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Thyroid cancer among "liquidators" of the Chernobyl accident

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Abstract. In 1986, immediately after the Chernobyl accident, the USSR Ministry of Health adopted a large scale programme of establishing an All-Union Distributed Registry of persons affected by radiation due to the accident. The registry was based at the Medical Radiological Research Centre of the Russian Academy of Medical Sciences (MRRC RAMS). In 1992, when the USSR was dissolved, this registry database contained information on 659 000 persons, including 284 000 Chernobyl accident emergency workers ("liquidators"). Currently, the Russian National Medical Dosimetric Registry (RNMDR) contains data on 435 276 persons, including 167 862 liquidators. This paper reviews the data for 47 verified thyroid cancers in the liquidator subgroup of the RNMDR. Analyses show that there is an excess relative risk of thyroid cancer per Gy of 5.31 (95% confidence intervals 0.04 and 10.58) and an excess absolute risk of thyroid cancer per 10^4 person-years per Gy of 1.15 (95% confidence intervals 0.08 and 2.22).

Introduction

Following the dissolution of the USSR there is no longer a centralized registry of Chernobyl "liquidators" from the nations of the Ukraine, Belarus and Russia and from other former Soviet Socialist Republics. However, the follow-up and analysis of liquidators residing in Russia has continued and this present study is based on the database in the Russian National Medical Dosimetric Registry (RNMDR) for the subgroup of 167 862 liquidators.

Among numerous problems being solved by workers of RMNDR the problem of collection, verification and analysis of information about oncological incidence among liquidators, including thyroid cancer incidence, is one of the most important.

At present, results of a number of studies [1–15] dealing with radiation induced thyroid cancer are available. A short list of these studies is given by Ron et al [1]. The type and level of radiation loads studied in such research are fairly broad. Thus, radiation doses range from approximately 0.1 to tens of Sv [2, 3]. The majority of the studies observes the child population (at the time of exposure). Fewer articles cover the adult population. Examples are Boice et al [4] (women only) and others [5–7] which give a wider age-specific distribution of cohorts under study.

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This paper discusses the cohort of those who participated in the recovery work carried out after the Chernobyl accident, consisting of men who were 32 years of age at the time of exposure and received an external radiation dose within the range 0–0.25 Gy. The study of the cohort of liquidators is of utmost importance because there is little research on the development of radiation-induced thyroid cancer for cohorts with such an age–sex distribution within the above dose range.

Because of this the data for the Chernobyl liquidators are of particular importance but, to date, relatively little work has been published from the RNMDR on radiation risks to exposed populations following the Chernobyl accident [16–20].

Materials and methods

The numbers of liquidators involved in the clean-up work at Chernobyl were 77 663 in 1986, 58 694 in 1987 and 31 565 during 1988–1990 giving a total of 167 862 persons in the RNMDR. Annual medical check-ups are given to all these persons and the data are accrued at 20 regional centres in Russia and then sent to the RNMDR in Obninsk. The accuracy of estimates of external doses received by the liquidators is not high and there may be a factor of uncertainty of 2.5–3.0 [21]. Table 1 gives the distribution of individual doses of 71% of the subgroup which are all that are available. As expected, the highest doses were received in 1986.

The age distribution of the liquidators is given

Table 1. Dose distribution for liquidators by years of arrival in zone

Years of arrival	Number of persons	Dose (mGy)					
		0–49	50–99	100–149	150–199	200–249	>250
1986	46575	18.2%	10.2%	10.1%	20.7%	36.3%	4.5%
1987	48077	24.0%	51.9%	9.7%	8.1%	5.8%	0.6%
1988–1990	24764	87.3%	9.7%	1.3%	0.7%	0.6%	0.4%
1986–1990	119416	34.5%	25.9%	8.1%	11.8%	17.5%	2.2%

in Table 2. The mean age of the liquidators at the time when they worked in the Chernobyl 30 km zone was 33.5 years. Therefore they would normally be expected to have at least a 25 years lifespan ahead of them.

We have estimated the absolute risk coefficient or the excess absolute risk (EAR) per unit dose 1 Gy by [22]

$$\mathrm{EAR} = \frac{O - E \times \alpha}{\mathrm{PY} \times D}$$

where O is the observed number of cases, E is the expected number of cases obtained from national statistics [23], PY is the person-years of observation, D is the external radiation dose in Grays and α is a coefficient which we have used to take into account the in-depth screening of the liquidators. A coefficient for a screening effect has been used previously, for example with the cohort of atomic bomb survivors [1] where the value was 2.4 for females and 3.5 for males.

