Iodine Deficiency in Belarusian Children as a Possible Factor Stimulating the Irradiation of the Thyroid Gland during the Chernobyl Catastrophe

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Ten years after the Chernobyl nuclear plant catastrophe more than 500 children in Belarus are suffering from thyroid cancer. The major cause of the high incidence of thyroid cancer in children under 15 years of age appears to be contamination resulting from that catastrophe, mainly with isotopes of radioactive iodine. Another important factor may be iodine deficiency in the environment. A countrywide program for investigation of goiter prevalence and iodine deficiency has been established in the Republic of Belarus with the assistance of the European World Health Organization office. The program will oversee the examination of 11,000 children and adolescents 6 to 18 years of age from 30 schools in urban and rural areas. The results obtained in a group of 824 children and adolescents (the pilot phase) are typical for significant iodine deficiency and moderate goiter endemism. It is clear that the present situation does not completely reflect the situation that existed at the time of the Chernobyl catastrophe. However, data from epidemiologic studies conducted many years before the accident showed high goiter prevalence in the contaminated aras, indicating that the prevalence of iodine deficiency at the time of the catastrophe was similar to the present one or even greater. Such an assumption could lead to a better understanding of the thyroid pathologies that have been observed. —*Environ Health Perspect* 105(Suppl 6):1487–1490 (1997)

Key words: iodine deficiency, Chernobyl, Belarus, children, thyroid gland, irradiation

Introduction

The accident at Chernobyl, the most serious in the history of the nuclear power industry, occurred on 26 April 1986. Among different radionuclides emitted into the atmosphere during the most critical 10 days of the catastrophe were large quantities of various isotopes of radioactive iodine with half-lives ranging from hours to days. Also present was ^{132}Te.

Meteorological conditions on those days caused the heaviest contamination in the Republic of Belarus. More than 23% of the country and 20% of the population were contaminated.

Among the most serious possible somatic health consequences of the catastrophe is the thyroid cancer occurring in those who were children at the time of the accident (*1–6*).

The relationship between thyroid cancer and external irradiation of the thyroid is well known. However, in Belarusian, Ukrainian, and Russian children the incidence of thyroid cancer began to increase 4 years after irradiation. Moreover, the disease appears to be a very invasive form (*5*) (Tables 1, 2).

This situation has stimulated many efforts to analyze various contributory factors in addition to radioactive isotopes including iodine deficiency in the environment and, as a consequence, in food and drinking water.

Review of Existing Data

Iodine Deficiency in Belarus

The first information on the study of urinary iodine concentration in Belarus comes from several groups of investigators. Before analyzing these data, however, it is worth noting that according to Delange and colleagues (*7*), median urinary iodine excretion in a normal population of school-age children (6–16 years of age) is more than 100 µg/liter, with a range of 85 to 163 µg/liter.

Mityukova et al. (*8*) conducted investigations from 1990 to 1994 on 1680 children from 14 settlements in nine regions of Gomel, Vitebsk, and Minsk Oblasts (*8*). They found a wide range of urinary iodine levels; 163 children had iodine urinary excretion below 20 µg/liter, which is considered severe iodine deficiency according to the World Health Organization (WHO) classification (*9*).

A second source of information is the data obtained by the International Council for Control of Iodine Deficiency Disorders (ICCIDD) team (Gutekunst and Gerasimov), who performed studies from 21 to 24 June 1991 (*10*). They investigated 321 adults and 270 children from the rehabilitation camp in the Gomel region. The children came from the city of

Table 1. Thyroid cancer in children after Chernobyl.

Oblast	Year 1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Brest	0	0	1	1	7	5	17	24	21	76
Vitebsk	0	0	0	0	1	3	2	0	1	7
Gomel	1	2	1	3	14	44	34	36	44	179
Grodno	1	1	1	2	0	2	4	3	5	19
Minsk	0	1	1	1	1	1	4	3	6	18
Mogilev	0	0	0	0	2	2	1	7	4	16
Minsk (city)	0	0	1	0	4	2	4	6	1	18
Belarus	2	4	5	7	29	59	66	79	82	333

Data from Gembicki et al. (*4*). Patients were 3 to 15 years of age at the time of diagnosis.

