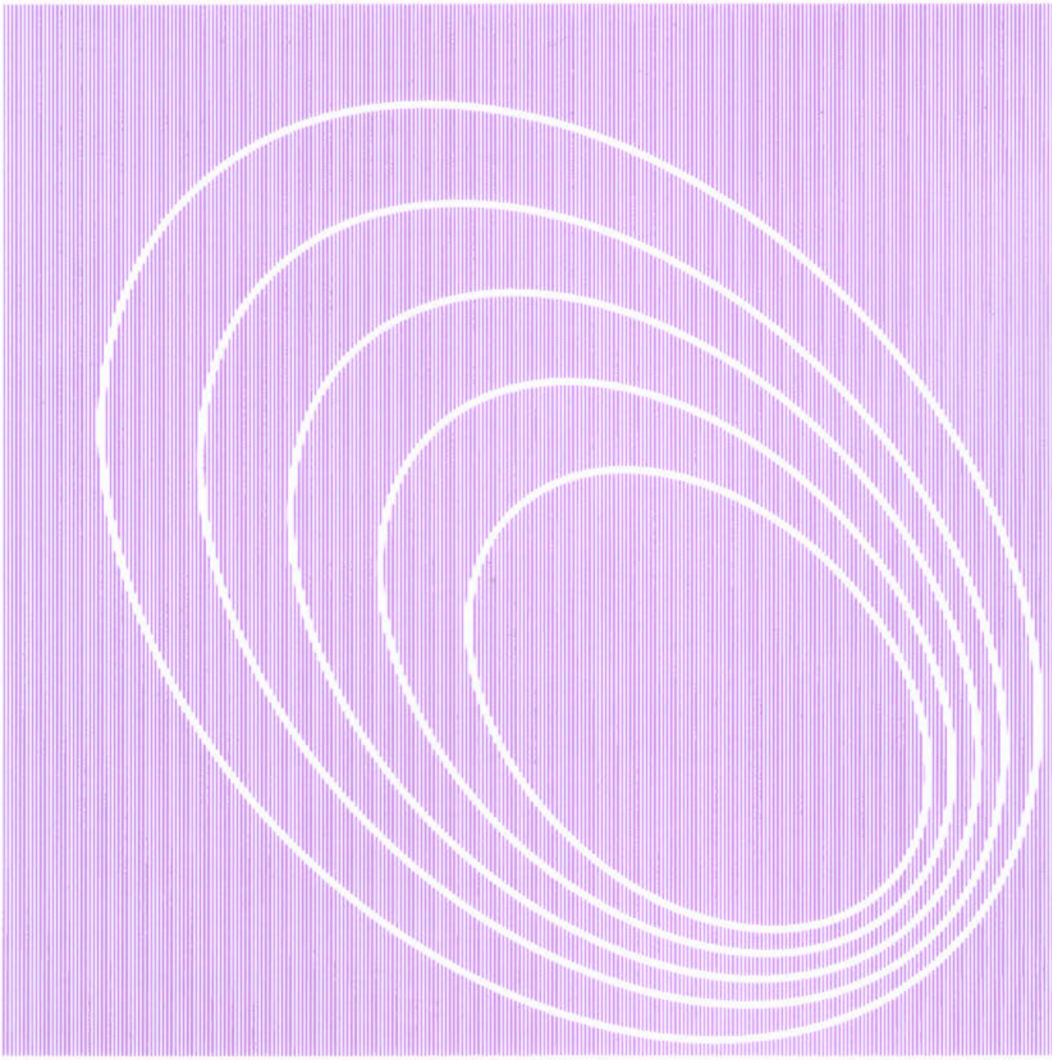
A Report on the 1993 Chernobyl Sasakawa Project Workshop

June 30 – July 2, 1993

Moscow



Sasakawa Memorial Health Foundation

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Foreword

On April 26, 1991, exactly five years after the accident at the Chernobyl nuclear power station, five special medical vehicles installed with the latest medical euqipment including a whole body counter, blood and thyroid gland analyzers were presented in Moscow's Red Square to 5 centers through what was then the Govenment of the USSR, thus inaugurating the five-year Chernobyl Sasakawa Health and Medical Cooperation Project. Having successfully completed the first two years, the project is now in its third year.

The objective of screening, with children who are the most vulnerable victimes of radioactive fallout as our main target, is to examine the health status of as many as children as possible in the affected regions in order to alleviate the concern of their parents over their children's health. While the objective was primarily motivated by humanitarian concern, the requirement of such humanitarian act to be meaningful obliged us to conduct screening with strictly scientific method. On our side, we were able to have full support of Japanese experts with their experience of radiation medicine gained in Hiroshima and Nagasaki.

As of the end of June 1993, a total of 49,000 children had been examined. The number is impressive considering the social turmoil presented by the historic political transformation of the former Soviet Union. This has been due mainly to the untiring commitment of the local medical staff including health ministries of three States and the unstinting efforts of their Japanese scientist colleagues who supported them. I would like to express my sincere respects and gratitude to them all.

In the belief that the precious data gathered in the course of this dedicated cooperative work should be made available so that the residents of affected areas might enjoy better understanding of their health, and at the same time that the scientific data should be published to facilitate understanding of the impact of the nuclear accident by the world community, a symposium was held in June 1992 in Mogilev, Belarus. (Its report is available in Japanese/English/Russian from Sasakawa Memorial Health Foundation.) This year again, a three-day workshop was organized in Moscow from June 30 to July 2, 1993 with the collaboration of the three States concerned. We are pleased to be able to share the fruit of the workshop in this report.

During past years, the activities of the project have been constantly scrutinized by both local medical staff and Japanese experts. Upon their recommendation, medical equipment with more precision and quicker examination performance has been added for the benefit of the victims, and an improved system enabling more effective screening is now in place. Also, a follow-up system of the children for further appropriate examination, if found necessary in the course of screening, is being considered.

We shall continue to devote ourselves to the compatibility of the principles we initially brought to this project, that is the pursuit of humane and scientific objectives. Far from mutually exclusive as might appear to be, these two aims when pursued unyiedingly will bring a deeper meaning and value to thier results, which will contribute not only to the better health of a child screened but to the better health of all the people on earth, today and in years to come. It is our intention to publish our data as broadly as possible, and we wish to invite constructive criticism of such data, to help us in our work for the health of people.

Prof. Kenzo Kiikuni
Executive Managing Director
Sasakawa Memorial Health Foundation

August 1993

Contents

Foreword 3

I. Reports of the Five Cooperative Centers
Results of the Examination of Children in Mogilev Oblast 7
Results of the Examination of the Health Status of Children Living in Gomel Oblast 22
Results of the Examination of the Health Status of Children in Klincy City and Klintsovskii Rayon 43
Results of the Examination of Children in Kiev Oblast 55
Results of the Examination of Children Living in the Northern Rayons of Zhitomir Oblast 72

II. Comments by Japanese Scientists
Comments on Thyroid-related Examinations and the 1993 Workshop Presentations — Shunichi Yamashita 87
Comments on the Activities at the Five Centers of Sasakawa Project — Blood examination, in particular — Kingo Fujimura and Shizuyo Kusumi 92
Report and Comments on the Workshop of the Sasakawa Health and Medical Cooperation Project — Masaharu Hoshi 96

III. Appendix
Appendix A. Location of the Five Cooperative Centers 99
Appendix B. Determination of the Standard Thyroid Volume in Children 100

Postscript 103

I. Reports of the Five Cooperative Centers

Results of the Examination of Children in Mogilev Oblast

Mogilev Regional Medical Diagnostic Center

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1. Introduction

The Chernobyl-Sasakawa Project has been implemented by the staff of the Department for Prophylaxy since its establishment on May 15, 1991. Diagnostic equipment installed in a Toyota bus and a set of fixed equipment donated by the Sasakawa Memorial Health Foundation are used in the work. The examined children are residents of Mogilev Oblast (Province), an area polluted with radionuclides as a result of the Chernobyl nuclear power station accident (see Appendix A).

The course of the examination includes the following: (1) collection of disease history, filling in of questionnaires; (2) anthropometric data; (3) dosimetric measurement with a whole body counter; (4) ultrasonography of the thyroid; (5) general blood count; (6) determination of thyroid hormones in the serum; (7) determination of iodine and creatinine in the urine; and (8) examination by a pediatrician.

The information thus obtained is processed at the Diagnostic Center and then entered in a database. Parents are informed in writing of the results of the examination. If abnormalities are found, the child in question is invited to visit the Diagnostic Center for a comprehensive examination, professional advice and recommendations for appropriate treatment.

2. Materials and Methods

2. 1 Study subjects

The subjects under study are children born between April 26, 1976 and April 26, 1986 and examined in the period between May 15, 1991 and December 31, 1992.

2. 2 Measurement of whole body Cs–137 concentration

To determine Cs–137 concentration in children's bodies, direct spectrometry of radionuclide activity is performed. This method is based on the registration of gamma radiation of the body. The whole body counter Model–101 manufactured by Aloka Company (Japan) is used.

2. 3 Thyroid examinations

Estimation of thyroid volume is performed with an arch-automatic ultrasonographic instrument (Aloka-520). Images of 11 cross sections of the thyroid are recorded on optic or floppy disc, then the total volume is calculated.

Diagnosis of thyroid disease is established on the basis of the following criteria of thyroid images: position; structure; echogenity; presence of nodules or cysts; and volume.

The children were divided into two groups according to thyroid volume: normal and goiter. The criterion for goiter is a thyroid volume exceeding the volume calculated by the formula:

$$LIMIT = 1.7 \times 10^{0.13 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of a child in years at the time of the examination, *height* is the height of a child in cm and *body weight* is the weight of a child in kg. See Appendix B for details.

The serum FT_4 and TSH levels are assayed with an Amerlite hormone analyzer. The immunometric technique based on enhanced luminescence is used in a non-RIA system. Assay is carried out by standardized protocol in parallels, i.e., with the six standard solutions A, B, C, D, E and F.

Titers of anti-thyroglobulin antibody (ATG) and anti-microsome antibody (AMC) are assayed by the reaction of indirect hemagglutination (Fujirevio).

2. 4 Hematological studies

The hematological study is conducted with a K–1000 analyzer to determine the following eight parameters: (1) white blood cell count (WBC); (2) red blood cell count (RBC); (3) hemoglobin (Hb); (4) hematocrit (Ht); (5) mean corpuscular volume (MCV); (6) mean corpuscular of hemoglobin (MCH); (7) mean corpuscular hemoglobin concentration (MCHC); and (8) platelet count (PLT). The leukocyte differentiation (hemogram) is determined using an Olympus biological microscope.

3. Results

3. 1 Study subjects

From May 15, 1991 to December 31, 1992, 6,129 children (2,997 boys and 3,132 girls) were examined. Ranging in age from 5 to 16 years, these children reside in more than 100 settlements in 10 rayons (Slavgorodskii, Klimovichskii, Chausskii, Krichevskii, Bykhovskii, Mogilevskii, Kostyukovichskii, Krasnopolskii, Cherikovskii and Klichevskii) and Mogilev City of Mogilev Oblast (Table 1).

The examined children live in territories where the Cs–137 contamination density is from 0 to 15 Ci/km^2 and in some where it exceeds 15 Ci/km^2 (Figure 1). The largest number of children (3, 764) was examined in Mogilev City and

Table 1. Classification of study subjects by sex and rayon.

Rayon	Boys	Girls	Total
Slavgorodskii	179 (7, 9, 12)[a]	193 (7, 10, 12)	372 (7, 10, 12)
Klimovichskii	44 (7, 8, 10)	42 (7, 8, 10)	86 (7, 8, 10)
Chausskii	306 (7, 8, 11)	335 (7, 9, 12)	641 (7, 9, 12)
Krichevskii	132 (6, 7, 8)	144 (6, 7, 8)	276 (6, 7, 8)
Bykhovskii	138 (5, 6, 8)	159 (6, 7, 8)	297 (6, 6, 8)
Mogilev City and Mogilevskii	1,864 (8, 11, 13)	1,900 (8, 11, 13)	3,764 (8, 11, 13)
Kostyukovichskii	136 (8, 11, 13)	155 (9, 12, 13)	291 (9, 12, 13)
Krasnopolskii	32 (6, 6, 7)	32 (6, 6, 7)	64 (6, 6, 7)
Cherikovskii	104 (9, 11, 12)	117 (10, 11, 12)	221 (9, 11, 12)
Klichevskii	62 (9, 10, 12)	55 (8, 10, 12)	117 (8, 10, 12)
Total	2,997 (7, 9, 13)	3,132 (6, 9, 13)	6,129 (7, 9, 13)

a. Each triplet gives the 25th, 50th and 75th sample percentiles of age distribution at the time of examination.

Figure 1. Cs–137 contamination levels (Ci/km^2) in the rayons of Mogilev oblast as measured in 1992.

a. The triplets give the 25th, 50th and 75th sample percentiles of contamination levels.

b. Minimum and maximum levels of contamination.

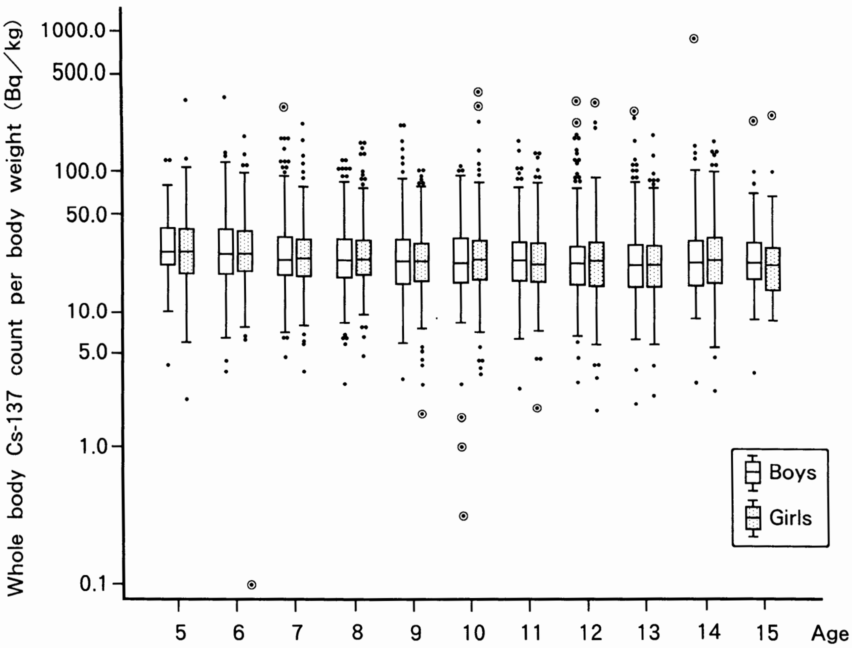

Figure 2. The box-and-whisker plots of whole body Cs-137 count per body weight by sex and age. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, which are called "outside" and "far out," respectively.