Following the government decree, liquidators undergo the annual medical examination in the state health institutions. Therefore, all diseases are actively registered. After verification, data about oncological diseases are registered in specialized documents and addressed to RNMDR. Data of the state statistics are formed mainly on the basis of the passive registration (upon visit to a health institution). Consequently, the level of the revealed incidence among liquidators will be higher than that in the referent population (men of Russia with appropriate age-specific distribution). This difference is probably at the basis of the screening effect.

To define a screening rate in the discussed cohort of liquidators, the standardized incidence ratio (SIR, the ratio of observed to expected cases) in the cohort of liquidators and men of Russia for the period 1986–1990 was used. This period of time referred to a latent period preceding the development of radiogenic thyroid cancer, which is equal to approximately 5 years, according to the modern understanding.

Based on the data of Table 3, the SIR is 260%, *i.e.* $\alpha = 2.6$. Reliable intervals for SIR (or α) were calculated according to Breslow and Day [24].

Having relations for EAR and E/PY, incidence rate in the control group (men of Russia), it is not difficult to get a relation for ERR, excess relative risk or the relative risk coefficient is the fractional increase in the baseline incidence for a unit dose [22].

The excess relative risk (ERR) is calculated by

$$\mathrm{ERR} = \frac{\mathrm{EAR} \times \mathrm{PY}}{E \times \alpha}$$

An attributive risk (AR) at 1 Gy (a proportion of radiogenic cancers in cancer incidence of the given localization in an exposed population) is obtained from the ratio:

$$\mathrm{AR} = \frac{\mathrm{ERR}}{1 + \mathrm{ERR}} \cdot 100\%$$

Assessing reliable intervals for EAR and ERR, the method of linearization of a random argument function [25] was used (α was also considered as a random argument with its variance).

Results

By 1 January 1995 a total of 47 thyroid cancers had been diagnosed in the liquidator population. The time interval between working in the Chernobyl 30 km zone and diagnosis of the thyroid cancer was in the range 1–8 years. The histopathologies of the lesions were as follows: 42.8% follicular cancer, 33.3% papillary cancer and 14.3% other types of carcinoma.

Table 2. Age distribution for liquidators with an established external dose by years of arrival in zone

Years of arrival	Age to 1 January 1996								
	<30	30–34	35–39	40–44	45–49	50–54	55–59	60–64	>65
1986	4.7%	13.8%	17.9%	22.0%	26.9%	8.6%	4.8%	0.9%	0.4%
1987	1.8%	7.9%	19.5%	36.6%	27.6%	4.9%	1.2%	0.3%	0.1%
1988–1990	1.6%	2.8%	29.1%	42.2%	20.7%	2.6%	0.7%	0.2%	0.1%
1986–1990	2.9%	9.3%	20.8%	31.7%	25.9%	5.9%	2.6%	0.5%	0.3%

Table 3. Main medico-dosimetric characteristics of EWs used in thyroid cancer incidence

Date of study	1986					1986	1987	1986–1987	1988–1990
	April–May	June	July	August–September	October–December	April–December	January–December	April 1986–Dec. 1987	January—December
Population	19623	9803	10920	20195	17122	77663	58694	136357	31565
Mean age (years)	32	32	34	34	35	33	33	33	34
Mean dose (Gy)	0.16	0.19	0.16	0.17	0.17	0.17	0.10	0.14	0.04
Number of thyroid cancers	8	6	4	6	4	28	15	43	4
Expected number of thyroid cancers	1.32	0.74	0.82	1.60	1.31	5.80	3.64	9.44	1.71
SIR (latent)		371		150		260	260	260	180
(95% CI)		(119, 865)		(16, 542)		(100, 540)	(80, 600)	(134, 452)	(80, 730)
SIR (post-latent)		844		508		670	590	645	330
(95% CI)		(449, 1440)		(218, 1002)		(420, 1030)	(280, 1080)	(438, 915)	(40, 1180)

Histological classification was carried out in a cancer dispensary (the state health institution) which is involved in verification, treatment and collection of information about oncological patients.

