were estimated,[2] namely 1 and 80 years after the accident at FDNPS.

2. For pathways of exposure that depend on the location of those exposed (i.e., external radiation from, and inhalation of, airborne radionuclides and external radiation from radionuclides deposited on the ground), collective doses were estimated as follows:

- For Fukushima Prefecture,[3] the collective doses were estimated as the sum, over all municipalities and the three age groups, of the product of the weighted mean dose for a given age group in a given municipality and the number of people within that age group;
- For those municipalities that were partly evacuated (e.g., Minamisoma City), an adjustment was made to take this into account;
- For all evacuated residents of Fukushima Prefecture, the collective doses were estimated as the sum, over all evacuation scenarios and the three age groups, of the product of the weighted mean dose for a given age group in a given evacuation scenario and the number of evacuees within that age group;
- For other prefectures in Japan, the collective doses were estimated as the sum, over all other prefectures and the three age groups, of the product of the weighted mean dose for a given age group for a given prefecture and the number of people within that age group.

3. The approaches used to estimate individual doses from external radiation from, and inhalation of, airborne radionuclides and external radiation from radionuclides deposited on the ground are described in attachments A-1 and A-10, respectively, for municipalities of Fukushima Prefecture and other prefectures; the individual doses are tabulated in attachments A-13, A-14, A-18 and A-19.

4. Exposure from ingestion of food depends more on the location of agricultural production and how it is subsequently distributed and marketed within Japan, rather than the location of the population, per se. A different approach was, therefore, adopted for assessing the collective dose from this pathway. The collective dose from ingestion was estimated as the sum over all

[1] The Committee has used the quantity, collective (effective) dose, for many years to compare the radiation exposures of populations from different sources of ionizing radiation, or following different protection measures. The collective (effective) dose is always estimated for a defined population over a specified period of time. It is the product of the mean effective dose to a specified population from a particular source, and the number of people in that population, integrated over a defined period of time. Importantly, calculated doses are recommended only for comparative purposes and not for estimations related to health effects. Collective dose is not intended as a tool for epidemiological risk assessment. Moreover, the aggregation of very low individual doses over extended time periods is inappropriate for use in risk projections and, in particular, the calculation of numbers of cancer deaths from collective doses based on individual doses that are well within the variation in background exposure should be avoided.

[2] In this report, the Committee has used the terms collective effective dose and collective absorbed dose to the thyroid and described them as being for different time periods. This follows the approach used in the UNSCEAR 2013 Report. Strictly, the correct terms are collective effective dose commitment and collective absorbed dose commitment to the thyroid (for the time-integrated quantity), and the descriptions should make clear that the dose commitment (time-integrated) has been truncated at the different time periods. The Committee has retained the same terms as used in the UNSCEAR 2013 Report for ease of comparison with that report and for simplicity, while recognizing that it is not strictly correct.

[3] As well as particular municipalities in Group 3 prefectures, namely Ibaraki, Miyagi, Tochigi and Yamagata Prefectures.

prefectures of the products of the average individual dose from ingestion within a given prefecture and the population of that prefecture. The estimation of individual doses from ingestion is described in attachments A-2 and A-3.

5. For Fukushima Prefecture the average individual dose from ingestion was estimated based on Murakami and Oki [Murakami and Oki, 2014] (see attachments A-2 and A-3) and that in subsequent years on the basis of market surveys and duplicate-diet studies and a model developed by Smith et al. [Smith et al., 2017] for estimating long-term doses in Japan from deposited caesium radionuclides (see attachment A-3).

6. For other prefectures, the average individual doses from ingestion were estimated based on measured levels of radionuclides in food in a given prefecture relative to those in Fukushima Prefecture – with the prefecture average individual dose scaled accordingly. Doses in the first year after the accident were based on an analysis in the UNSCEAR 2013 Report [UNSCEAR, 2014] of an extensive database of measurements of food sampled in 2011 from food markets all over Japan. For ingestion of ^{131}I, for Group 3 prefectures, the average dose ratio was 0.27 and for all other prefectures 0.075. For ingestion of caesium radionuclides over the first year, corresponding ratios were 0.23 and 0.143, respectively [4] [UNSCEAR, 2014]. Doses in subsequent years for ingestion of caesium radionuclides were estimated from market survey and duplicate-diet studies carried out in a number of prefectures and the model of Smith et al. [Smith et al., 2017]. For Group 3 prefectures, the average ratio was 0.75 and for all other prefectures the average ratio was 0.33 (see attachment A-3).

