ATTACHMENT A-22

ESTIMATION OF THYROID DOSES TO EVACUEES FROM INHALATION OF RADIOIODINE AND COMPARISON WITH THOSE DERIVED FROM MEASUREMENTS OF PEOPLE AND ESTIMATED BY OHBA ET AL.

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

Content

This attachment contains an assessment of thyroid doses to evacuees from the inhalation of radioiodine. The doses have been estimated using the methodology described in attachment A-10 for each of the evacuation scenarios specified in attachment A-11. The estimated doses have been compared with those derived from measurements of radioiodine in people (see attachment A-2) and those estimated independently by Ohba et al. [Ohba et al., 2020]. These comparisons were made for the purposes of validating the methodology used by the Committee for assessing doses from inhalation and how it was implemented. Additional analyses were made to provide further insights into uncertainties associated with the Committee's estimates of distributions of doses to evacuees and to identify the origins of differences with those of Ohba et al.

Notes

CONTENTS

I. INTRODUCTION

1. This attachment contains an assessment of thyroid doses to evacuees from the inhalation of radioiodine and its precursors where appropriate (e.g., isotopes of tellurium). The doses have been estimated using the methodology described in attachment A-10 for each of the evacuation scenarios specified in attachment A-11. The estimated doses have been compared with those derived from measurements of radioiodine in people (see attachment A-2) and those estimated independently by Ohba et al. [Ohba et al., 2020]. These comparisons were made for the purposes of validating the methodology used by the Committee for assessing doses from inhalation and how it was implemented. Additional analyses were made to provide further insights into uncertainties associated with the Committee's estimates of distributions of doses to evacuees and to identify the origins of differences with those of Ohba et al.

II. EVACUATION SCENARIOS

2. Doses were estimated for 40 groups of evacuees who were evacuated at different times and moved to different locations (see table A-22.1 and for more details see attachment A-11). Doses were estimated separately for the period before and during the evacuation (up to 25 March 2011) and were based on atmospheric transport, dispersion and deposition modelling (ATDM) of radionuclide concentrations in air and deposition densities in the days following the accident provided by Terada et al. [Terada et al., 2020] (see attachment A-9).

3. In 2011 prefectural authorities issued a questionnaire to all residents within Fukushima Prefecture (two million people) to ascertain their activities and, specifically, their locations and movements during and after the accident. Approximately 21% of the population completed the questionnaire. The National Institute for Radiological Science (NIRS) used the results of this survey to define 18 scenarios representative of the movements of residents within a few tens of kilometres of the Fukushima Daiichi Nuclear Power Station (FDNPS), following the accident [Akahane, 2013]. In the UNSCEAR 2013 Report [UNSCEAR, 2014], these 18 evacuation scenarios were used to estimate doses to evacuees.

4. Ohba et al. [Ohba et al., 2020] refined these evacuation scenarios by conducting a hierarchical clustering analysis of 100 to 300 randomly sampled behavioural questionnaires of children from each of the seven municipalities in the evacuation area. This resulted in 37 new representative evacuation scenarios; these have been used for the updated assessment of doses to evacuees from evacuated localities, as outlined in table A-22.1 (No. 1 to No. 37) and in attachment A-11. These 37 new evacuation scenarios did not include evacuees from Hirono Town and Katsurao Village; the Committee, therefore, included three of the original 18 evacuation scenarios to represent evacuees from these two locations (resulting in 40 evacuation scenarios in total, see table A-22.1 (No. 38 to No. 40).

5. The methodology for assessing doses to evacuees from the plume of airborne radionuclides for these scenarios is described in attachment A-10, and the scenarios themselves in attachment A-11. The resulting doses (from all pathways and radionuclides and to each of the three age groups considered) can be found in attachment A-18. The focus of the remainder of this attachment is doses to the thyroid of evacuees from inhalation of radioiodine (and its precursors where relevant), in particular by 1-year-old infants, and on comparisons with the estimates presented by [Ohba et al., 2020].