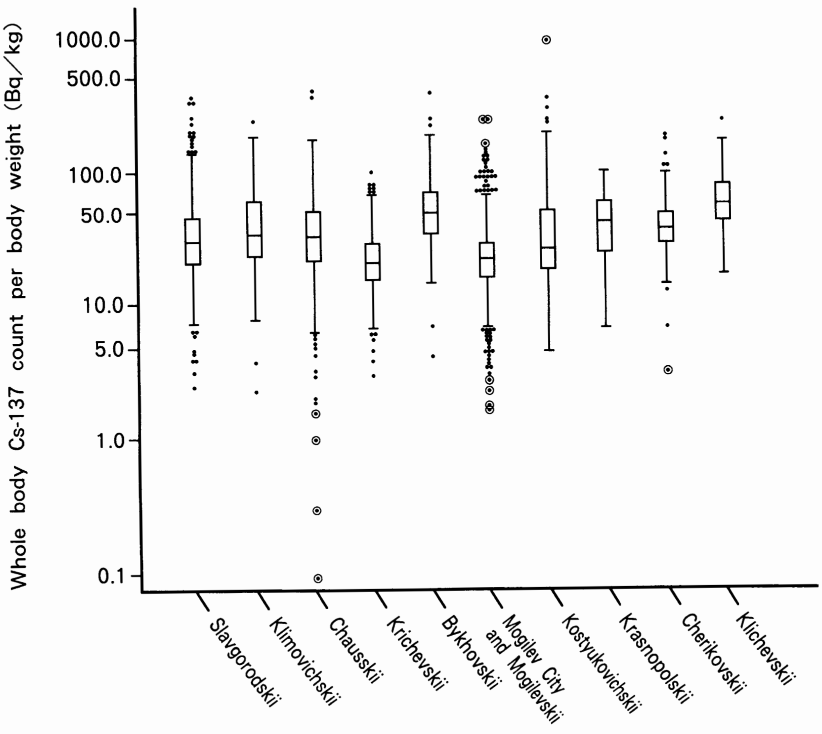

Figure 3. The box-and-whisker plots of whole body Cs-137 count per body weight by rayon. See Figure 2 for details.

Mogilevskii rayon, while the smallest number (64) was examined in Krasnoplskii rayon. The triplet on the map of Mogilev Oblast indicates the 25 th, 50th and 75th percentiles of the distribution of Cs–137 contamination level in each rayon. The two numbers are the minimal and maximal contamination level in each rayon.

3. 2 Measurement of whole body Cs–137 concentration

The distribution of specific Cs–137 concentration in the bodies of examined children by sex and age is shown in Figure 2. The median of Cs–137 specific activity was practically the same in boys and girls.

The distribution of specific Cs–137 concentration in the bodies of examined children by place of residence in rayons of Mogilev Oblast is shown in Figure 3. The minimal value of the median of Cs–137 specific activity (20 Bq/kg) was found in children residing in Krichevskii rayon, while the maximal value of the median (54 Bq/kg) was found in the Klichevskii rayon.

3. 3 Thyroid examinations

The relationship between thyroid volume and sex and age is shown in Figure 4. The trend has been toward an increase in thyroid volume with age in both boys and girls.

Figure 5 shows that the prevalence of goiter was higher in girls than in boys, a finding that was particularly significant in Slavgorodskii, Kostyukovichskii and Klichevskii rayons. The highest prevalence of goiter among boys and girls was found in Krichevskii rayon and Klichevskii rayon, respectively.

The prevalence of thyroid disease by sex and rayon of residence is given in Table 2. Abnormality of thyroid echogenity was found in 38 children (24 girls), autoimmune thyroiditis in 15 children (11 girls), nodules in seven children (four girls), and cysts in six children (three girls). Hypoplasia was found in 32 children (15 girls).

A positive titer of ATG was found in 24 children including 21 girls (Table 3). A positive titer of AMC was found in 50 children including 39 girls. The positive titer of both ATG and AMC was found more frequently in girls than in boys.

An increase in serum TSH level and simultaneous decrease in serum FT_4 level were found in four boys and five girls (Table 4). Six children were reexamined, and the data of the first examination were confirmed in one child. A decreased level of TSH and simultaneous increase in FT_4 level were found in two boys and three girls. Three of these children were reexamined, but the data of the previous examination could not be confirmed.

3. 4 Hematological studies

The relationship between hemoglobin level and age and sex is shown in Figure 6. The median of hemoglobin level is within normal limits in all age

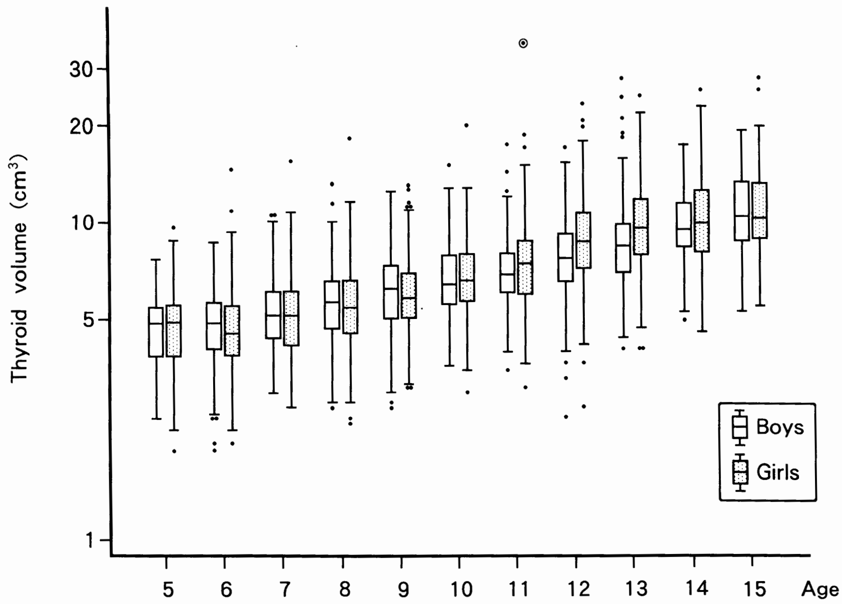

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. See Figure 2 for details.

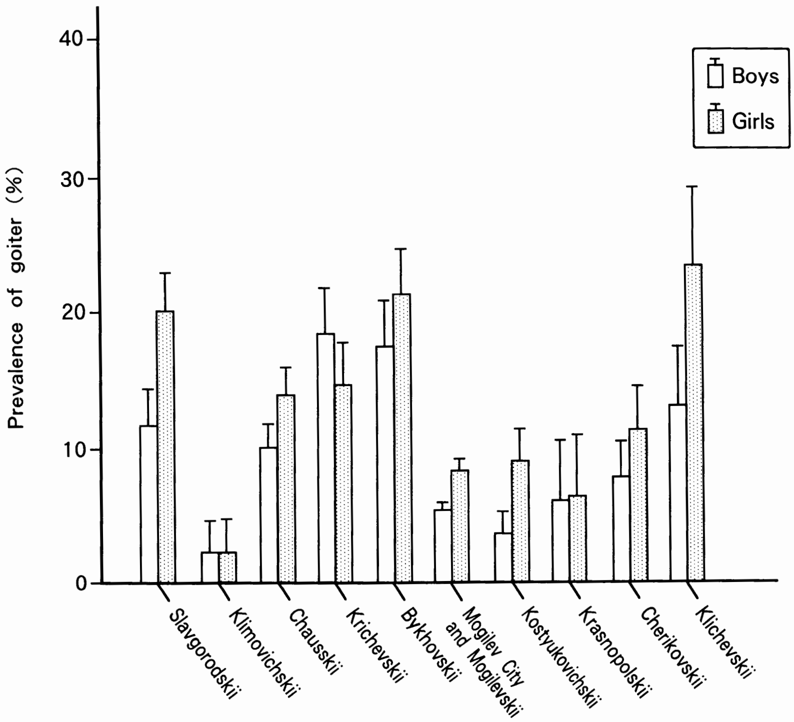

Figure 5. Prevalence of goiter by sex and rayon. The whiskers denote the standard errors. See page 8 for the definition of goiter.

groups. The trend has been toward an increase in hemoglobin level. The median of hemoglobin level is higher in boys than in girls except among nine

Table 2. Subjects with thyroid abnormalities by sex and rayon.

Rayon	Number of subjects examined		Diagnosis							
			Nodular lesion		Cystic lesion		Abnormal echogenity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Slavgorodskiii	179	193	0	0	0	0	0	3	2	0
Klimovichskii	44	42	0	0	0	0	1	0	2	2
Chausskii	306	335	0	2	0	0	3	4	1	2
Krichevskii	132	144	0	0	0	0	0	0	0	0
Bykhovskii	138	159	0	0	0	0	0	0	1	1
Mogilev City and Mogilevskii	1,864	1,900	3	2	3	3	8	17	5	6
Kostyukovichskii	136	155	0	0	0	0	0	0	2	1
Krasnopolskii	32	32	0	0	0	0	0	0	3	3
Cherikovskii	104	117	0	0	0	0	0	0	0	0
Klichevskii	62	55	0	0	0	0	2	0	1	0
Total	2,997	3,132	3	4	3	3	14	24	17	15

a. B, boys; G, girls.

Table 3. Number of subjects with anti-thyroglobulin and/or anti-microsome antibodies by sex and rayon.

Rayon	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Slavgorodskii	362	176	186	2	0	2	9	1	8
Klimovichskii[a]									
Chausskii	621	299	322	0	0	0	1	1	0
Krichevskii	269	128	141	2	0	2	1	0	1
Bykhovskii	295	137	158	1	0	1	1	1	0
Mogilev City and Mogilevskii[b]	2,464	1,226	1,238	17	3	14	33	7	26
Kostyukovichskii	286	136	150	1	0	1	3	1	2
Krasnopolskii	61	29	32	0	0	0	0	0	0
Cherikovskii	208	99	109	0	0	0	1	0	1
Klichevskii	112	61	51	1	0	1	1	0	1
Total	4,678	2,291	2,387	24	3	21	50	11	39

a. No subjects were measured their antibodies because reagents were unavailable at the time of examination.
b. One girl was not measured anti-thyroglobulin antibody.

year-old children. The relationship between hemoglobin level and the rayon of residence is shown in Figure 7. The smallest value of the median of hemoglobin level was found in children residing in Klimovichskii rayon.

The relationship between white blood cell count (WBC) and sex and age is shown in Figure 8. The median of WBC is within normal limits at all ages. Leukocytosis was found in 246 children (cf. Table 5, page 19). The maximal

Table 4. Number of subjects with hypothyroidism or hyperthyroidism by sex and rayon.

Rayon	Number of subjects with measurement			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Slavgorodskii	362	176	186	3	1	2	0	0	0
Klimovichskii	78	40	38	0	0	0	0	0	0
Chausskii	621	299	322	0	0	0	1	1	0
Krichevskii	269	128	141	1	0	1	0	0	0
Bykhovskii	295	137	158	0	0	0	1	0	1
Mogilev City and Mogilevskii	3,642	1,816	1,826	4	2	2	3	1	2
Kostyukovichskii	286	136	150	1	1	0	0	0	0
Krasnopolskii	61	29	32	0	0	0	0	0	0
Cherikovskii	208	99	109	0	0	0	0	0	0
Klichevskii	112	61	51	0	0	0	0	0	0
Total	5,934	2,921	3,013	9	4	5	5	2	3

a. Diagnosed when free $T_4 < 10.0$ pmol/l and $TSH > 2.90$ μIU/ml.
b. Diagnosed when free $T_4 > 25.0$ pmol/l and $TSH < 0.24$ μIU/ml.

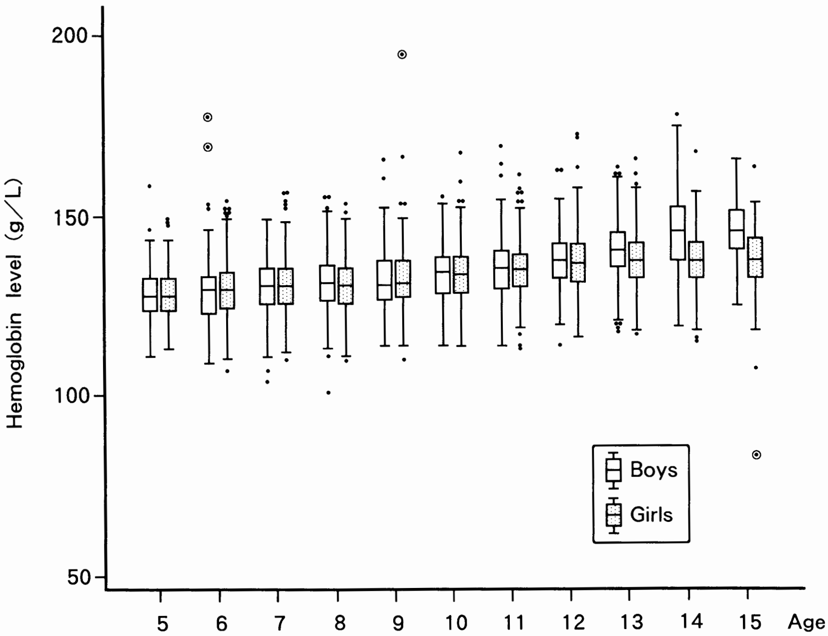

Figure 6. The box-and-whisker plots of hemoglobin level by sex and age. See Figure 2 for details.

leukocyte count was 28.1×10^9/L. With regard to clinical symptoms, signs of acute respiratory disease and acute attacks of chronic inflammation disease have been noted in most of the children with leukocytosis. The relationship between WBC and the rayon of residence is shown in Figure 9. The median of WBC is within normal limits in all rayons. The maximal number of children with leukocytosis (102) was found in Mogilev City and in Mogilevskii rayon (Table 5).

