Annex XI of Technical Volume 4
RISK ASSESSMENTS FOR WORKERS AND THE POPULATION FOLLOWING THE CHERNOBYL ACCIDENT

XI–1. EMERGENCY WORKERS

The doses received by emergency workers at the Fukushima Daiichi NPP were much lower than those of the Chernobyl emergency workers (referred to as 'liquidators') and there is no evidence of an increased risk for Chernobyl workers below an equivalent dose of 150 mGy, so the inferred risks are expected to be small. Nevertheless, it is useful to adopt a similar modelling approach. The main estimates of radiation risks for the cohort of Chernobyl emergency workers who received moderate doses are in good quantitative agreement with the results for atomic bomb survivors [XI–1, XI–2] if the linear non-threshold (LNT) model is used. The minimum latency period for radiation related solid cancers in the Russian cohort was estimated as four years [XI–3]. No statistically significant relationship was found between the thyroid cancer incidence and external radiation for the Russian cohort of liquidators [XI–4].

Both linear (LNT) and linear quadratic models were used, and the difference in the goodness of fit was found to be statistically insignificant. Non-parametric estimates were also obtained using dose groups, and these showed no direct evidence of radiation risks for doses less than 150 mGy. For solid cancer mortality in the Russian cohort of liquidators, the non-parametric risk assessments showed statistically significant radiation risk for whole body doses higher than 150 mGy — dose group 2 (Fig. XI–1) [XI–5].

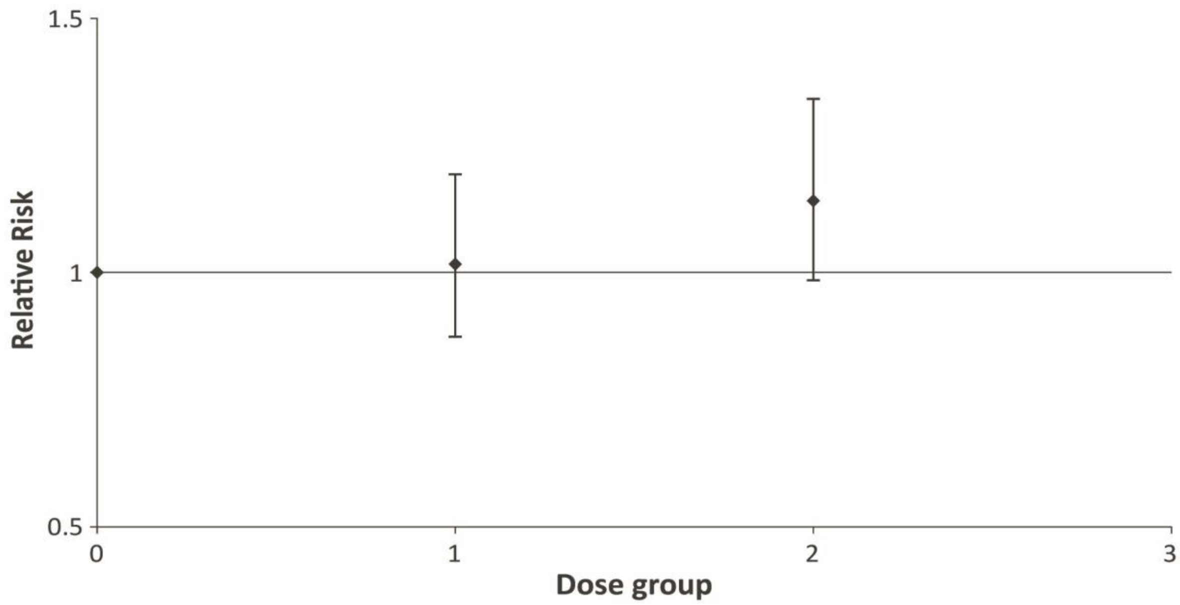

FIG. XI–1. Estimates of relative risk (RR) of death from solid cancers by dose groups (cited from the cohort study [XI–5], Figure 9). Points: RR = 1.01 for the mean dose 94.3 mGy and RR = 1.14 for the mean dose of 210 mGy; the vertical lines represent 95% confidence intervals; the horizontal solid line represents the control level RR = 1. Dose groups: 0 — control group (0–50 mGy]; 1 — (50–150 mGy); 2 — (>150 mGy).

For leukaemia, excluding chronic lymphocytic leukaemia (CLL), in the Russian cohort of liquidators the non-parametric risk assessments also demonstrated statistically significant radiation risks for whole body doses higher than 150 mGy for the follow-up period 1986-1997 (Table XI–1) [XI–6]. This significance did not persist when analysed over the period 1986-2007.

TABLE XI–1. RELATIVE RISK (RR) OF LEUKAEMIA FOR THE STUDIED COHORT (CLL EXCLUDED)*

Follow-up period	Dose group, mGy	Mean dose, mGy	Number of cases	Person-years	RR	90% CI
1986–2007	0–50	15.2	41	517 457	1.00	—
	50–150	91.6	30	454 277	0.75	(0.50; 1.33)
	150–500	210.5	40	407 846	1.10	(0.76; 1.60)
1986–1997	0–50	11.9	17	338 576	1.00	—
	50–150	91.8	9	243 186	0.71	(0.35; 1.44)
	150–500	210.5	25	226 256	1.90	(1.11; 3.25)
1998–2007	0–50	21.6	24	178 881	1.00	—
	50–150	91.3	21	211 091	0.76	(0.47; 1.25)
	150–500	210.6	15	181 590	0.62	(0.36; 1.07)

* Cited from Ref. [XI–6], Table 4 (CLL: chronic lymphocytic leukaemia).