Table A-22.1. Evacuation scenarios considered in the dose assessment (inhalation doses received or committed between 11–25 March)

Scenario	*Location at 11 March 2011*	*Start > Route > Destination*	*Evacuation start time*[a,b]
01(FT1)	Futaba Town	Futaba > Kawamata > OOP[c]	AM2 on 12 March
02(FT2)	Futaba Town	Futaba > Iwaki > OOP	PM1 on 12 March
03(FT3)	Futaba Town	Futaba > Odaka > Fukushima > OOP	AM2 on 12 March
04(FT4)	Futaba Town	Futaba > Haramachi> Koriyama	PM2 on 12 March
05(FT5)	Futaba Town	Futaba > Namie > Kawamata > OOP	PM1 on 12 March
06(TM1)	Tomioka Town and Kawauchi Village	Kawauchi > OOP	PM2 on 15 March
07(TM2)	Tomioka Town	Tomioka > Ono > OOP	PM1 on 12 March
08(TM3)	Tomioka Town	Tomioka > Kawauchi > Koriyama > OOP	AM2 on 12 March
09(TM4)	Tomioka Town	Tomioka > Iwaki	PM1 on 12 March
10(NR1)	Naraha Town	Naraha > Iwaki > OOP	AM2 on 12 March
11(NR2)	Naraha Town	Naraha > Iwaki > OOP	AM2 on 12 March
12(NR3)	Naraha Town	Naraha > Iwaki	AM2 on 12 March
13(NR4)	Naraha Town	Naraha > Hirono > Aizu District > OOP	AM2 on 12 March
14(NR5)	Naraha Town	Naraha > Iwaki > OOP > Iwaki	AM2 on 12 March
15(OK1)	Okuma Town	Okuma > Tamura > Aizu district	PM1 on 12 March
16(OK2)	Okuma Town	Okuma > Tamura	AM2 on 12 March
17(OK3)	Okuma Town and Futaba Town[d]	Futaba > Kawamata > Iwaki > OOP	AM2 on 12 March
18(OK4)	Okuma Town and Tamura City[d]	Tamura	(no further evacuation)
19(OK5)	Okuma Town	Odaka > Haramachi > Sukagawa > OOP	AM1 on 12 March
20(NM1)	Namie Town	Namie > Haramachi > OOP	AM2 on 12 March
21(NM2)	Namie Town	Namie > Soma	PM1 on 12 March
22(NM3)	Namie Town	Namie > Tsushima > Koriyama	AM2 on 12 March
23(NM4)	Namie and Tsushima[d]	Tsushima > Nihonmatsu	AM2 on 16 March
24(NM5)	Namie Town	Namie > Kawamata > OOP	AM2 on 13 March
25(IT1)	Iitate Village	Iitate > Koriyama	AM2 on 16 March
26(IT2)	Iitate Village	Iitate > Kawamata > Fukushima > Aizu district	AM2 on 15 March
27(IT3)	Iitate Village	Iitate > OOP	AM2 on 19 March
28(IT4)	Iitate Village	Iitate	22 June
29(OD1)	Odaka ward of Minamisoma City	Odaka > Haramachi > Iwaki > OOP	PM2 on 12 March
30(OD2)	Odaka ward of Minamisoma City	Odaka > Kawamata > Aizu District > OOP	PM1 on 12 March
31(OD3)	Haramachi ward of Minamisoma City	Haramachi > Date > Haramachi > OOP	AM2 on 12 March
32(OD4)	Odaka ward of Minamisoma City	Odaka > Haramachi > Fukushima > OOP	PM2 on 12 March
33(OD5)	Odaka ward of Minamisoma City	Odaka > Haramachi > Soma > OOP	PM1 on 12 March
34(HK1)	Haramachi ward of Minamisoma City	Haramachi > Fukushima > OOP	PM1 on 17 March
35(HK2)	Iitate Village	Iitate > Koriyama > OOP	AM1 on 12 March
36(HK3)	Kashima ward of Minamisoma City	Kashima > Haramachi > Iitate > OOP	AM2 on 12 March
37(HK4)	Haramachi ward of Minamisoma City	Haramachi > Soma	PM1 on 18 March
38 (10[e])	Hirono Town	Hirono Town > Ono Town Office	12 March
39 (12[e])	Katsurao Village	Katsurao Village > Azuma Gymnasium	14 March
40 (14[e])	Katsurao Village Office	Katsurao Village > Azuma General Gymnasium	21 March