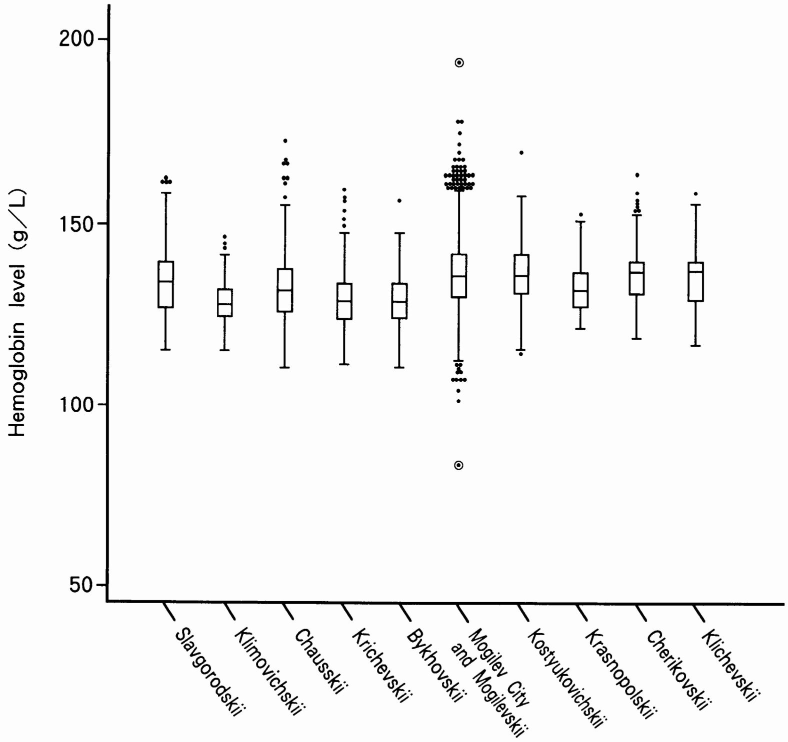

Figure 7. The box-and-whisker plots of hemoglobin level by rayon. See Figure 2 for details.

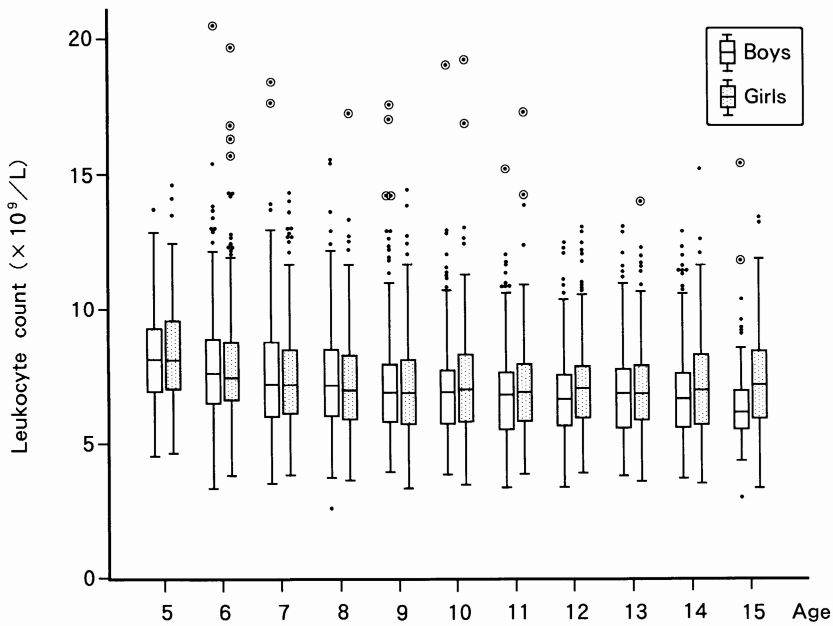

Figure 8. The box-and-whisker plots of leukocyte count by sex and age. See Figure 2 for details.

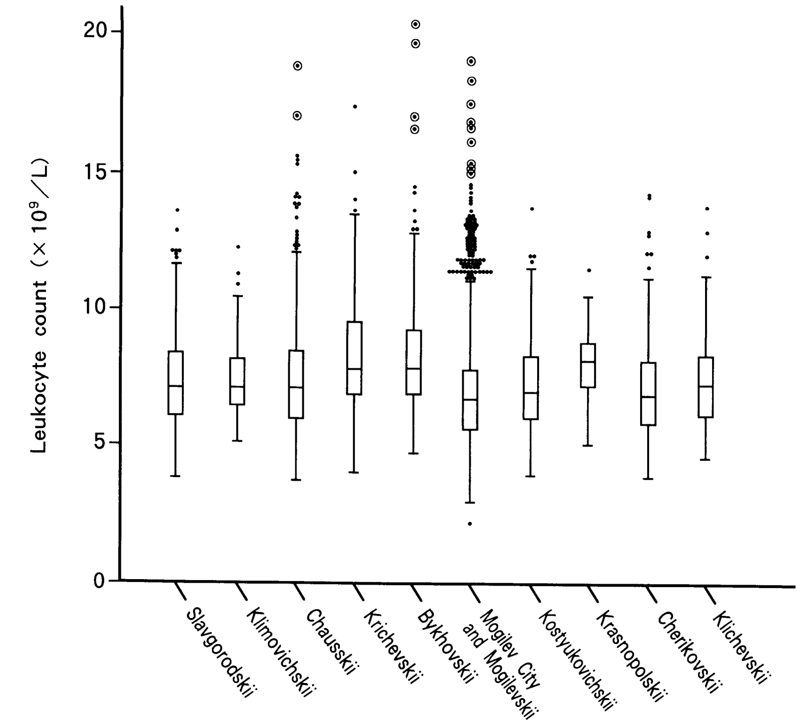

Figure 9. The box-and-whisker plots of leukocyte count by rayon. See Figure 2 for details.

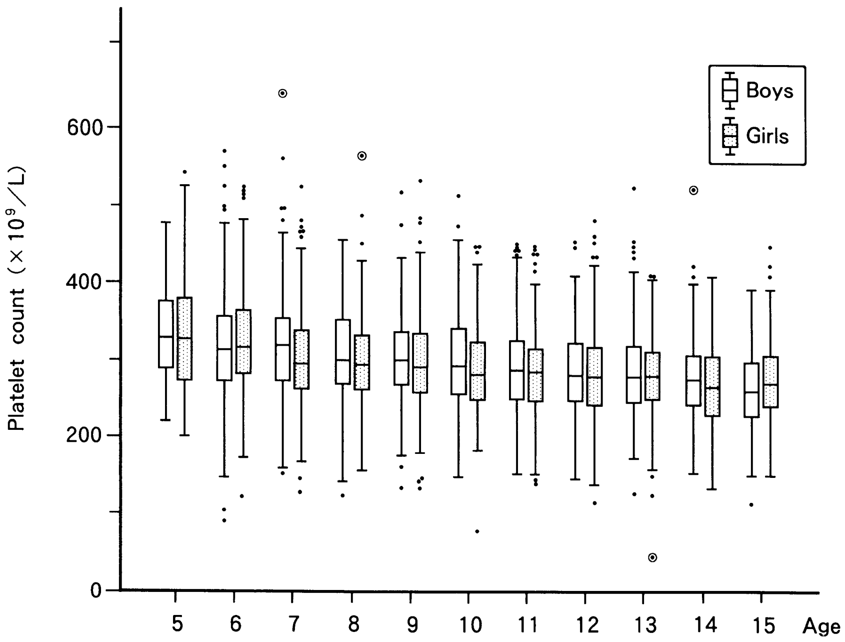

Figure 10. The box-and-whisker plots of platelet count by sex and age. See Figure 2 for details.

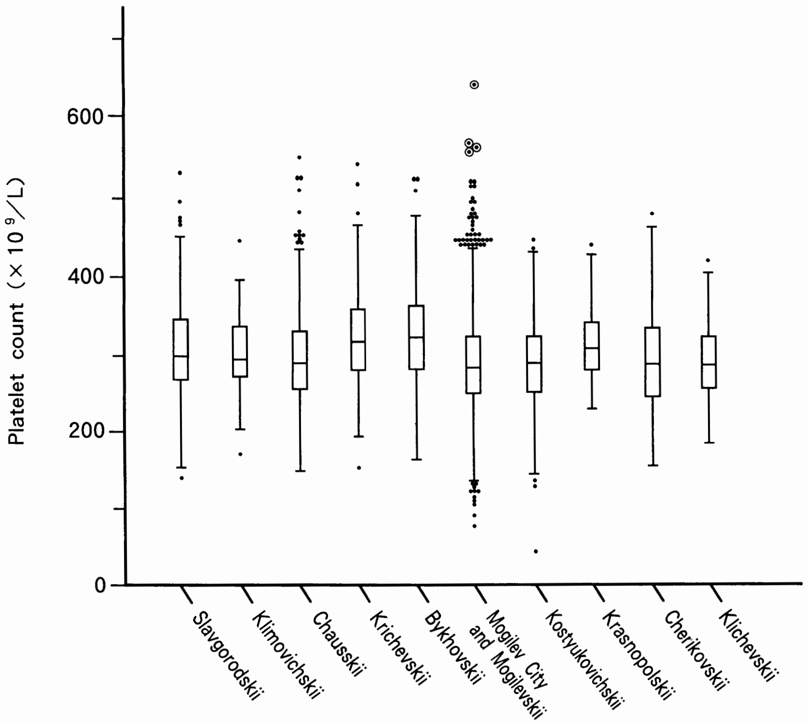

Figure 11. The box-and-whisker plots of platelet count by rayon. See Figure 2 for details.

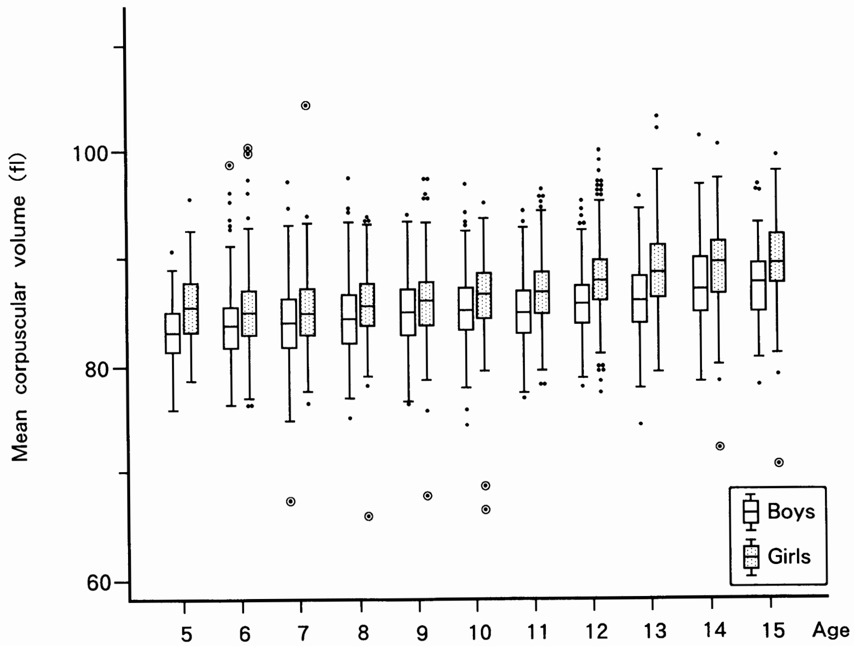

Figure 12. The box-and-whisker plots of mean corpuscular volume by sex and age. See Figure 2 for details.

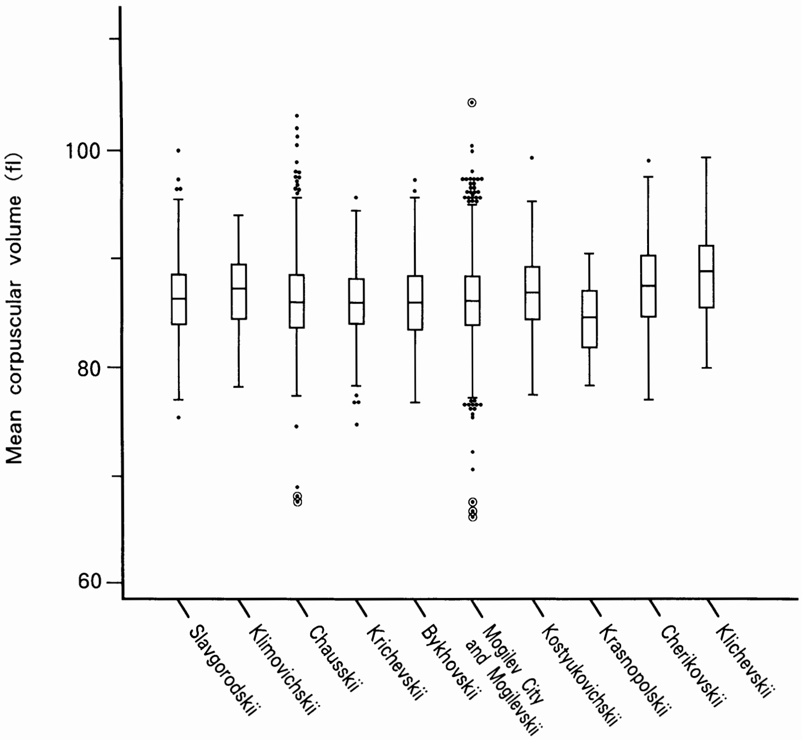

Figure 13. The box-and-whisker plots of mean corpuscular volume by rayon. See Figure 2 for details.