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Abbreviations used: ICCIDD, International Council for Control of Iodine Deficiency Disorders; WHO, World Health Organization.

Table 2. Incidence of thyroid cancer in Belarusian children from 1986 to 1994, per 100,000.

	Year								
Oblast	1986	1987	1988	1989	1990	1991	1992	1993	1994
Brest	0	0	0.3	0.3	1.7	1.1	4.5	6.7	5.9
Vitebsk	0	0	0	0	0.3	1.0	0.7	0	0.3
Gomel	0.3	0.5	0.5	1.0	3.3	11.3	8.8	9.4	11.7
Grodno	0.4	0.4	0.4	0.8	0	0.8	1.5	1.5	1.8
Minsk	0	0.3	0.3	0.3	0.3	0.3	1.1	1.1	1.6
Mogilev	0	0	0	0	0.7	0.7	0.4	2.4	1.4
Minsk (city)	0	0	0.3	0	1.3	0.5	1.0	1.3	0.5
Belarus	0.1	0.2	0.3	0.3	1.2	2.5	2.8	3.4	3.5

Data from Gembicki et al. (*4*). Patients were 3 to 15 years of age at the time of diagnosis.

Gomel and surrounding regions affected by the Chernobyl accident.

The goiter prevalence in this group was 8.5% in children who had a median urinary iodine excretion of 10.7 µg/liter and 46% in children excreting iodine at levels lower than 10 µg/liter.

Another source of information is the investigation sponsored by the Sasakawa Health Foundation and conducted in Mogilev and Gomel Oblasts (*11*).

In Mogilev Oblast 12,356 children were investigated from 15 May 1991 through 31 December 1993. Goiter prevalence in this oblast ranged from 4 to 35%. The data on urine iodine excretion showed that among 1729 children, urinary iodine concentration was over 100 µg/liter in only about 30 cases; in more then 30% of the children it was less than 10 µg/liter.

In Gomel Oblast 12,791 children were investigated and goiter prevalence was 5 to 45%. Urine iodine concentration was measured in 235 children. Only a few of them excreted more than 100 µg/liter; 44 cases, (about 20%) excreted less than 10 µg/liter.

As the data on urinary iodine excretion in Belarus are limited it was decided to begin the investigations using the protocol applied in similar studies performed in Poland.

Studies done in Poland from March 1992 to February 1993 showed that two eastern regions of Poland bordering Belarus had low urinary iodine excretion and high prevalence of goiter (*12*).

For example, in Białystok region goiter prevalence in 1431 children investigated was 41% in rural and 36% in urban populations. The mean urinary iodine excretion was 52.07 µg/liter in children without goiter and 42.3 µg/liter in children with goiter. In Lublin region goiter was found in 21.8% of 1686 children investigated. Average urinary iodine excretion was 52.6 µg/liter in children with goiter and 56.76 µg/liter in children without goiter (*13*). The results observed in Polish regions so close to Belarus suggested the possibility of a similar situation in Belarus, stimulating countrywide epidemiologic studies.

The results of the investigation of goiter prevalence and urinary iodine excretion completed to date are important. However, they come mainly from two oblasts, Mogilev and Gomel, and differ significantly. Some of these results indicate that goiter prevalence is rather low and urinary iodine excretion rather high. One of the explanations may be the iodine supplementation given to these children after the Chernobyl accident, probably in large and uncontrolled quantities, and which may continue today.

Therefore, WHO and the Belarusian authorities determined there is an urgent need to extend the study on goiter prevalence across the whole country to produce a statistically significant survey in school-age children and adolescents that includes estimations of thyroid volume and structure by ultrasonography and urinary iodine concentration.

Program Goals

The goals of the WHO International Iodine Deficiency Program are *a*) to determine the extent and severity of iodine deficiency in various geographical areas of the country; *b*) to study thyroid size and structure in relation to iodine deficiency in children and adolescents of Belarus 6 to 18 years of age, born before and after the Chernobyl accident, and to consider those elements with respect to radioactive iodine; and *c*) to create a map of iodine status of all the regions involved, forming the basis for an effective and safe strategy for iodine prophylaxis in Belarus.