[a] AM1, AM2, PM1, PM2 refer to early morning, late morning, early afternoon and late afternoon, respectively.
[b] The focus of Ohba et al. [Ohba et al., 2020] was on evacuation before 26 March 2011. The timings of later evacuations (in particular, of the municipalities of Iitate Village and parts of Tamura City in May and June 2011) are as set out in the UNSCEAR 2013 Report.
[c] OOP denotes out of prefecture and indicates that the destination was a prefecture other than Fukushima Prefecture.
[d] In these scenarios, people were evacuated from the first named location to the second named location on the day of the earthquake (11 March 2011).
[e] Number in brackets corresponds to the number of the evacuation scenario in the UNSCEAR 2013 Report [UNSCEAR, 2014].

III. COMPARISONS WITH OHBA ET AL. [OHBA ET AL., 2020]

6. Ohba et al. [Ohba et al., 2020] used estimates of air concentrations of radioiodine from the ATDM results of Terada et al. [Terada et al., 2020] in their assessment of doses to evacuees, and made similar assumptions about the dose coefficients for intakes of radioiodine and of the reduction in doses due to sheltering inside buildings as have been used in the Committee's assessment. Table A-22.2 provides a summary of the main similarities and differences between the modelling approaches used by the Committee and Ohba et al. [Ohba et al., 2020].

Table A-22.2. Main differences in the modelling approaches used by the Committee and Ohba et al. [Ohba et al., 2020] for estimating inhalation doses to evacuees

The Committee's assessment	*Ohba et al. (2020)*	*Effect on the estimated thyroid doses from inhalation*
Spatial resolution		
Concentrations of radionuclides in air were derived from the full 1 × 1 km grid of the ATDM local model [Terada et al., 2020], i.e., from about 35 000 grid cells	Concentrations of radionuclides in air were derived from nearest of 152 landmarks, for which ATDM results [Terada et al., 2020] were provided	Could have some influence in areas with strong gradient of air concentration
Time resolution		
<u>Basic data:</u> Concentrations of radionuclides in air were derived from the full 1-hour time grid of the ATDM local model [Terada et al., 2020] <u>Evacuation routes:</u> If evacuation was assumed for a 6-hour-segment, the evacuation route was modelled as a straight line connecting the start point and the end point, and a linear movement along this route was assumed during the 6 hours (i.e., it was assumed that the evacuation started at the beginning of the 6-hour-segment, the destination was reached at the end of that period and that exposure during evacuation only occurred while the plume was estimated to have been present along the evacuation route)	<u>Basic data:</u> Concentrations of radionuclides in air were derived from averaging over 6-hour-segments based on the full 1-hour time grid of the ATDM local model [Terada et al., 2020] <u>Evacuation routes:</u> Not clear from the publication how exactly modelling was performed during the evacuation itself. It is possible that the air concentration at the starting point of evacuation was applied for the full 6-hour-segment, during which evacuation was assumed	The differences in how the exposure was estimated during the evacuation could have a significant effect, in particular where the plume arrived during the 6-hour-segment assumed for when the evacuation occurred: in these cases the Committee's dose estimates would be lower than those of [Ohba et al., 2020] due to the latter averaging over the full 6 hours. This is the case for e.g., scenarios FT1, OK2, OD2, NM1, HK4 (as indicated by (b) in the last column of table A-22.5)
Reduction factor		
A dose reduction factor of 0.5 was applied only for those 6-hour-segments, in which people remained at the same location throughout (to take account of staying indoors and the filtering effect of buildings). But for those 6-hour-segments, in which people were evacuated and for the 6-hour-segment immediately before evacuation no shielding (i.e., a reduction factor of 1.0) was applied (as the Committee assumed that people would wait outdoors before evacuation and also assumed that the shielding effect during transportation would be negligible)	A generic dose reduction factor of 0.5, relative to that outdoors, was applied to take account of time spent indoors before, and/or in vehicles during evacuation	The differences in the application of reduction factors during and before evacuation can lead to a difference of up to 50% in estimated doses, if a significant contribution to the total dose occurred during and before evacuation. Scenarios where a significant dose contribution (i.e., >50%) occurred before and/or during evacuation result in doses higher than those estimated by [Ohba et al., 2020] (due to the assumption of no dose reduction during evacuation) include e.g., FT2, IT1, OD1 and OD4 (as indicated by (a) in the last column of table A-22.5)