7. Collective doses to the Japanese population are summarized by exposure pathway, prefecture group and age group for the first year after the accident at FDNPS in table A-20.1 and for 80 years after the accident in table A-20.2.

[4] See appendix C and attachment C-15 of the UNSCEAR 2013 Report [UNSCEAR, 2014].

Table A-20.1. Collective doses to the Japanese population in the first year after the accident at the Fukushima Daiichi Nuclear Power Station [a]

Exposure pathway	*Prefecture/s*	*Collective absorbed dose to thyroid (man Gy)*				*Collective effective dose (man Sv)*			
		Adults	*6–15 years*	*0–5 years*	*Total*	*Adults*	*6–15 years*	*0–5 years*	*Total*
Inhalation	Group 1: Evacuated locations	250	39	33	320	16	2.4	1.9	21
	Group 2: Fukushima [b]	2 400	430	320	3 200	120	20	14	150
	Group 3: Some neighbouring [c]	430	78	49	560	25	4.3	3.2	32
	Group 4: All others	1 200	230	180	1 700	38	13	9.2	60
	All	4 300	800	600	5 700	200	39	28	270
Ingestion	Group 1: Evacuated locations	96	23	21	140	3.9	0.9	0.9	5.7
	Group 2: Fukushima [b]	720	170	130	1 000	60	9.1	6.3	76
	Group 3: Some neighbouring [c]	830	200	150	1 200	64	10	7.1	82
	Group 4: All others	3 400	780	590	4 700	400	50	31	480
	All	5 000	1 200	900	7 100	530	70	46	640
External dose	Group 1: Evacuated locations	56	6.3	4.5	66	56	6.6	4.6	68
	Group 2: Fukushima [b]	2 200	260	190	2 700	2 200	260	190	2 600
	Group 3: Some neighbouring [c]	2 700	310	230	3 200	2 600	320	200	3 100
	Group 4: All others	4 400	510	370	5 200	4 200	510	400	5 100
	All	9 300	1 100	790	11 000	9 000	1 100	800	11 000
All	All	19 000	3 000	2 300	24 000	9 800	1 200	870	12 000

[a] All doses quoted to two significant figures but this should not be interpreted as a reflection of their precision.
[b] Excluding evacuated locations.
[c] Ibaraki, Miyagi, Tochigi and Yamagata Prefectures.

Table A-20.2. Collective doses to the Japanese population integrated to 80 years after the accident at the Fukushima Daiichi Nuclear Power Station [a]

Exposure pathway	*Prefecture/s*	*Collective absorbed dose to thyroid (man Gy)*				*Collective effective dose (man Sv)*			
		Adults	*6–15 years*	*0–5 years*	*Total*	*Adults*	*6–15 years*	*0–5 years*	*Total*
Inhalation	Group 1: Evacuated locations	250	39	33	320	16	2.4	1.9	21
	Group 2: Fukushima [b]	2 400	430	320	3 200	120	20	14	150
	Group 3: Some neighbouring [c]	430	78	49	560	25	4.3	3.2	32
	Group 4: All others	1 200	230	180	1 700	38	13	9.2	60
	All	4 300	780	600	5 700	200	39	28	270
Ingestion	Group 1: Evacuated locations	96	23	21	140	3.9	0.9	0.9	5.7
	Group 2: Fukushima [b]	750	170	130	1 100	84	11	7.4	100
	Group 3: Some neighbouring [c]	900	200	160	1 300	140	15	10	170
	Group 4: All others	3 900	810	610	5 300	990	80	51	1 100
	All	5 700	1 200	910	7 800	1 200	110	69	1 400
External dose	Group 1: Evacuated locations	56	6.3	4.5	66	56	6.6	4.6	68
	Group 2: Fukushima [b]	9 100	1 000	710	11 000	8 800	1 000	720	11 000
	Group 3: Some neighbouring [c]	10 000	1 100	780	12 000	9 700	1 100	800	12 000
	Group 4: All others	17 000	1 900	1 300	20 000	17 000	1 900	1 400	20 000
	All	36 000	4 000	2 800	43 000	35 000	4 000	2 900	42 000
All	All [b]	46 000	6 000	4 400	57 000	37 000	4 100	3 000	44 000

[a] All doses quoted to two significant figures but this should not be interpreted as a reflection of their precision.
[b] Excluding evacuated locations.
[c] Ibaraki, Miyagi, Tochigi and Yamagata Prefectures.

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