To realize these goals, approximately 11,000 children and adolescents from 30 schools selected at random and located in 15 urban and 15 rural regions will be examined. The following age groups will be investigated: 6 to 8, 11 to 12, 13 to 14,

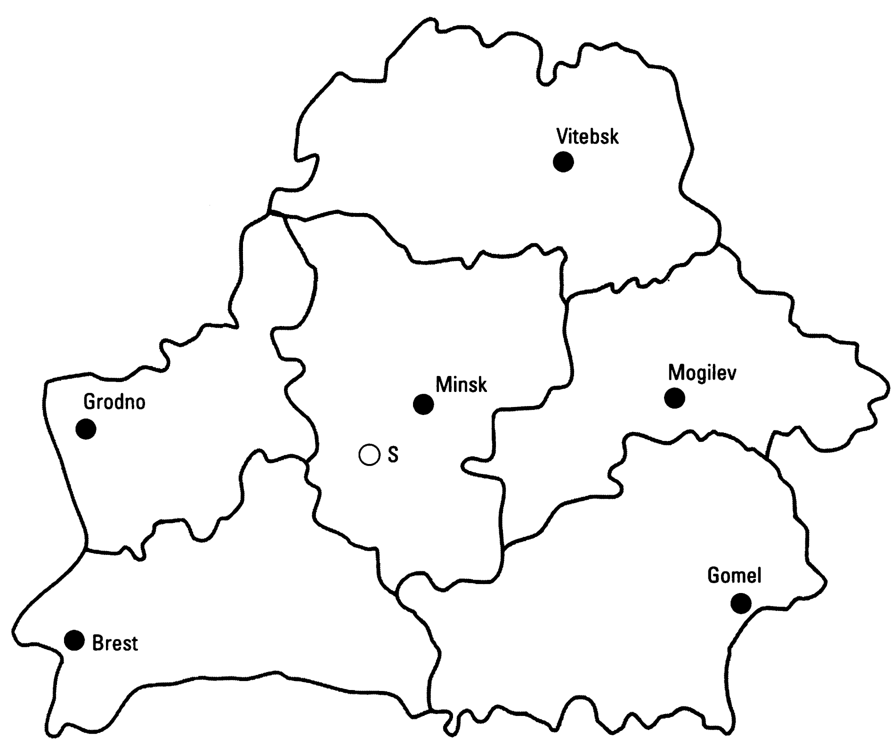

Figure 1. The six oblasts of Belarus. ●, Oblast capitals. ○S, Village of Stankovo.

15 to 16, and 17 to 18 years of age. Each group will consist of 30 individuals of each sex. Approximately 360 children will be examined from each school. Figure 1 shows the six oblasts of Belarus.

Preliminary Results from Two Schools

Results from studies of a group of 824 children and adolescents are presented in Gembicki et al. (*14*) and Perez et al. (*15*). Four hundred thirty children from urban Minsk and 394 children from rural Stankovo were examined. The presence of goiter investigated by palpation was observed in 64.7% of the children in Minsk and 71.8% in Stankovo (Table 3).

In Minsk grade IB goiter was observed in 44.2% of the group and grade II in 20.5%; in Stankovo observed percentages were 48.2 and 23.6%, respectively. In Minsk thyroid volume in the children as determined by ultrasonography ranged from 4.66 to 13.71 ml in boys, depending on age, and 4.38 to 11.38 in girls. In Stankovo, thyroid volumes were 4.5 to 16.48 ml in boys and 4.52 to 12.83 in girls (Table 4).

Urinary concentration of iodine in casual samples was greater than than 100 µg/liter in only 24.5% of the children in Minsk and 11.2% in Stankovo. Iodine concentration from 50 to 100 µg/liter was observed in 48.8 and 39.1% of children from Minsk and Stankovo, respectively. Iodine concentrations of 20 to 50 µg/liter were observed in 20.3% of the children from Minsk and 41.5% from Stankovo; concentrations below 20 µg/liter were seen in 6.4% of the children from Minsk and 8.1% from Stankovo (Table 5).

Discussion

The most recent ICCIDD recommendations (*7*) concerning the upper limit of normal thyroid volume in school children, as determined by ultrasonography, are presented in Table 6.

The ICCIDD also suggests that when 5% of a population has thyroid volumes over the recommended limits, the region must be recognized as an endemic goiter area. In the pilot studies we found that in comparable age groups 6.3 to 13% of the children exceeded these recommended values (Table 7) (*14,15*).