The Committee's assessment	*Ohba et al. (2020)*	*Effect on the estimated thyroid doses from inhalation*
Dose coefficients		
Japan-specific dose coefficients for inhalation of radioiodine were adopted (see attachment A-2); these range from 0.45–0.57 of the ICRP values for ^{131}I for 1-year-old infants (the range varying with the chemical form of iodine, the isotope and the age group)	Dose coefficients from ICRP publication 71 [ICRP, 1995, Publication 71] were reduced by a generic factor of 0.62 to take account of a Japan-specific diet	The differences in dose coefficients are small and would not greatly affect comparisons between the respective dose estimates
Contribution of short-lived radionuclides		
For each of the 35 000 cells of the ATDM grid the contribution of short-lived radionuclides was assessed for each 1-hour time step (based on the ATDM results for ^{132}Te and an assumed ratio of ^{133}I/^{131}I in air of 1.1 at 12:00 on 12 March). The contribution of short-lived radionuclides to the dose to the thyroid were in the range of 2 to 50% of those from ^{131}I, varying with plume arrival time/s	The contributions of short-lived radionuclides to the dose to the thyroid were 59% of those from ^{131}I for exposure to plumes on the 12–13 March 2011 and 8% for those on 15–16 March 2011	The contributions of short-lived radionuclides are broadly comparable: but some small differences in estimated doses may have occurred at locations where [Ohba et al., 2020] assumed a higher contribution of 59% (i.e., for Futaba, Namie and Odaka scenarios) relative to that assumed by the Committee

7. A comparison of the Committee's dose estimates with those of Ohba et al. [Ohba et al., 2020] therefore provides a good quality check on the Committee's estimates. However, some caution is warranted in making such comparisons. In deriving their distributions of doses, Ohba et al. have taken account of the individual variability of behaviour, based on the sampled questionnaire results, as well as uncertainties in dose coefficients and dose reduction factors, but not in the air concentration estimates derived using ATDM. The Committee, on the other hand, has not taken account of individual variability of behaviour (as it did not have access to the questionnaire results), but has taken account of uncertainties in air concentrations derived using ATDM, as well as in other factors, including dose coefficients and dose reduction factors (see attachment A-12 for further details). Parameters of the dose distributions (medians, percentiles) presented by Ohba et al. are therefore not strictly comparable with equivalent parameters of the dose distributions derived by the Committee, although comparisons of average doses are valid. Nevertheless, because many of the detailed results of Ohba et al. are presented in terms of medians, median dose estimates are also compared in section IV below, although the limitations of the comparisons should be noted.

8. Table A-22.3 provides a comparison between the average thyroid doses to evacuees from inhalation of ^{131}I[1] estimated by the Committee and those estimated by Ohba et al. [Ohba et al., 2020]. Because Ohba et al. only presents average (as opposed to median) doses for each evacuated locality, and not for each scenario, the doses are the averages over all scenarios relevant to each locality. For all localities, the results are consistent, with the Committee's estimates within the uncertainty intervals of the Ohba et al. results. The largest difference is for Odaka ward, where the average doses differ by a factor of 1.6. This difference is mainly caused by differences for scenario OD4, which dominates the average dose for Odaka ward (as it represents 71.5% of all evacuees from Odaka ward). In scenario OD4, a significant contribution (i.e., >50%) to the total inhalation dose occurred before and/or during evacuation (see table A-22.4 below). Ohba et al. assumed a reduction factor of 0.5 relative to the inhalation dose "outdoors" to take account of being indoors before, and/or in a vehicle during, evacuation; in the Committee's estimates, no reduction was assumed.

[1] The average doses from inhalation of radioiodine (and precursors) as a whole estimated by the Committee and Ohba et al. showed similar agreement.

9. The good agreement (within the uncertainties) between the Committee’s estimates of mean doses to the thyroid from inhalation of radioiodine and those of Ohba et al. is not surprising, given that both used largely comparable methodologies and input data. However, this good agreement provides a quality check on the methodology used by the Committee to estimate doses from inhalation or radionuclides and how it has been implemented.