The relationship between platelet count (PLT) and sex and age is shown in Figure 10. The median of PLT is within normal limits at all ages. The trend has been toward a decrease in PLT in both girls and boys. The relationship between PLT and the rayon of residence is shown in Figure 11. The median of PLT is within normal limits in all rayons. The maximal number of children with thrombocytosis and thrombocytopenia was found in Mogilev City and in Mogilevskii rayon, but the prevalence was not high in either rayon (Table 5).

The relationship between MCV and sex and age is shown in Figure 12. The MCV median is within normal limits in both girls and boys at all ages. MCV was higher in girls than in boys at all ages. The relationship between MCV and the rayon of residence is shown in Figure 13. The MCV median is within normal limits in all rayons. The maximal number of children with microcytic red blood cells was found in Mogilevskii and Chausskii rayons, but the prevalence was not high in either rayon (Table 5).

The frequency of deviations of hemogram from normal by rayon of residence is given in Table 5. The results of the general blood count in the 6,129 children reveal the following hematological abnormalities: anemia – nine children (five girls) residing in Mogilevskii rayon; leukopenia – 22 children including 21 residing in Mogilevskii rayon; thrombocytopenia – seven children including five residents of Mogilevskii rayon; lymphopenia – 112 children

Table 5. Frequency of subjects with hematological abnormalities by rayon.[a]

Item (unit)[c]	Abnormality criteria	SLA	KLI	CHA	KRI	BYK	MOG	KOS	KRA	CHR	KLC	Total
Blood analysis		Rayon[b]										
Hb (g/L)	<110[d]						4 (0.1)					4 (0.1)
	>180[d]											
	<110[e]						5 (0.1)					5 (0.1)
	>160[e]			3 (0.5)			8 (0.2)			1 (0.4)		12 (0.2)
WBC ($\times 10^9$/L)	<3.8[d]			1 (0.2)			14 (0.4)					15 (0.2)
	>10.6[d]	11 (2.9)	2 (2.3)	19 (2.9)	19 (6.8)	13 (4.3)	61 (1.6)	5 (1.7)	1 (1.6)	9 (3.9)	3 (2.5)	143 (2.3)
	<3.6[e]						7 (0.2)					7 (0.1)
	>11.0[e]	5 (1.3)	1 (1.1)	19 (2.9)	16 (5.8)	16 (5.4)	41 (1.1)	2 (0.7)		2 (0.9)	1 (0.8)	103 (1.7)
PLT ($\times 10^9$/L)	<100				1 (0.4)		5 (0.1)	1 (0.3)				7 (0.1)
	>440	8 (2.1)	1 (1.1)	12 (1.8)	9 (3.2)	13 (4.3)	42 (1.1)	2 (0.7)		6 (2.5)		93 (1.5)
MCV (fl)	<80	11 (2.9)	1 (1.1)	20 (3.0)	14 (5.0)	11 (3.7)	150 (3.9)	5 (1.7)	6 (8.8)	8 (3.4)	1 (0.8)	227 (3.7)
	>100			4 (0.6)			2 (0.1)					6 (0.1)
Ly ($\times 10^9$/L)	<1.2		2 (2.1)	4 (0.6)	1 (0.4)		98 (2.5)	4 (1.3)		1 (0.4)	2 (1.6)	112 (1.8)
	>3.5	55 (14.5)	10 (10.5)	123 (18.1)	95 (33.5)	132 (44.0)	357 (9.0)	38 (12.4)	16 (23.2)	24 (10.1)	12 (9.8)	862 (14.1)
Ne ($\times 10^9$/L)	<1.4			4 (0.6)			15 (0.4)			1 (0.4)		20 (0.3)
	>6.6	18 (4.7)	2 (2.1)	28 (4.1)	23 (8.1)	27 (9.0)	137 (3.4)	13 (4.2)	3 (4.3)	10 (4.2)	8 (6.6)	269 (4.4)
Eo ($\times 10^9$/L)	>0.5	91 (24.0)	27 (28.4)	226 (33.2)	97 (34.2)	64 (21.3)	537 (13.5)	67 (21.9)	19 (27.5)	61 (25.6)	29 (23.8)	1,218 (19.9)
Mo ($\times 10^9$/L)	<0.12	161 (42.5)	40 (42.1)	117 (17.2)	107 (37.7)	132 (44.0)	679 (17.0)	46 (15.0)	11 (15.9)	15 (6.3)	3 (2.5)	1,311 (21.4)
	>1.00		1 (1.1)	18 (2.6)	3 (1.1)		61 (1.5)	2 (0.7)		4 (1.7)	6 (4.9)	95 (1.6)
Number of children measured		372	86	641	276	297	3,764	291	64	221	117	6,129

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. SLA, Slavgorodskii; KLI, Klimovichskii; CHA, Chausskii; KRI, Krichevskii; BYK, Bykhovskii; MOG, Mogilev City and Mogilevskii; KOS, Kostyukovichskii; KRA, Krasnopolskii; CHR, Cherikovskii; KLC, Klichevskii.

c. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

d. Criteria for boys.

e. Criteria for girls.

Table 6. Frequency of subjects with hematological abnormalities by Cs-137 level.[a]

Blood analysis		Whole body Cs-137 count per body weight (Bq/kg)					Total
Item (unit)[b]	Abnormality criteria	0–50	50–100	100–200	200–500	≥500	
Hb (g/L)	<110[c]	4 (0.1)					4 (0.1)
	>180[c]						
	<110[d]	5 (0.1)					5 (0.1)
	>160[d]	12 (0.2)					12 (0.2)
WBC ($\times 10^9$/L)	<3.8[c]	14 (0.3)	1 (0.2)				15 (0.2)
	>10.6[c]	112 (2.0)	24 (4.1)	6 (5.5)	1 (5.3)		143 (2.3)
	<3.6[d]	7 (0.1)					7 (0.1)
	>11.0[d]	91 (1.7)	10 (1.7)	2 (1.8)			103 (1.7)
PLT ($\times 10^9$/L)	<100	7 (0.1)					7 (0.1)
	>440	83 (1.5)	10 (1.7)				93 (1.5)
MCV (fl)	<80	206 (3.7)	18 (3.1)	3 (2.7)			227 (3.7)
	>100	5 (0.1)	1 (0.2)				6 (0.1)
Ly ($\times 10^9$/L)	<1.2	105 (1.8)	7 (1.2)				112 (1.8)
	>3.5	732 (12.8)	111 (18.5)	16 (13.7)	3 (15.8)		862 (14.1)
Ne ($\times 10^9$/L)	<1.4	18 (0.3)		1 (0.9)	1 (5.3)		20 (0.3)
	>6.6	218 (3.8)	40 (6.7)	8 (6.8)	2 (10.5)	1 (100)	269 (4.4)
Eo ($\times 10^9$/L)	>0.5	1,036 (18.1)	158 (26.3)	20 (17.1)	4 (21.1)		1,218 (19.9)
Mo ($\times 10^9$/L)	<0.12	1,146 (20.0)	130 (21.6)	30 (25.6)	5 (26.3)		1,311 (21.4)
	>1.00	82 (1.4)	12 (2.0)	1 (0.9)			95 (1.6)
Number of children measured		5,424	579	106	19	1	6,129

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

(1.8%); neutropenia – 20 children (0.3%); eosinophilia – 1,218 children (19.9%); and monocytosis – 95 children (1.6%). In most of the children the eosinophilia is caused by parasitic and allergic diseases. Leukemoid reaction of the lymphocytic type was found in a nine year-old girl. Pelger anomaly of neutrophiles was found in four children.

The relationship between hematological abnormalities and Cs-137 specific activity (Bq/kg) is shown in Table 6. The group of children in which the specific activity ranged from 0 to 50 Bq/kg was the largest, and most of the deviations were registered in this group. Because of the small size of the other groups, it is difficult to conduct a comparative analysis. In the 20 children in whom the level of specific activity of Cs-137 was 200 Bq/kg or over, the following deviations from normal have been found: neutropenia in one child and eosinophilia in four children. Anemia, thrombocytopenia and lymphopenia have not been found.

4. Discussion

The fact that simultaneous studies are being conducted in the other four centers is of great importance because it allows the comparison of obtained results.

The results of our examinations of thyroid function in children carried out in the 1991–1992 period revealed deviations from normal in thyroid hormone levels even five or six years after the Chernobyl accident. In most cases these deviations are not obvious signs of disease. However, because diseases such as hypothyroidism, autoimmune thyroiditis and thyroid neoplasia are often preceded by changes in hormonal and immune status found by laboratory testing, the careful observation of persons exposed to radiation as a result of the Chernobyl accident, especially children and residents of endemic-goiter rayons, is vitally important.

When hematologic data are discussed, attention should be focused on two factors which can influence general conclusions: (1) single-time examination, which may disclose random changes; and (2) the existence of somatic diseases in children.

To define the primary causes of changes in hematologic parameters, it is necessary to carry out parallel examinations in "pure" rayons. Although Mogilev City belongs to a zone where the Cs–137 contamination level ranges between 0 and 1 Ci/km^2, it is impossible to recognize the town as a pure zone because the air is highly polluted with various harmful substances from industrial sources. A large portion of deviations from normal in general blood count were found in the children of Mogilev City. The changes in blood morphology may be an adaptive response to the action of endogenic and exogenic factors only one of which is radiation. The necessity for further monitoring of the hemopoietic system in children exposed to low doses of radiation is obvious.

In conclusion, it should be noted that the examinations are of great importance not only for research purposes but for each examined child because they allow the early discovery of disease, the timely prescription of treatment, and the prevention of the unfavorable results of disease.

Results of the Examination of the Health Status of Children Living in Gomel Oblast

Gomel Specialized Medical Dispensary

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1. Introduction

The Chernobyl disaster caused an unfavorable situation in Gomel Oblast (Province) in the Republic of Belarus. More than 80% of an area with a population of approximately 1.35 million was contaminated with Cs-137 at a contamination density of 1 Ci/km^2 or over (cf. Appendix A). More than 100,000 residents of areas recognized as unfavorable zones for living have been resettled elsewhere.

The Chernobyl accident adversely affected both demographic rates in the oblast and the level of morbidity in the population. A decrease in the number of residents and birth rate has been registered along with an increase in general and infantile mortality, diseases of the thyroid and other endocrine organs, abnormalities in blood circulation and the digestive system, nervous and mental disorders, etc.

Under these conditions, a long-term program for medical examinations and the study of the health state of children exposed to radiation as a result of the Chernobyl accident is of inestimable importance for health care bodies and for the population of the oblast. This program was cooperated by the Sasakawa Memorial Health Foundation and began operation in 1991. The program is financed mainly by the foundation and enjoys the participation of a large number of prominent Japanese scientists.

Involving the examination of children in accordance with a unified protocol, the program provides a means for the study of changes in the thyroid with time, for the estimation of parameters of peripheral blood, and for the measurement of Cs-137 concentration in the body. This will eventually make possible the objective assessment of the health state of each child and the development of individual regimens for health improvement.

Data on the accumulation of radionuclides in children's bodies, pathologic changes in the thyroid, and deviation of peripheral blood parameters from normal observed in the course of the examinations provide the conceptual basis for the development of preventive measures directed to the treatment and health improvement of children.

A total of 7,461 children were examined by the staff of the dispensary during the period from May 1991 to 31 December 1992. Among these, 6,496 were born between 26 April 1976 and 26 April 1986. Information on this cohort of 6,496 children is presented in this report.

To examine children, the mobile diagnostic laboratory donated by the foundation was dispatched to the various places of residence. The laboratory is equipped with proper facilities for dosimetry, sonography and laboratory testing. Individual groups of children have also been examined directly at the specialized dispensary using the medical equipment donated by the foundation.

2. Materials and Methods

2. 1 Study subjects

Children residing in areas with a Cs–137 contamination density above 1 Ci/km^2 as well as those resettled from zones dangerous for living were chosen for examinations. The children under examination live in settlements in Braginskii, Buda-Koshelevskii, Gomelskii, Dobrushskii, Elskii, Zlobinskii, Kormyanskii, Lelchitskii, Loevskii, Petrikovskii, Rechitskii, Hoynikskii, Checherskii, Vetkovskii, Zitkovinchskii, Kalinkovichskii, Mozirskii, Narovlyanskii, Oktyabrskii, Rogachevskii and Svetlogorskii rayons as well as in Gomel City and Mozir City.

The information was analyzed for the oblast as a whole and for each individual rayon. Data on the examination of the whole cohort regardless of sex as well as data on the examination of boys and girls grouped according to age and rayon of residence were analyzed. All rayons of the Gomel Oblast with the distribution of Cs–137 contamination density (Ci/km^2) as well as the extreme values are given in Figure 1.

Measurement of Cs–137 concentration in the bodies of children and thyroid and hematological studies were performed by special techniques using the appropriate facilities.

2. 2 Measurement of whole body Cs–137 concentration

To determine whole body Cs–137 concentration, we used a gamma-spectrometer Model-101 equipped with a collimator manufactured by Aloka Company. The results of measurements were processed by the software installed in the computer.

Energetic calibration of gamma-spectrometer with a standard source of Cs–137 and Co–60 was performed first. This procedure facilitated the estimation of errors caused by varying the parameters of the spectrometer amplifier and thus promoted the achievement of steady results. Measurement of external background without a phantom was conducted next. To correct the results of measurement of body gamma-radiation, the value of the external background was subtracted from the readings of the unit. The following step was measurement of radiation background with phantoms made from organic glass panes 5,

Figure 1. Cs–137 contamination levels (Ci/km^2) in the rayons of Gomel oblast as measured in 1992.

a. The triplets give the 25th, 50th and 75th sample percentiles of contamination levels.

b. Minimum and maximum levels of contamination.