Table 3. Distribution by sex of examined children according to the degree of thyroid enlargement discovered by palpation.

		Degree of thyroid enlargement[a]							
		0		1A		1B		2	
	Sex	*n*	%	*n*	%	*n*	%	*n*	%
Minsk									
Subtotal	M	18	9.0	64	32.0	87	43.5	31	15.5
	F	13	5.7	57	24.9	103	44.8	57	24.6
Total	M + F	31	7.2	121	28.1	190	44.2	88	20.5
Stankovo									
Subtotal	M	2	1	61	30.8	102	51.5	33	16.7
	F	2	1	46	23.5	88	44.9	60	30.6
Total	M + F	4	1	107	27.2	190	48.2	93	23.6

Abbreviations: F, female; M, male. [a]WHO classification (*15*) for grades of goiter.

Table 4. Thyroid volume in examined children, in milliliters, as determined by ultrasonography, $\bar{X} \pm$ SEM.

		Age, years					
		6–8	9–10	11–12	13–14	15–16	17–18
Minsk							
Boys	$\bar{X}$	4.66	5.83	6.58	9.83	12.2	13.71
	SEM	0.29	0.22	0.37	0.59	0.83	0.88
Girls	$\bar{X}$	4.38	5.58	8.05	10.21	11.92	11.38
	SEM	0.22	0.28	0.59	0.43	0.63	0.58
Stankovo							
Boys	$\bar{X}$	4.50	6.23	7.00	10.00	12.82	16.48
	SEM	0.17	0.27	0.24	0.72	0.46	2.03
Girls	$\bar{X}$	4.52	5.51	8.14	9.90	12.04	12.83
	SEM	0.18	0.36	0.42	0.61	0.53	0.83

Table 5. Distribution by sex of examined children according to the level of urinary iodine excretion.

		Level of urinary iodine excrection, µg/liter							
		< 20		20–50		50–100		> 100	
	Sex	*n*	%	*n*	%	*n*	%	*n*	%
Minsk									
	M	10	5.0	46	23.2	99	50	43	21.9
	F	17	7.5	40	17.7	108	47.8	61	27
Total	M+F	27	6.4	86	20.3	207	48.8	104	24.5
Stankovo									
	M	16	8.1	79	39.9	79	39.9	24	12.1
	F	16	8.2	84	43.1	75	38.5	20	10.2
Total	M+F	32	8.1	163	41.5	154	39.1	44	11.2

Table 6. Upper limit of normal for thyroid volume in school children, determined by ultrasonography, in milliliters.

Age, years	Boys	Girls
6	5.2	5.6
7	5.7	6.2
8	6.7	7.5
9	6.9	8.1
10	8.2	9.4
11	9.4	10
12	10.7	12.6
13	12	14
14	13.7	15.5
15	16.5	15.5

Data from Delange et al. (*7*).

Table 7. Distribution of examined children with thyroid volume higher then the recommended upper normal limit.

	Age, years				
Group	6–8	9–10	11–12	13–14	15
Minsk					
M	5	5	3	8	1
F	1	1	3	5	7
Stankovo					
M	2	4	2	4	3
F	2	3	0	6	5
Subtotal					
M	7	9	5	12	4
F	3	4	3	11	12
Total					
M+F	10 (7.7%)	13 (10.2%)	8 (6.3%)	23 (13.8%)	16 (24.0%)

Therefore, after analysis of the results of the pilot study (*14,15*), we concluded that the results were typical for at least moderate goiter endemism and significant iodine deficiency.

Low iodine uptake causes compensatory thyroid hyperplasia and higher uptake of iodine. Radioiodine fallout during nuclear accidents may also accumulate more radioactive iodine, increasing the possibility of unexpected pathologies in iodine-deficient thyroid glands. In an irradiated thyroid where a malignant transformation may have been initiated, iodine deficiency may act to accelerate the appearance of cancer at a clinical level.

Conclusions

These preliminary results indicate at least moderate goiter endemism and significant iodine deficiency, and will be essential in developing a safe strategy for goiter prophylaxis, as well as a better understanding of the pathogenesis of thyroid disorders observed in this study.

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