10. The doses estimated by the Committee from inhalation of ^{131}I by evacuees have also been compared with doses derived from measurements of the thyroids of evacuees (see attachment A-2). The broad agreement, within their respective uncertainties, between the two estimates provides further validation of the methodology used by the Committee and how it has been implemented.

Table A-22.3. Comparison of the Committee’s estimates of mean absorbed doses (via inhalation of ^{131}I) to the thyroid of 1-year-old evacuees from localities within Fukushima Prefecture with those of Ohba et al. [Ohba et al., 2020]

Municipality	*Mean absorbed dose to the thyroid from inhalation of ^{131}I (mGy)*							
	Futaba Town	*Tomioka Town*	*Naraha Town*	*Okuma Town*	*Namie Town*	*Odaka ward (Minamisoma City)*	*Haramachi/ Kashima wards (Minamisoma City)*	*Iitate Village*
Committee’s estimates	2.7	1.3	2.0	2.9	3.9	16.1	4.2	4.1
Ohba et al.	3.6 (0.9, 7.5)	1.1 (0.3, 2.3)	2.1 (0.5, 4.4)	2.1 (0.5, 4.3)	4.0 (1.0, 8.4)	9.8 (2.4, 21)	4.7 (1.2, 9.9)	4.0 (1.0, 8.5)

IV. FURTHER, MORE DETAILED ANALYSIS

11. To provide some further insight into uncertainties associated with the Committee’s estimates of doses to evacuees and differences with those of Ohba et al., additional analyses and comparisons have been made for each evacuation scenario, while recognizing that the respective medians and other percentiles being used for the comparison are of very different distributions (see paragraph 7).

12. The Committee’s estimated absorbed doses (averages and medians of the distribution of doses) to the thyroid of a 1-year-old infant from inhalation of radioiodine in air in the period 11 to 25 March 2011 are summarized in table A-22.4.

13. The percentages of the inhalation dose committed before and/or during evacuation are also presented in table A-22.4; the remaining percentage was received at the evacuation destination up to 25 March 2011. For nine of the evacuation scenarios this percentage is more than 50%, but needs to be qualified as follows:

- Firstly, the estimated doses may be strongly influenced by the assumptions on protective measures implemented before and/or during the evacuation as well as at the final destination (i.e., sheltering, shielding while travelling inside vehicles, etc.);
- Secondly, the estimated doses may be strongly influenced by the assumptions about the exact timing of the evacuations, in particular when they began.

Table A-22.4. Estimated average and median absorbed doses from the inhalation of radioiodine to the thyroids of 1-year-old evacuees from localities within Fukushima Prefecture

The doses tabulated are average and median values for each evacuation scenario and comprise doses received or committed before and during evacuation and at the final destination up to 25 March 2011