10, 15 and 20 cm in thickness.

After these preparatory procedures, the whole body Cs–137 concentration was measured. The subject sits in front of the collimator while the operator inputs personal data such as body weight, height, size of chest and then performs the measurement. The results of these measurements are stored in the computer and printed.

2. 3 Thyroid examinations

The examination of the thyroid gland consists of ultrasound investigation, assay of the levels of thyroid stimulating hormone (TSH) and free T_4 (FT_4) in serum as well as titer of anti-microsome antibodies (AMC) and anti-thyroglobulin antibodies (ATG). If a deviation from normal is found the child in question is examined by an endocrinologist.

Ultrasound examination was performed with an SSD–520 unit manufactured by Aloka Company and further examination with an Aloka–630. A quantitative and qualitative analysis of the state of the thyroid and surrounding tissues, blood vessels and lymph nodes was carried out. Biometry of the thyroid with consideration for sex and age was performed by the technique developed in the Department of Radiology at the Medical Radiological Research Center of Russian Academy of Medical Sciences (MRRC RAMS). Using tomographic scanning, we determined the volumetric parameters of the thyroid and examined the sharpness of the thyroid image, its outline, echostructure and the presence of pathologic structures such as nodules, cysts and congenital abnormalities. Fine needle puncture biopsy was performed to establish diagnoses.

The functional state of the thyroid was studied by the immune enzymatic technique using an Amerlite unit manufactured by Amersham Company, and FT_4 and TSH assay was performed using kits made by the same company.

The titer of AMC and ATG was assayed visually by reaction of passive hemagglutination using diagnostic kits provided by Fujirevio Company.

The techniques mentioned above are the main criteria for establishing diagnoses.

2. 4 Hematological studies

Hematological tests were carried out for the following eight parameters: (1) white blood cell count (WBC); (2) red blood cell count (RBC); (3) hemoglobin concentration (Hb); (4) platelet count (PLT); (5) hematocrit (Ht); (6) mean corpuscular volume (MCV); (7) mean corpuscular hemoglobin concentration (MCHC); and (8) mean corpuscular hemoglobin (MCH). Blood testing was conducted with a hemoanalyzer Sysmex K-1000.

Special EK-0205 vacuum tubes were used for blood sampling. The peripheral blood hemogram (neutrophil, lymphocyte, monocyte, eosinophil and basophil) was analyzed with an Olympus-BH-2 microscope.

3. Results

3. 1 Study subjects

The results of the examination of 6,496 children (3,151 boys and 3,345 girls) were analyzed.

The number of examined children by sex along with the 25th, 50th and 75th percentiles of the age distribution in an individual rayon and in the oblast as a whole is given in Table 1. With regard to age, 25% of the examined children were 4 to 6 years old, 50% were 4 to 9 years old and 75% were 4 to 11 years old. The distribution was the same in girls as in the total, but in boys the age distribution was as follows: 25% - 4 to 6 years old, 50% - 4 to 8 years old and 75% - 4 to 11 years old.

3. 2 Measurement of whole body Cs-137 concentration

The Cs-137 concentration in each child's body presented as Cs-137 specific activity (Bq/kg) was used for analysis. When the number of examined children in a rayon was less than 10, the data obtained in this rayon were excluded from the consideration. These data have not been used for the designing of figures.

Arrangement of data on Cs-137 specific activity in children in each rayon is presented in Figure 2. The highest level of Cs-137 specific activity was observed among children living in Braginskii, Elskii, Kormyanskii and

Table 1. Classification of study subjects by sex and rayon.[a]

Rayon	Boys	Girls	Total
Braginskii	335 (7, 10, 12)[b]	326 (7, 10, 12)	661 (7, 10, 12)
Buda-Koshelevskii	162 (7, 9, 12)	189 (7, 10, 12)	351 (7, 9, 12)
Gomelskii	804 (7, 9, 12)	830 (7, 10, 12)	1,634 (7, 10, 12)
Dobrushskii	644 (6, 8, 10)	712 (6, 8, 11)	1,356 (6, 8, 10)
Elskii	179 (5, 7, 11)	225 (6, 8, 11)	404 (6, 8, 11)
Zlobinskii	20 (7, 10, 12)	11 (10, 11, 14)	31 (8, 10, 13)
Kormyanskii	55 (6, 7, 9)	54 (6, 7, 8)	109 (6, 7, 9)
Lelchitskii	30 (5, 6, 10)	42 (5, 7, 10)	72 (5, 7, 10)
Loevskii	306 (5, 7, 10)	261 (5, 8, 11)	567 (5, 7, 10)
Petrikovskii	92 (5, 6, 10)	130 (5, 7, 11)	222 (5, 7, 11)
Rechitskii	10 (6, 7, 10)	14 (7, 10, 12)	24 (6, 8, 12)
Hoynikskii	159 (7, 8, 11)	147 (8, 9, 12)	306 (7, 9, 12)
Checherskii	31 (8, 12, 13)	44 (8, 10, 12)	75 (8, 10, 13)
Gomel City	290 (6, 8, 11)	326 (7, 10, 11)	616 (7, 9, 11)
Mozir City	11 (8, 10, 12)	7 (8, 9, 12)	18 (8, 10, 12)
Total	3,128 (6, 8, 11)	3,318 (6, 9, 11)	6,446 (6, 9, 11)

a. Subjects in the following rayons are not shown because the number was less than 10: Vetkovskii, Zitkovinchskii, Kalinkovichskii, Mozirskii, Narovlyanskii, Oktyabrskii, Rogachevskii and Svetlogorskii.

b. Each triplet gives the 25th, 50th and 75th sample percentiles of age distribution at the time of examination.

Lelchitskii rayons.

The Cs–137 specific activity by sex and age is shown in Figure 3. The Cs–137 specific activity was the same as the total in both boys and girls from the age of 5 to 11 years, but it was slightly lower in 5–6 year-old boys than in girls of the same age. The values of Cs–137 specific activity did not differ between boys and girls from 7 to 11 years of age. In boys of 11 years old or older, accumulation of Cs–137 was higher than in girls of the same age. In most cases the values of Cs–137 specific activity lie in the range between 30 and 80 Bq/kg. The 25th, 50th and 75th percentiles of Cs–137 specific activity distribution were 40, 60 and 150 Bq/kg, respectively. The minimal Cs–137 specific activity (0.5 Bq/kg) was found in an 11 year-old boy, while the maximal Cs–137 specific activity (1,011 Bq/kg) was found in an eight year-old boy.

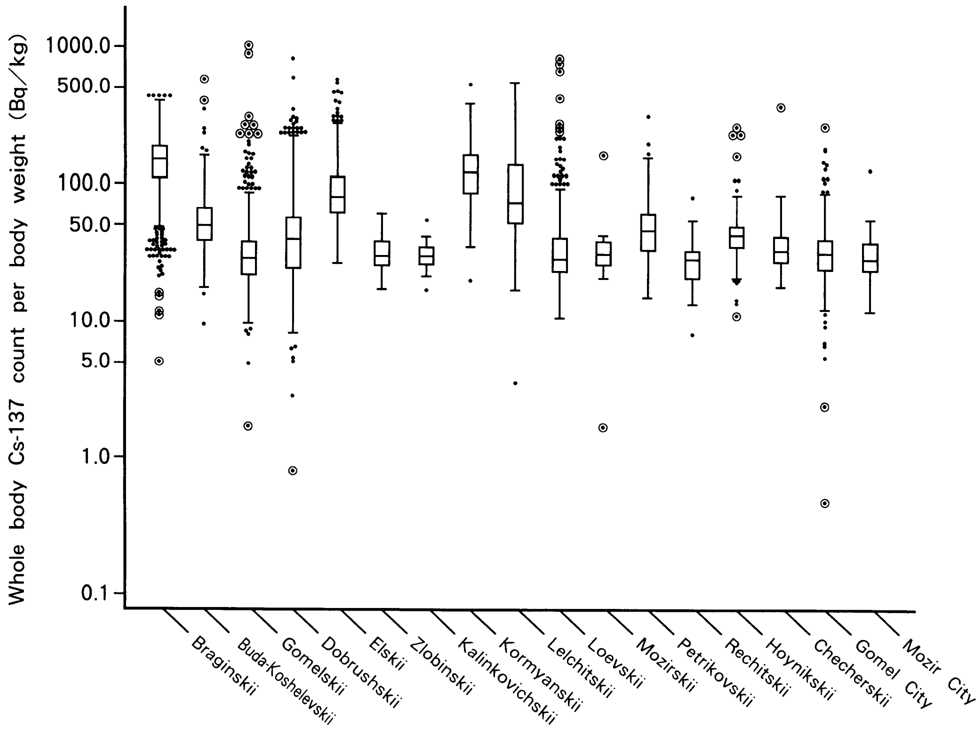

Figure 2. The box-and-whisker plots of whole body Cs–137 count per body weight by rayon. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, which are called "outside" and "far out," respectively.

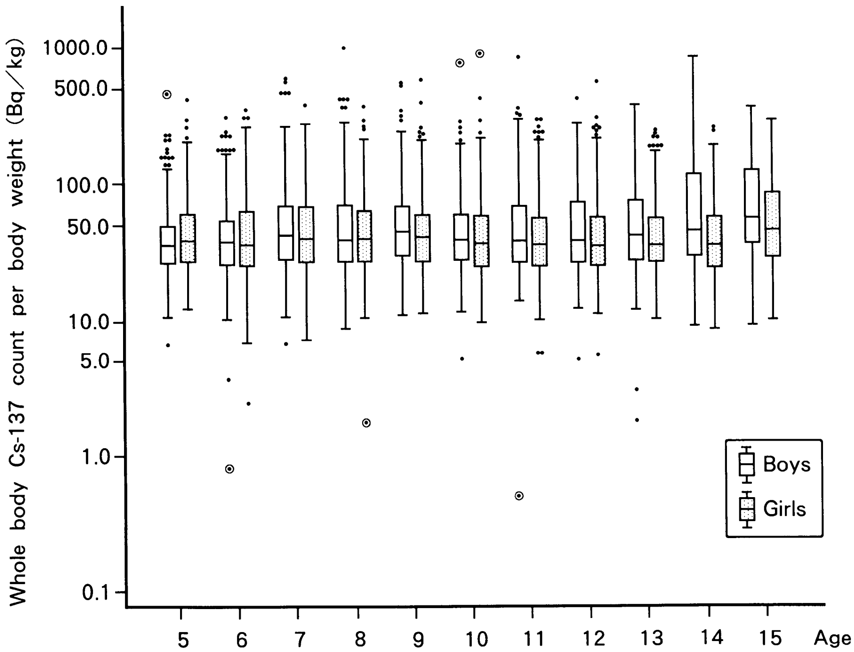

Figure 3. The box-and-whisker plots of whole body Cs–137 count per body weight by sex and age. See Figure 2 for details.

3. 3 Thyroid examinations

The changes in thyroid volume with age in boys and girls are shown in Figure 4. The volume increases until the age of 14 and levels off thereafter. The median of thyroid volume is 5 cm^3 and 12 cm^3 at the age of five and 14 years, respectively. The thyroid volume did not differ between boys and girls of the same age.

Goiter was defined as a thyroid volume exceeding the limit calculated by the following formula:

$$LIMIT = 1.7 \times 10^{0.13 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of a child in years, *height* is the height of a child in cm and *body weight* is the weight of a child in kg. See Appendix B for details.

The number of boys and girls with goiter in the rayons under study is shown in Table 2. The prevalence of goiter by sex and rayon of residence is shown in Figure 5. A significantly high prevalence of goiter was found in Elskii, Loevskii and Hoynikskii rayons. The number of girls and boys with goiter is practically the same (33.7%) in Hoynikskii rayon. In Loevskii rayon, goiter was found in 25% of boys and in 32% of girls. The lowest number of goiter cases was found in Braginskii rayon (2.4% of boys and 1.2% of girls), even though the radiocontamination density in this rayon is the highest in the oblast.

As shown in Figure 6, a significantly high proportion of thyroid abnormalities (nodule, cysts, abnormal echogenity, calcification and anomaly) was found

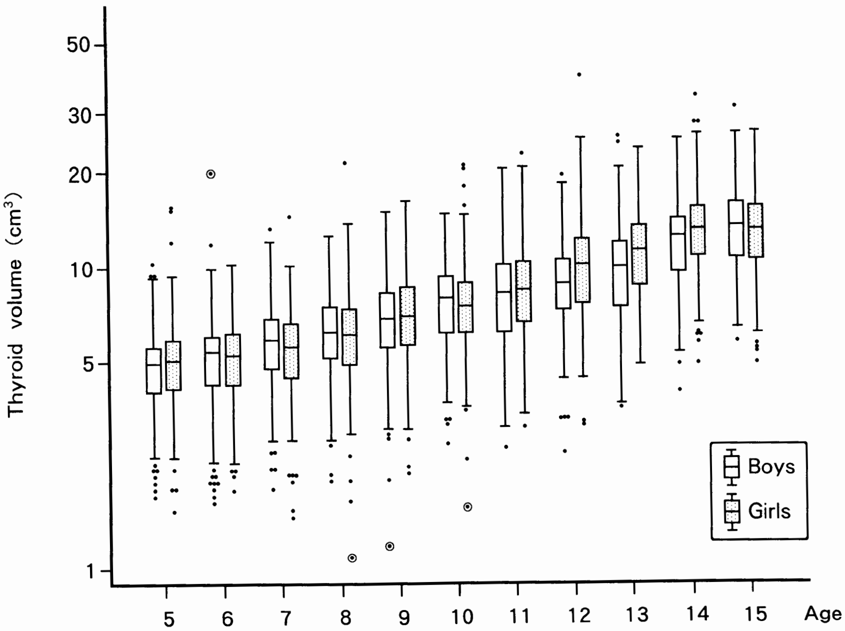

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. See Figure 2 for details.

Table 2. Subjects with goiter by sex and rayon.