For all haematological malignancies among Belarusian, Russian and Baltic liquidators, the non-parametric risk assessments in dose groups gave statistically significant radiation risks for doses to the bone marrow above 200 mGy [XI–7].

For thyroid cancer among Belarusian, Russian and Baltic liquidators [XI–8] the non-parametric risk assessment in dose groups showed statistically significant radiation risks for thyroid doses above 300 mGy (Fig. XI–2).

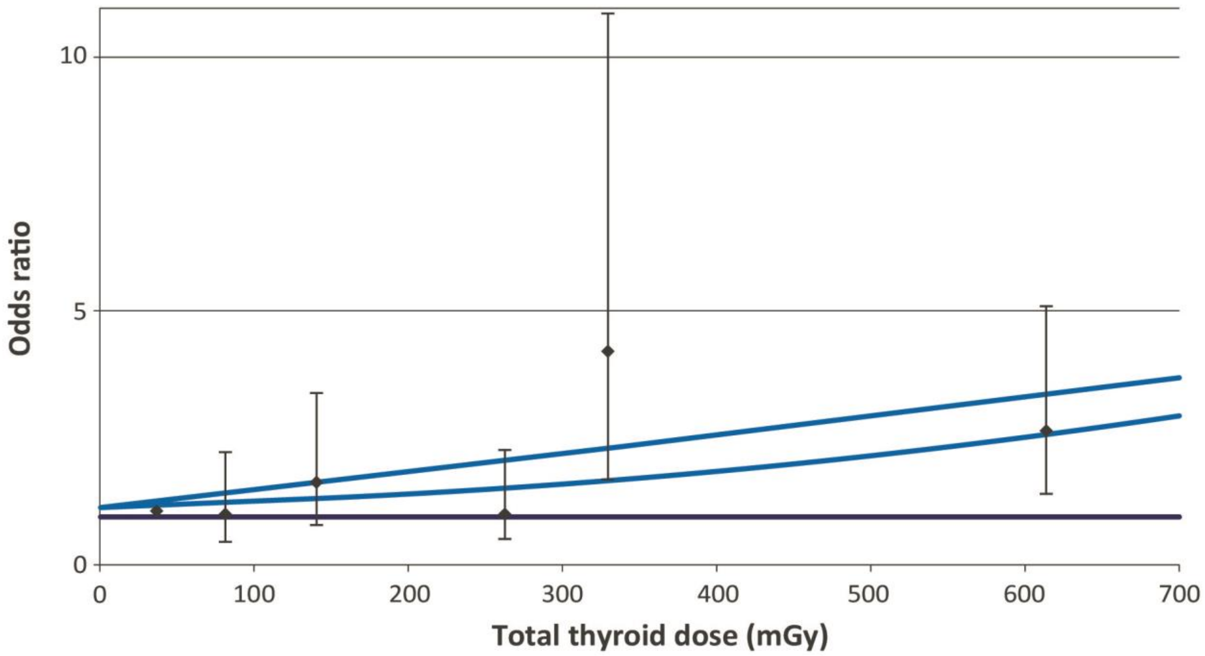

FIG. XI–2. Comparison of the odds ratios (OR) estimated by linear and quadratic risk models with the odds ratios estimated in six dose categories (cited from the nested case-control study [XI–9]).

XI–2. THE GENERAL POPULATION

The main stochastic effect after the Chernobyl accident was the elevated risk of thyroid cancer among children and adolescents. In the Russian Federation, for thyroid cancer among children and adolescents, the non-parametric risk assessment in different dose groups showed statistically significant radiation risks for thyroid doses higher than 250 mGy (Table XI–2) [XI–10, XI–11].

TABLE XI–2. ESTIMATES OF RELATIVE RISK (RR) OF THYROID CANCER INCIDENCE FOR CHILDREN AND ADOLESCENTS (0–17 YEARS AT THE AGE OF EXPOSURE)*

Dose group, Gy	Mean dose, Gy	Number of cases	Person-years	RR (95% CI)	p-value
0–0.05	0.027	49	288 218	1	—
0.05–0.1	0.072	53	318 536	1.01 (0.68; 1.49)	> 0.5
0.1–0.15	0.124	37	212 491	1.18 (0.77; 1.81)	0.046
0.15–0.2	0.173	18	131 218	0.91 (0.52; 1.53)	> 0.5
0.2–0.25	0.222	18	97 500	1.64 (0.93; 2.76)	0.085
0.25–0.3	0.273	16	75 420	2.15 (1.18; 3.69)	0.013
0.3–0.35	0.324	17	44 432	3.12 (1.75; 5.30)	< 0.001
0.35–0.5	0.418	20	94 791	2.31 (1.35; 3.83)	0.003
> 0.5	0.860	19	107 504	2.40 (1.36; 4.03)	0.002

* cited from Ref. [XI-11], Table 2.

The screening effect due to wide introduction of ultrasound examinations in contaminated areas after the Chernobyl accident led to elevated rates of a thyroid cancer incidence in these areas in comparison with general Russian statistics: by a factor of about four for adults and eight for children and adolescents. As shown in [XI–11], this screening effect is not related to thyroid dose and must be allowed for in risk assessment.

Another radiation related effect after the Chernobyl accident was the elevated rates of some non-cancer thyroid diseases. During the first ten years after exposure, diffuse goitre was found to be related to high radiation doses for young men (less than 25 years old at the time of diagnosis): the odds ratio at 1 Gy for males was 1.36 with 95% CI (1.05, 1.99) [XI–12].

For any future epidemiological studies of the consequences of the Fukushima Daiichi accident, the Chernobyl experience should be taken into account [XI–13], and the effect of age at exposure for thyroid cancer is important [XI–14].

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