Scenario	*Start > Route > Destination*	*Absorbed dose in the thyroid (mGy)*		*Percentage of dose received before and during evacuation (%)*
		Average	*Median*	
01(FT1)	Futaba > Kawamata > OOP	1.1	0.4	3
02(FT2)	Futaba > Iwaki > OOP	12.1	3.8	83
03(FT3)	Futaba > Odaka > Fukushima > OOP	7.6	2.1	13
04(FT4)	Futaba > Haramachi> Koriyama	9.8	3.7	63
05(FT5)	Futaba > Namie > Kawamata > OOP	0.5	0.2	63
06(TM1)	Kawauchi > OOP	0.0	0.0	0
07(TM2)	Tomioka > Ono > OOP	1.6	0.7	2
08(TM3)	Tomioka > Kawauchi > Koriyama > OOP	1.2	0.5	21
09(TM4)	Tomioka > Iwaki	7.6	3.2	0
10(NR1)	Naraha > Iwaki > OOP	0.9	0.3	5
11(NR2)	Naraha > Iwaki > OOP	3.3	1.3	0
12(NR3)	Naraha > Iwaki	7.7	3.2	0
13(NR4)	Naraha > Hirono > Aizu District > OOP	0.3	0.1	2
14(NR5)	Naraha > Iwaki > OOP > Iwaki	4.5	1.9	3
15(OK1)	Okuma > Tamura > Aizu District	3.1	1.0	58
16(OK2)	Okuma > Tamura	3.6	1.2	53
17(OK3)	Futaba > Kawamata > Iwaki > OOP	2.7	1.1	9
18(OK4)	Tamura	0.8	0.3	0
19(OK5)	Odaka > Haramachi > Sukagawa > OOP	4.3	1.7	33
20(NM1)	Namie > Haramachi > OOP	3.3	1.4	0
21(NM2)	Namie > Soma	10.9	4.4	1
22(NM3)	Namie > Tsushima > Koriyama	1.0	0.4	83
23(NM4)	Tsushima > Nihonmatsu	6.9	2.7	43
24(NM5)	Namie > Kawamata > OOP	10.2	3.0	1
25(IT1)	Iitate > Koriyama	7.9	3.2	93
26(IT2)	Iitate > Kawamata > Fukushima > Aizu District	0.3	0.1	25
27(IT3)	Iitate > OOP	3.2	1.3	0
28(IT4)	Iitate	4.0	1.6	0
29(OD1)	Odaka > Haramachi > Iwaki > OOP	25.7	10.1	81
30(OD2)	Odaka > Kawamata > Aizu District > OOP	0.1	0.0	37
31(OD3)	Haramachi > Date > Haramachi > OOP	0.2	0.1	4
32(OD4)	Odaka > Haramachi > Fukushima > OOP	18.9	7.4	97
33(OD5)	Odaka > Haramachi > Soma > OOP	10.7	4.3	16
34(HK1)	Haramachi > Fukushima > OOP	3.3	1.3	1
35(HK2)	Iitate > Koriyama > OOP	0.5	0.2	0

Scenario	*Start > Route > Destination*	*Absorbed dose in the thyroid (mGy)*		*Percentage of dose received before and during evacuation (%)*
		Average	*Median*	
36(HK3)	Kashima > Haramachi > Iitate > OOP	7.6	3.1	0
37(HK4)	Haramachi > Soma	13.7	5.6	27
38(10)[a]	Hirono Town > Ono Town Office	1.2	0.5	-
39(12)[a]	Katsurao Village > Azuma Gymnasium	0.2	0.1	-
40(14)[a]	Katsurao Village > Azuma General Gymnasium	7.3	2.8	-

[a] Number in bracket corresponds to number of evacuation scenario in UNSCEAR 2013 Report [UNSCEAR, 2014].

14. For some evacuation scenarios the estimated doses are very strongly influenced by the exact timing of evacuation assumed in the model. The influence of this parameter was evaluated by comparing the following doses:

(a) Doses estimated for the evacuation patterns described by [Ohba et al., 2020] for each scenario (i.e., assuming that the evacuation started exactly at the beginning of the 6-hour-period during which evacuation was estimated to have occurred – this was the assumption adopted by the Committee in its assessment of doses presented in this attachment and elsewhere in its update of the UNSCEAR 2013 Report); and

(b) Doses estimated with an evacuation pattern shifted by +6 hours (i.e., assuming that the evacuation started exactly at the end of the 6-hour period during which evacuation was estimated to have occurred).

15. Doses for these two assumptions are shown in table A-22.5 and the extent to which they differ varies greatly between the evacuation scenarios. For 5 of the scenarios, the doses increased by more than a factor of 2 if the evacuation occurred at the end rather than the beginning of the period when evacuation was estimated to have occurred (i.e., 6 hours later); e.g., for scenario FT4 the estimated median dose increased from 3.7 mGy to about 14 mGy assuming the evacuation to have occurred at the end rather than the beginning of the period. Uncertainty in the exact time at which evacuation actually began may, therefore, result in large uncertainties in the estimated doses for some scenarios.

16. The estimated doses are medians or averages (for 1-year-old infants) for groups of evacuees who followed similar evacuation routes. There will have been considerable variation about these values for individuals depending on various factors (e.g., their behaviour before evacuation, when they began to evacuate, mode and duration of evacuation, etc.). Taking account of this variability and uncertainties in ATDM, individual doses have been estimated to range from about 10 times higher to 11 times lower than the median dose (at the 5th and 95th percentiles) when averaged over all 40 evacuation scenarios. For the small number of hospital and nursing-home patients and other individuals in the 20-km zone for whom the 40 evacuation scenarios were not representative, higher doses may have been received.