Rayon	Number of subjects examined			Number of subjects with goiter		
	Boys	Girls	Total	Boys	Girls	Total
Braginskii	335	324	659	8	4	12
Gomelskii	804	830	1,634	99	136	235
Dobrushskii	644	712	1,356	35	43	78
Elskii	179	225	404	45	64	109
Zlobinskii	20	11	31	1	2	3
Kormyanskii	55	54	109	2	3	5
Lelchitskii	30	42	72	0	3	3
Loevskii	306	261	567	75	84	159
Mozirskii	15	14	29	2	2	4
Petrikovskii	92	130	222	1	4	5
Hoynikskii	159	147	306	54	49	103
Checherskii	31	44	75	5	7	12
Gomel City	290	326	616	39	54	93
Total	2,960	3,120	6,080	366	455	821

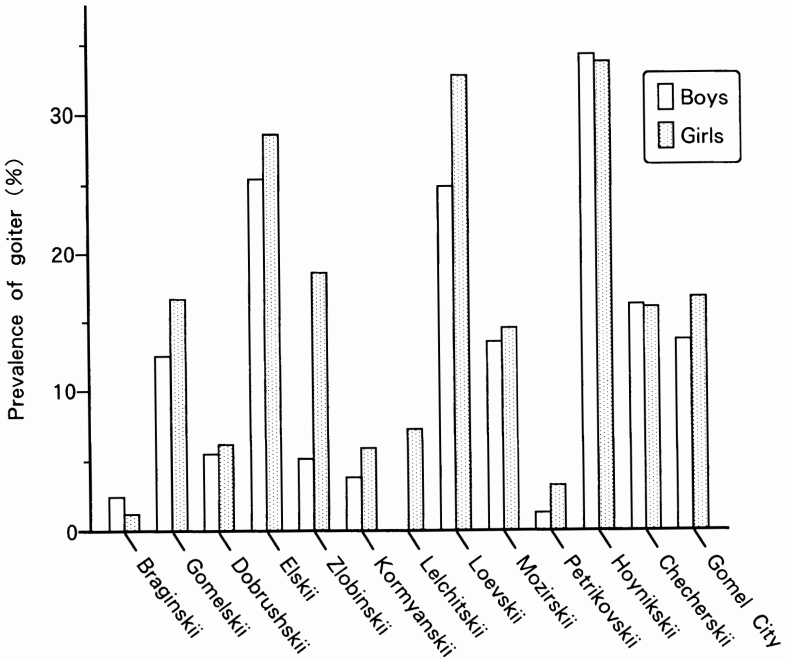

Figure 5. Prevalence of goiter by sex and rayon. See page 28 for the definition of goiter.

in Gomelskii (7.1% of boys and 14.8% of girls), Lelchitskii (6.7% of boys and 4.8% of girls), Buda-Koshelevskii (1.9% of boys and 9.5% of girls) and Hoynikskii (4.4% of boys and 6.8% of girls) rayons. The lowest proportion of abnormal cases was found in Dobrushskii rayon (0.6% of boys and 2.1% of girls).

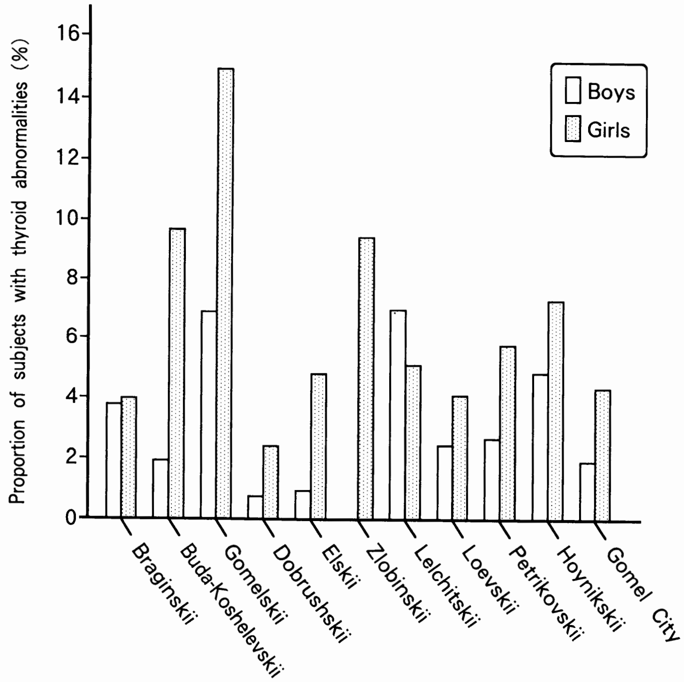

Figure 6. Proportion of subjects with thyroid abnormalities by sex and rayon.

Table 3 show the distribution of children with thyroid diseases by rayon of residence and sex:

The highest number of nodular formations was found in Gomelskii rayon – 23 children (13 boys and 10 girls) and in Gomel City – seven children (two

Table 3. Subjects with thyroid abnormalities by sex and rayon.

Rayon	Number of subjects examined		Diagnosis: Nodular lesion		Cystic lesion		Abnormal Echo-genity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Braginskii	335	324	4	2	0	0	9	11	0	0
Buda-Koshelevskii	162	189	0	0	0	0	3	18	0	0
Gomelskii	804	830	13	10	3	5	25	33	16	75
Dobrushskii	644	712	2	2	0	0	2	12	0	1
Elskii	179	225	0	0	0	0	1	10	0	0
Zlobinskii	20	11	0	0	0	0	0	0	0	1
Lelchitskii	30	42	1	0	0	0	1	2	0	0
Loevskii	306	261	2	3	0	1	4	5	0	1
Petrikovskii	92	130	1	0	0	0	1	7	0	0
Hoynikskii	159	147	1	0	0	0	6	10	0	0
Gomel City	290	326	2	5	0	0	2	8	0	0
Total	3,021	3,197	26	22	3	6	54	116	16	78

a. B, boys; G, girls.

boys and five girls). The total number of children with nodular formations was 48 (26 boys and 22 girls). The comprehensive examination of children with nodular formations revealed thyroid cancer in seven subjects (two boys and five girls). The ultrasonographic finding of one of these cases is shown in Figure 7.

Cysts were found in nine children. The prevalence of cysts in girls was twice as high as that in boys. In Gomelskii rayon, cysts were found in eight children (three boys and five girls).

Abnormal echogenity was found in 170 children (54 boys and 116 girls). In descending order of frequency, abnormal echogenity was found in Gomelskii, Buda-Koshelevskii, Braginskii, Hoynikskii, Dobrushskii, Elskii, Gomel City, Loevskii, Petrikovskii and Lelchitskii rayons. The general trend was toward an increase in the number of cases of abnormal echogenity among girls.

Congenital developmental abnormalities were registered mainly in Gomelskii rayon with 91 cases (16 boys and 75 girls). The total number of congenital abnormalities was 94 (16 boys and 78 girls).

The results of the study to date indicate the existence of definite thyroid abnormalities among the children of Gomel Oblast.

Table 4 shows the number of children with simultaneously high TSH and low free T_4 levels (hypothyroidism) and with simultaneously low TSH and high free T_4 levels (hyperthyroidism) arranged by sex and rayon of residence. Table 5 shows the number of children with anti-thyroglobulin and anti-

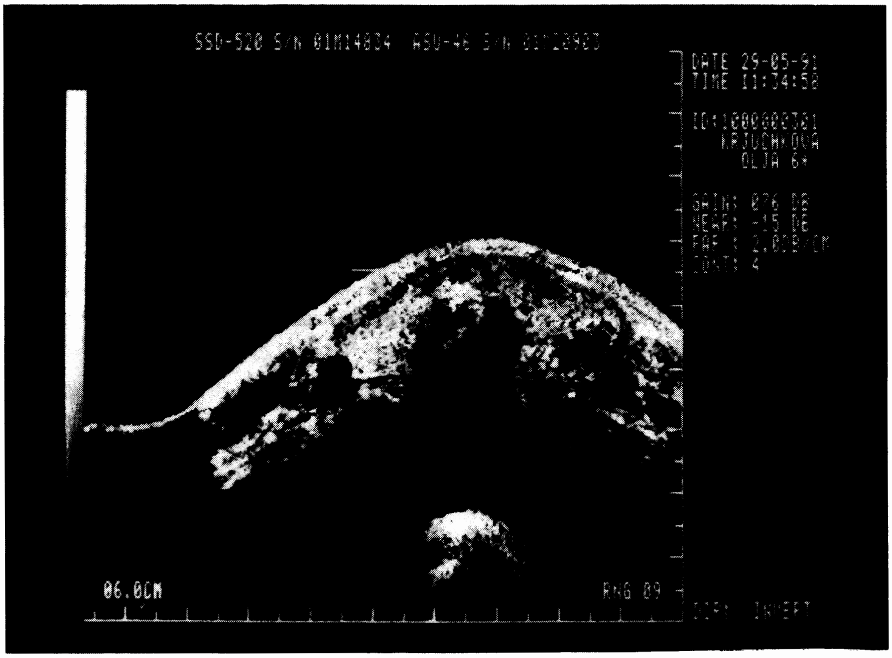

Figure 7. An ultrasonograph of thyroid in a 5-year old girl (born on 29 August 1985 and examined on 29 May 1991) with papillary adenocarcinoma.

Table 4. Number of subjects with hypothyroidism or hyperthyroidism by sex and rayon.

Rayon	Number of subjects measured			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Braginskii	659	335	324	1	1	0	0	0	0
Buda-Koshelevskii	351	162	189	2	1	1	0	0	0
Gomelskii	1,634	804	830	5	1	4	3	1	2
Dobrushskii	1,356	644	712	4	1	3	0	0	0
Elskii	404	179	225	1	0	1	0	0	0
Kormyanskii	109	55	54	1	1	0	0	0	0
Loevskii	567	306	261	3	2	1	1	1	0
Hoynikskii	306	159	147	1	1	0	0	0	0
Gomel City	616	290	326	3	1	2	0	0	0
Total	6,002	2,934	3,068	21	9	12	4	2	2

a. Diagnosed when free $T_4 < 10.0$ pmol/l and $TSH > 2.90$ μIU/ml.
b. Diagnosed when free $T_4 > 25.0$ pmol/l and $TSH < 0.24$ μIU/ml.

Table 5. Number of subjects with anti-thyroglobulin and/or anti-microsome antibodies by sex and rayon.

Rayon	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Braginskii	659	335	324	2	2	0	2	1	1
Buda-Koshelevskii	351	162	189	4	1	3	7	4	3
Gomelskii	1,634	804	830	19	7	12	50	19	31
Dobrushskii	1,356	644	712	16	7	9	35	16	19
Elskii	404	179	225	10	2	8	29	11	18
Kormyanskii	109	55	54	0	0	0	1	0	1
Loevskii	567	306	261	1	0	1	4	1	3
Hoynikskii	306	159	147	5	3	2	9	5	4
Gomel City	616	290	326	9	2	7	19	6	13
Total	6,002	2,934	3,068	66	24	42	156	63	93

microsome antibodies by sex and rayon of residence. The results of the examination of thyroid function revealed the highest number of deviations from normal among the children of Gomelskii, Dobrushskii and Elskii rayons. The number of girls with an increased level of hormones was slightly higher than that of boys. At the same time, the number of girls with positive titers of ATG and AMC was 1.5–2 times higher than that of boys.

3. 4 Hematological studies

The hematological data are shown in Figures 8–19. The data on hemoglobin, WBC, platelet, lymphocytes, neutrophil count and MCV are arranged according to sex, age and residence. Most of the measurements were within normal limits for all parameters, and only minor fluctuations were

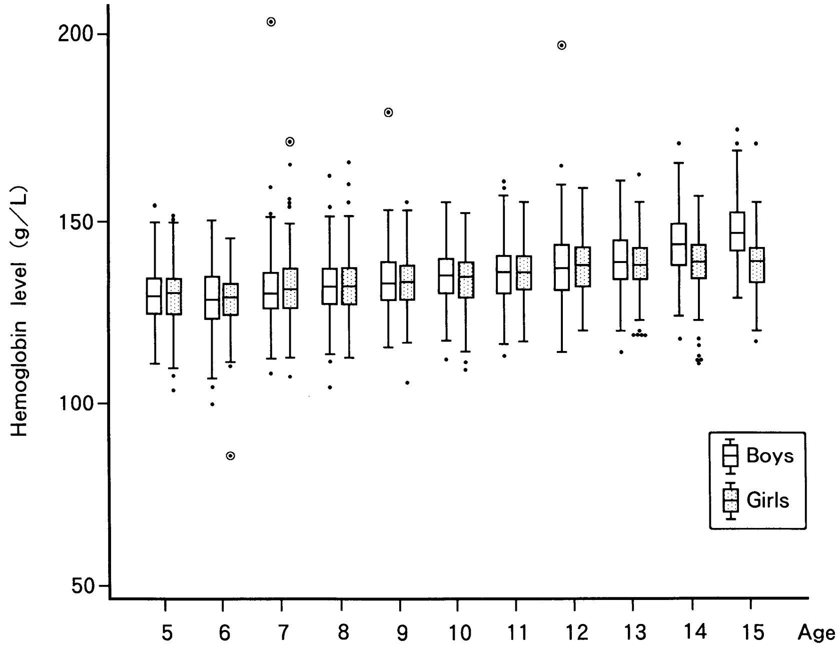

Figure 8. The box-and-whisker plots of hemoglobin level by sex and age. See Figure 2 for details.