Overall, 28 thyroid cancers were detected in the emergency workers of 1986, 15 in emergency workers of 1987 and four those of 1988–1990.

Table 4 gives the age distribution of thyroid cancer in liquidators. It shows that in 33 persons (67.3%) thyroid cancer was detected at 35–49 years of age.

Table 5 gives the thyroid cancer distribution as a function of radiation dose. Liquidators with thyroid cancer have a mean radiation dose of 140 mGy.

Table 3 lists the SIR for various observation periods. We have defined 1986–1990 as the latent period for thyroid cancer and 1991–1994 as the post-latent period. Our control group was taken from standard data by age for Russian males [23].

The liquidators with the highest increased risk are those who worked in the 30 km zone in 1986 and 1987; and of the 1986 liquidators the highest risk was for the period April–July.

Figure 1 shows the incidence of thyroid cancer as a function of time post-accident in 100 000 males. There is a considerable difference between expected and observed results for 4–5 years post-accident. Figure 2 shows the trend of thyroid cancer SIR for those liquidators who were on site 1986–1987. The expected values [22, 26] account for only some 50% of the increased thyroid cancers in what we term the post-latent period.

Table 6 presents radiation risk estimates for the

Table 4. Age distribution of thyroid cancer

Age on discovery of cancer	Number of liquidators
25–29	1
30–34	3
35–39	12
40–44	12
45–49	7
50–54	3
55–59	6
60–64	3
25–64	47

Table 5. Dose distribution of thyroid cancer

Dose (mGy)	0–49	50–99	100–199	200–249	>250
Number of liquidators	11	8	3	3	5
Number of persons	41199	30929	23764	20898	2626

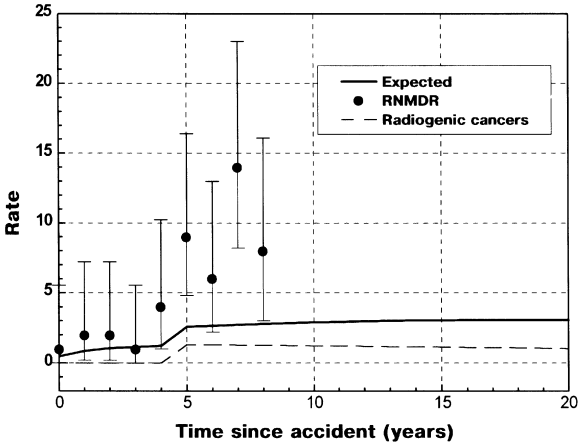

Figure 1. Thyroid cancer incidence rate among emergency workers as a function of time since the accident.

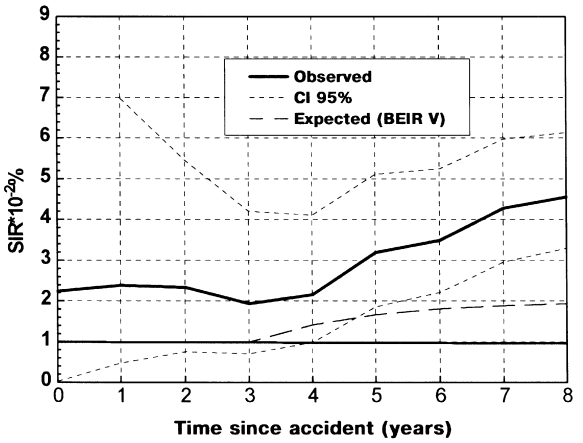

Figure 2. Dynamics of thyroid cancer incidence SIR among emergency workers (1986–1987 workers).

liquidators. It is seen that there is good agreement between our results and BEIR V [22].

Conclusions

We have presented unique information on radiation risk for the liquidators who worked in the Chernobyl 30 km zone and who now reside in Russia. The group reported on here can be considered to be a representative sample of the liquidators. Although the data we have for each individual liquidator are not very accurate in terms of received radiation dose, what is presented is considered to be the best estimate.

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Table 6. Radiation risk of thyroid cancer incidence among EWs (1986–1994 observation period)

Data source	EAR/10^4 PY Gy (95% CI)	ERR/Gy (95% CI)	AR (at 1 Gy)%
EWs	1.15 (0.08, 2.22)	5.31 (0.04, 10.58)	84
BEIR V	1.25	5.8	85

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