17. Selected parameters of the distributions of thyroid doses to evacuees from inhalation of radioiodine estimated by the Committee are presented in table A-22.5 and a comparison is made with the median doses estimated by Ohba et al. [Ohba et al., 2020]. As has been noted, the respective medians represent medians of different (and in many respects not directly comparable) distributions. The doses estimated by the Committee are broadly consistent with those of Ohba et al. when account is taken of their respective uncertainties and the different meaning of median values. A trend can be observed that the median doses estimated by the Committee are systematically lower than the median values estimated by Ohba et al.; this can be explained by

the fact that the uncertainty distributions estimated by the Committee are wider than the dose distributions of Ohba et al. For 3 of the 37 scenarios (FT5, TM1 and OD2) the median doses estimated by Ohba et al. fall outside the uncertainty interval (5th–95th percentile) of the Committee's estimates; the origins of these differences are addressed below.

Table A-22.5. Comparison of the Committee's estimates of median absorbed doses (via inhalation) to the thyroid of 1-year-old evacuees from localities within Fukushima Prefecture with those of Ohba et al. [Ohba et al., 2020]

Scenario	*Start > Route > Destination*	*Dose from inhalation of radioiodine (mGy)*					*Comments*
		Committee's estimates				*Ohba et al.*	
		5th percentile	*95th percentile*	*Median*		*Median*	
				*Evacuation at **start** of 6-h-segment*	*Evacuation at **end** of 6-h-segment*		
01(FT1)	Futaba > Kawamata > OOP	0.0	3.9	0.4	0.7	0.4	b
02(FT2)	Futaba > Iwaki > OOP	0.4	43.9	3.8	12.3	4.2	a, b
03(FT3)	Futaba > Odaka > Fukushima > OOP	0.1	30.2	2.1	3.8	7.9	b
04(FT4)	Futaba > Haramachi> Koriyama	0.4	36.5	3.7	14.3	8.8	a, b
05(FT5)	Futaba > Namie > Kawamata > OOP	0.0	2.0	0.2	2.2	9.7	a, b
06(TM1)	Kawauchi > OOP	0.0	0.0	0.0	0.2	0.1	b
07(TM2)	Tomioka > Ono > OOP	0.1	6.0	0.7	0.7	1.6	
08(TM3)	Tomioka > Kawauchi > Koriyama > OOP	0.0	4.4	0.5	0.5	0.5	
09(TM4)	Tomioka > Iwaki	0.3	28.3	3.2	3.2	9.4	
10(NR1)	Naraha > Iwaki > OOP	0.0	3.5	0.3	0.3	0.6	
11(NR2)	Naraha > Iwaki > OOP	0.1	12.5	1.3	1.3	2.8	
12(NR3)	Naraha > Iwaki	0.3	28.0	3.2	3.2	6.4	
13(NR4)	Naraha > Hirono > Aizu District > OOP	0.0	1.0	0.1	0.1	<0.1	
14(NR5)	Naraha > Iwaki > OOP > Iwaki	0.2	16.3	1.9	1.3	4.3	c
15(OK1)	Okuma > Tamura > Aizu District	0.1	12.1	1.0	1.0	2.2	a
16(OK2)	Okuma > Tamura	0.1	13.9	1.2	1.5	1.5	a, b
17(OK3)	Futaba > Kawamata > Iwaki > OOP	0.1	10.2	1.1	1.5	2.9	b
18(OK4)	Tamura	0.0	2.9	0.3	0.3	0.7	
19(OK5)	Odaka > Haramachi > Sukagawa > OOP	0.2	15.8	1.7	3.0	8.2	b
20(NM1)	Namie > Haramachi > OOP	0.1	12.5	1.4	1.6	2.9	b
21(NM2)	Namie > Soma	0.5	40.6	4.4	6.2	21	b
22(NM3)	Namie > Tsushima > Koriyama	0.0	3.6	0.4	0.4	0.3	a
23(NM4)	Tsushima > Nihonmatsu	0.3	26.0	2.7	2.7	5.9	
24(NM5)	Namie > Kawamata > OOP	0.1	41.6	3.0	3.0	11	
25(IT1)	Iitate > Koriyama	0.3	29.5	3.2	3.2	5.2	a