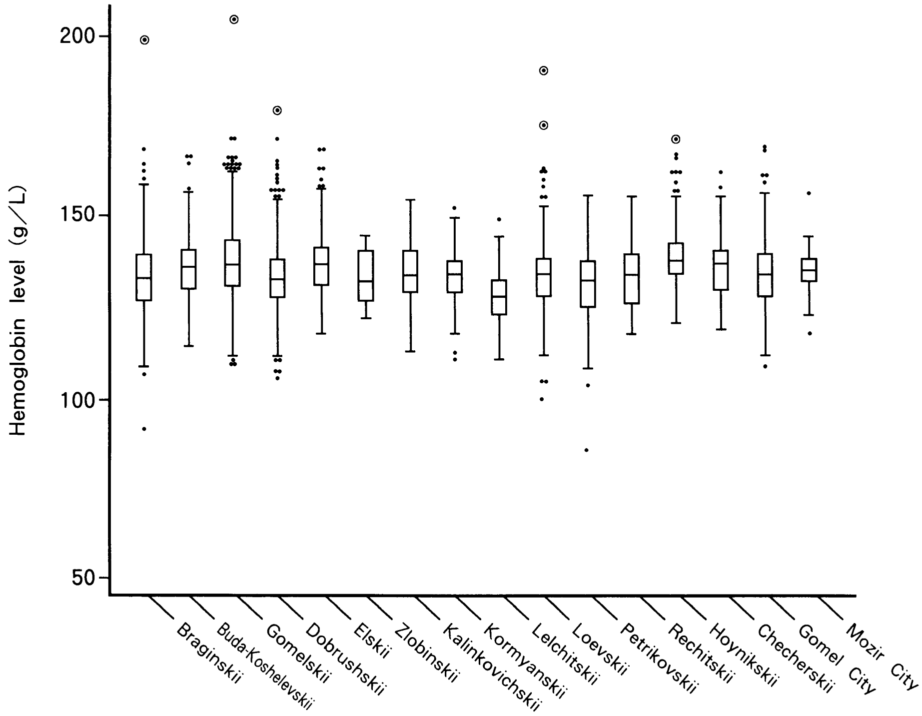

Figure 9. The box-and-whisker plots of hemoglobin level by rayon. See Figure 2 for details.

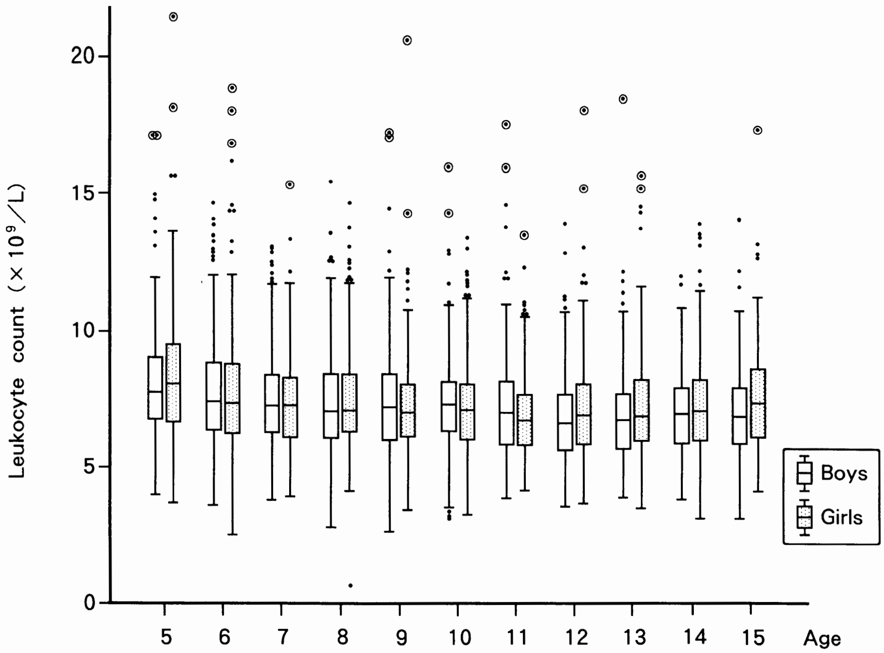

Figure 10. The box-and-whisker plots of leukocyte count by sex and age. See Figure 2 for details.

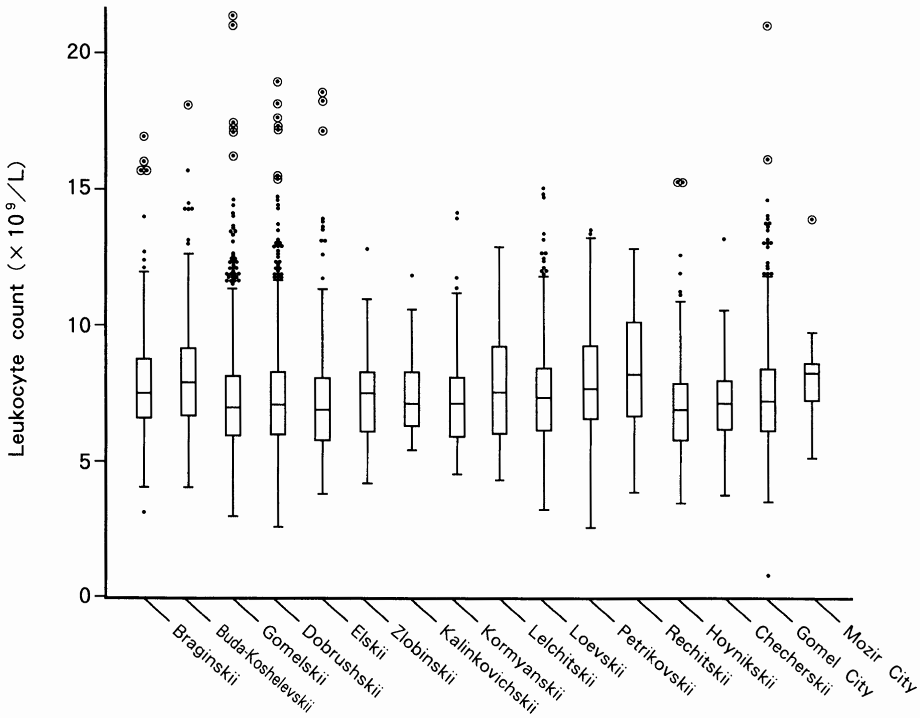

Figure 11. The box-and-whisker plots of leukocyte count by rayon. See Figure 2 for details.

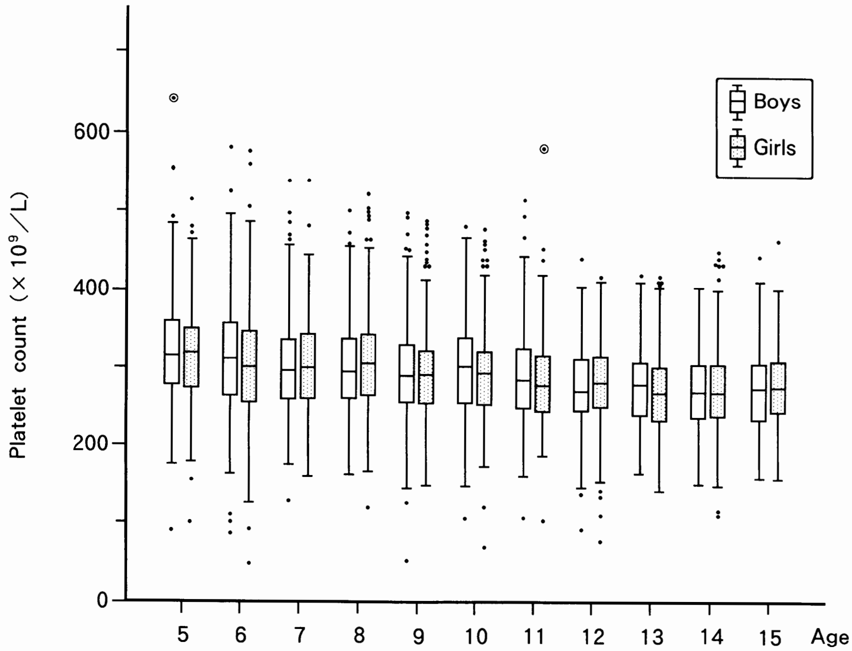

Figure 12. The box-and-whisker plots of platelet count by sex and age. See Figure 2 for details.

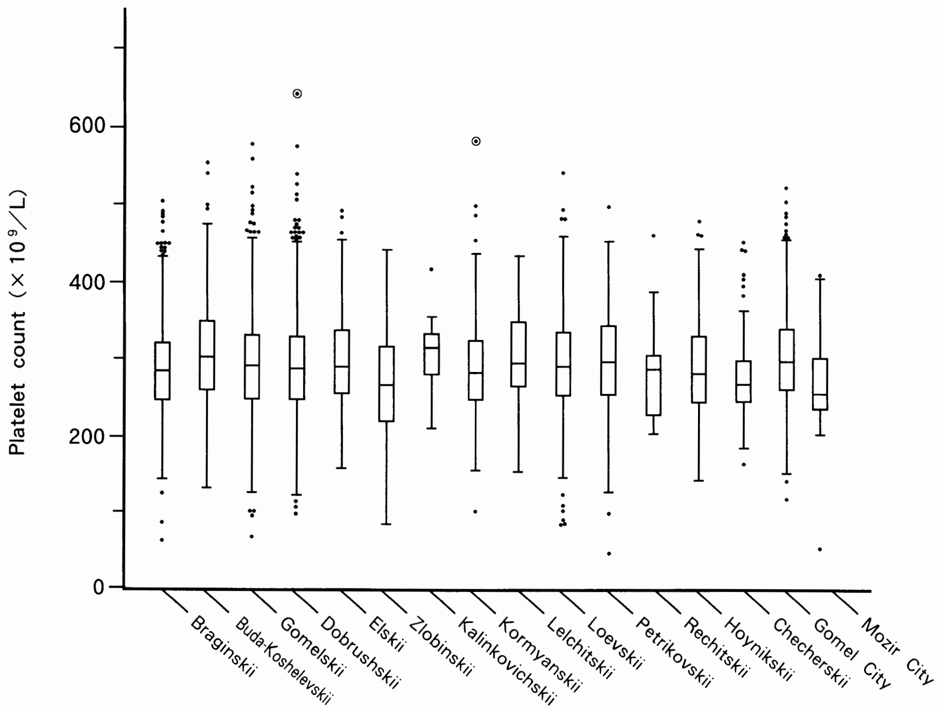

Figure 13. The box-and-whisker plots of platelet count by rayon. See Figure 2 for details.

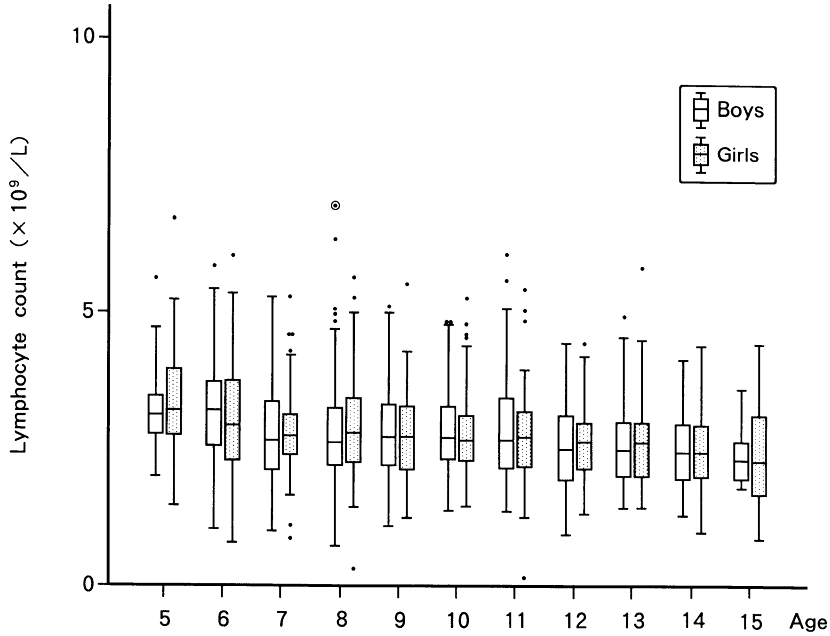

Figure 14. The box-and-whisker plots of lymphocyte count by sex and age. See Figure 2 for details.

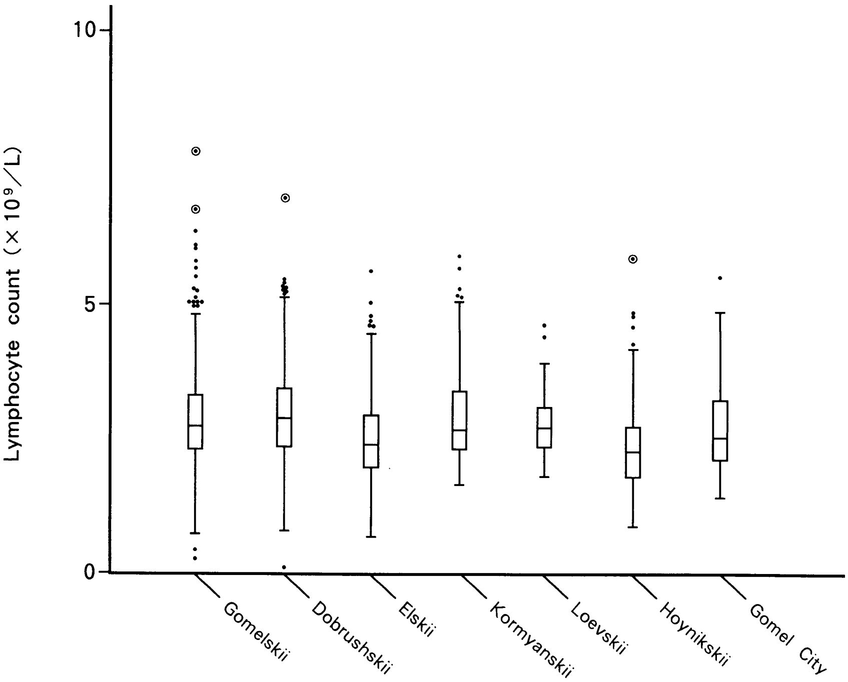

Figure 15. The box-and-whisker plots of lymphocyte count by rayon. See Figure 2 for details.