Scenario	*Start > Route > Destination*	*Dose from inhalation of radioiodine (mGy)*					*Comments*
		Committee's estimates				*Ohba et al.*	
		5th percentile	*95th percentile*	*Median*		*Median*	
				*Evacuation at **start** of 6-h-segment*	*Evacuation at **end** of 6-h-segment*		
26(IT2)	Iitate > Kawamata > Fukushima > Aizu District	0.0	1.0	0.1	0.1	0.2	
27(IT3)	Iitate > OOP	0.1	12.0	1.3	1.3	5.3	
28(IT4)	Iitate	0.2	14.8	1.6	1.6	6.1	
29(OD1)	Odaka > Haramachi > Iwaki > OOP	1.0	96.6	10.1	10.0	15	
30(OD2)	Odaka > Kawamata > Aizu District > OOP	0.0	0.5	0.0	0.3	8.2	b
31(OD3)	Haramachi > Date > Haramachi > OOP	0.0	0.6	0.1	0.1	<0.1	
32(OD4)	Odaka > Haramachi > Fukushima > OOP	0.7	71.6	7.4	7.5	10	a
33(OD5)	Odaka > Haramachi > Soma > OOP	0.4	39.7	4.3	6.6	20	b
34(HK1)	Haramachi > Fukushima > OOP	0.1	12.2	1.3	1.4	3	
35(HK2)	Iitate > Koriyama > OOP	0.0	1.8	0.2	0.2	0.4	
36(HK3)	Kashima > Haramachi > Iitate > OOP	0.3	28.1	3.1	3.1	9.6	
37(HK4)	Haramachi > Soma	0.6	50.9	5.6	6.2	22	b

Comments:
a – More than 50% of inhalation dose estimated to have occurred before and/or during evacuation.
b – Increase of inhalation dose if evacuation occurred at the end rather than the beginning of the period when evacuation was estimated to have occurred (i.e., 6 hours later).
c – Decrease of inhalation dose if evacuation occurred at the end rather than the beginning of the period when evacuation was estimated to have occurred (i.e., 6 hours later).

18. Differences in the doses estimated by the Committee and those of [Ohba et al., 2020] have resulted from differences in the modelling approaches adopted (see table A-22.2 for more detail):

– For the evacuation scenarios FT2, FT4, FT5, OK1, OK2, NM3, IT1, OD1 and OD4 a significant contribution (i.e., >50%) to the total inhalation dose occurred before and/or during evacuation (see table A-22.4). Ohba et al. [Ohba et al., 2020] assumed a reduction factor of 0.5 relative to the inhalation dose "outdoors" to take account of being indoors before, and/or in a vehicle during, evacuation; in the Committee's estimates, no reduction was assumed (i.e., evacuees assumed to be outdoors before evacuation and any reduction in doses during transportation assumed to be negligible). These different modelling assumptions would result in the doses estimated [Ohba et al., 2020] being lower than those estimated by the Committee by up to 50%;

– For the evacuation scenarios FT5 and OD2 the plume was estimated to have arrived at some time during the 6-hour period when evacuation was assumed to have occurred. In such cases the Committee's modelling approach resulted in lower doses than those estimated by [Ohba et al., 2020]. Ohba et al. assigned the average dose during the full 6-hour-segment to the evacuees, whereas the Committee assigned only the dose received from the estimated arrival of the plume till the evacuees reached their destination at the end of the 6-hour period (i.e., evacuation was assumed in all cases to start at the beginning of a 6-hour-segment (i.e., before plume arrival in these cases));

– For the evacuation scenarios FT1, FT2, FT3, FT4, FT5, TM1, OK5, OD2, OD5 and NM2 the estimated doses were strongly influenced by the exact timing of the evacuation assumed in the model (see table A-22.5). Changing the assumed time of evacuation from the start to the end of the 6-hour period of evacuation would have resulted in significant increases in the Committee’s estimates of median doses, e.g., from 3.8 to 12.3 mGy for FT2, from 3.7 to 14.3 mGy for FT2, and from 4.3 to 6.6 mGy for OD5.

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