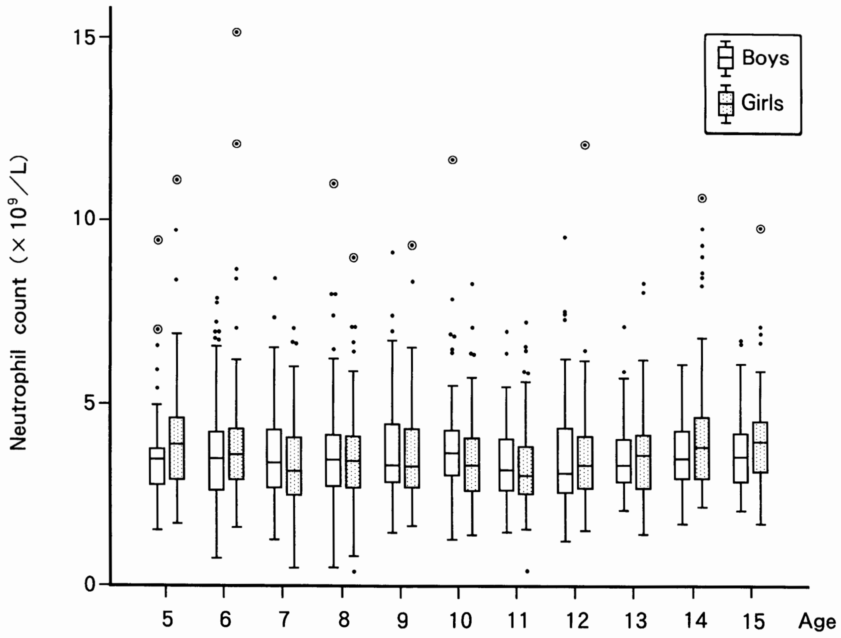

Figure 16. The box-and-whisker plots of neutrophil count by sex and age. See Figure 2 for details.

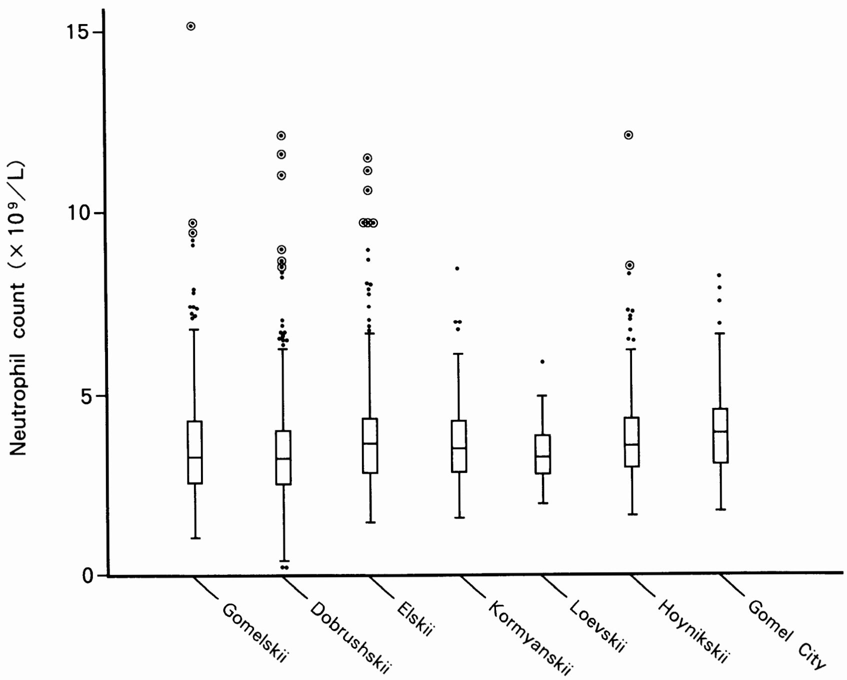

Figure 17. The box-and-whisker plots of neutrophil count by rayon. See Figure 2 for details.

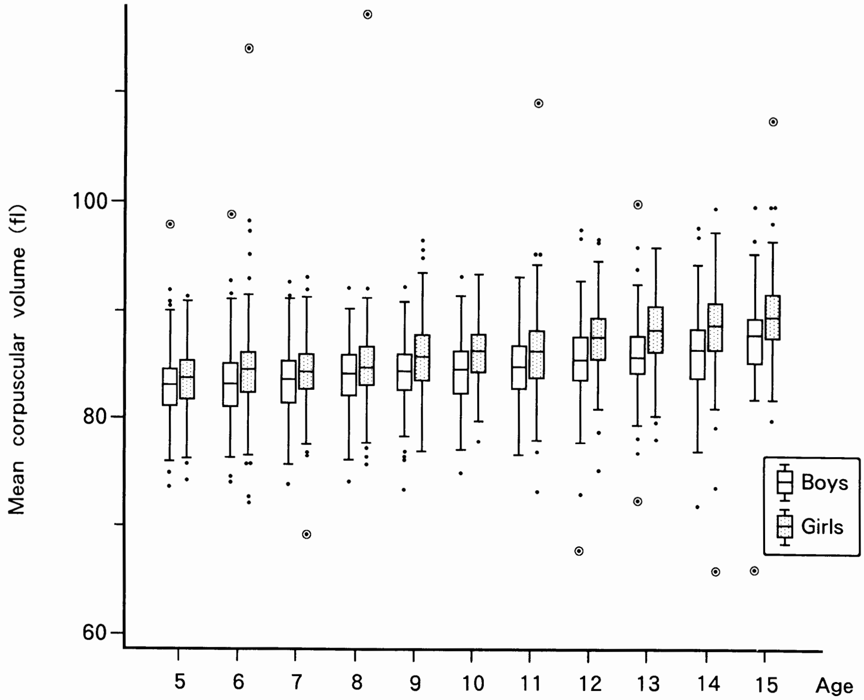

Figure 18. The box-and-whisker plots of mean corpuscular volume by sex and age. See Figure 2 for details.

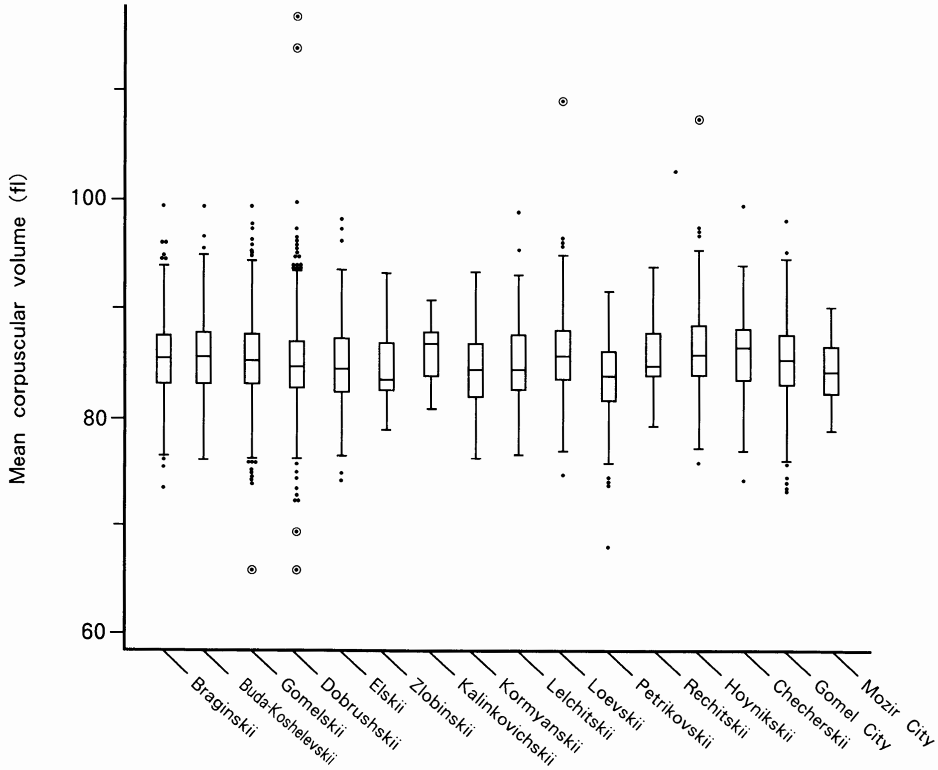

Figure 19. The box-and-whisker plots of mean corpuscular volume by rayon. See Figure 2 for details.

observed.

An increase in hemoglobin with age was noted, especially in boys. In girls the parameter stabilizes at 12–15 years of age. At the same time, a slight decrease in PLT with age was observed among both boys and girls. A slight increase in MCV with age was noted, especially in girls.

The deviations of hemoglobin level, white blood cell count (WBC), platelet count (PLT), and mean corpuscular volume (MCV) from normal limits observed in children by sex and Cs–137 specific activity are shown in Table 6. An increase in the parameters mentioned above has occurred among children in Gomelskii, Dobrushskii, Loevskii, Braginskii, Hoynikskii, Elskii and Kormyanskii rayons.

Table 6. Frequency of subjects with hematological abnormalities by Cs–137 level.[a]

Blood analysis		Whole body Cs–137 count per body weight (Bq/kg)					Total
Item (unit)[b]	Abnormality criteria	0–50	50–100	100–200	200–500	≥500	
Hb (g/L)	<110[c]	4 (0.1)	2 (0.1)	1 (0.1)			7 (0.1)
	>180[c]	1 (0.0)		1 (0.1)			2 (0.0)
	<110[d]	3 (0.1)	2 (0.1)	1 (0.1)	1 (0.4)		7 (0.1)
	>160[d]	7 (0.2)					7 (0.1)
WBC ($\times 10^9$/L)	<3.8[c]	12 (0.3)	4 (0.3)				16 (0.2)
	>10.6[c]	103 (2.3)	45 (3.3)	22 (3.0)	8 (3.6)		178 (2.7)
	<3.6[d]	7 (0.2)	1 (0.1)				8 (0.1)
	>11.0[d]	87 (1.9)	33 (2.4)	19 (2.6)	2 (0.9)		141 (2.2)
PLT ($\times 10^9$/L)	<100	19 (0.4)	2 (0.1)	2 (0.3)	1 (0.4)		24 (0.4)
	>440	93 (2.0)	25 (1.7)	16 (2.1)	1 (0.4)	1 (7.7)	136 (2.1)
MCV (fl)	<80	274 (5.8)	64 (4.5)	39 (5.1)	9 (3.9)	2 (15.4)	388 (6.0)
	>100	8 (0.2)	4 (0.3)	1 (0.1)			13 (0.2)
Number of children measured[e]		4,235	1,310	720	220	11	6,496
Ly ($\times 10^9$/L)	<1.2	18 (1.4)	3 (0.7)	3 (1.6)	1 (1.8)		25 (1.3)
	>3.5	239 (18.9)	71 (16.4)	29 (15.6)	12 (21.4)		351 (18.1)
Ne ($\times 10^9$/L)	<1.4	20 (1.6)	2 (0.5)	1 (0.5)			23 (1.2)
	>6.6	43 (3.4)	17 (3.9)	8 (4.3)	3 (5.4)		71 (3.7)
Eo ($\times 10^9$/L)	>0.5	259 (20.5)	87 (20.1)	45 (24.2)	10 (17.9)	1 (33.3)	402 (20.7)
Mo ($\times 10^9$/L)	<0.12	183 (14.5)	35 (8.1)	18 (9.7)	8 (14.3)		244 (12.5)
	>1.00	27 (2.1)	13 (3.0)	5 (2.7)	1 (1.8)		46 (2.4)
Number of children measured[f]		1,266	434	186	56	3	1,945

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

e. Number of children measured for Hb, WBC, PLT and MCV.

f. Number of children measured for Ly, Ne, Eo and Mo.

A hemoglobin level below normal was found in seven boys in Braginskii, Loevskii and Perikovskii rayons and Gomel City and in seven girls in these rayons as well as Dobrushskii, Hoynikskii and Gomelskii rayons. A hemoglobin level above 180 g/L was found in two boys, and a level above 160 g/L was found in seven girls.

A decrease in WBC was observed in 16 boys and eight girls while an increase in WBC was observed in 178 boys and 141 girls.

A PLT below 100×10^9/L was found in 24 children, and a PLT above 440×10^9/L was found in 136 children.

An MCV below 80 fl was noted in 388 children or 6% of all examined subjects.

It should be noted that there was no trend toward a deviation from the normal range when the blood parameters were arranged according to level of radionuclide accumulation.

The deviation from normal range of lymphocyte, neutrophil, eosinophil and monocyte count is shown in the lower part of Table 6 according to radionuclide accumulation in the body. These data were obtained from 1,945 children examined in the second half of 1992 because the analysis of hemogram had not been conducted before that time.

A decrease and increase in lymphocyte count were noted in 25 and 351 children, respectively.

A decrease and increase in neutrophil count were observed in 23 and 71 children, respectively.

Eosinophilia was found in 402 children (20.7% of all examined subjects), 175 and 85 of whom are residents of Dobrushskii rayon and Gomelskii rayon, respectively. Figure 20 shows the relationship between eosinophil count and sex and age of examined children. Eosinophilia was more pronounced in children of a younger age, regardless of sex.

A decrease and increase in monocyte count were found in 244 (12.5%) and 46 (2.4%) of the children, respectively. No relationship was found between monocyte count and sex or age (Figure 21).

Specific changes in hemogram were found in 1,162 of the 1,945 examined children (59.7%). The highest number of deviations was noted among children in Dobrushskii (508 or 75.8% of the 670 examined subjects), Gomelskii (284 or 58.0% of the 490 examined subjects), Loevskii and Petrikovskii rayons while the lowest was observed in Elskii, Kormyanskii and Hoynikskii rayons.

4. Discussion and Conclusions

The Cs–137 specific activity accumulated in the body of each child lies in the range between 30 to 80 Bq/kg. No significant difference in Cs–137 specific activity has been found between boys and girls. The highest levels of Cs–137 in the body were found among children living in the most contaminated areas where contamination density is 15 Ci/km^2 or more. In these areas the level of

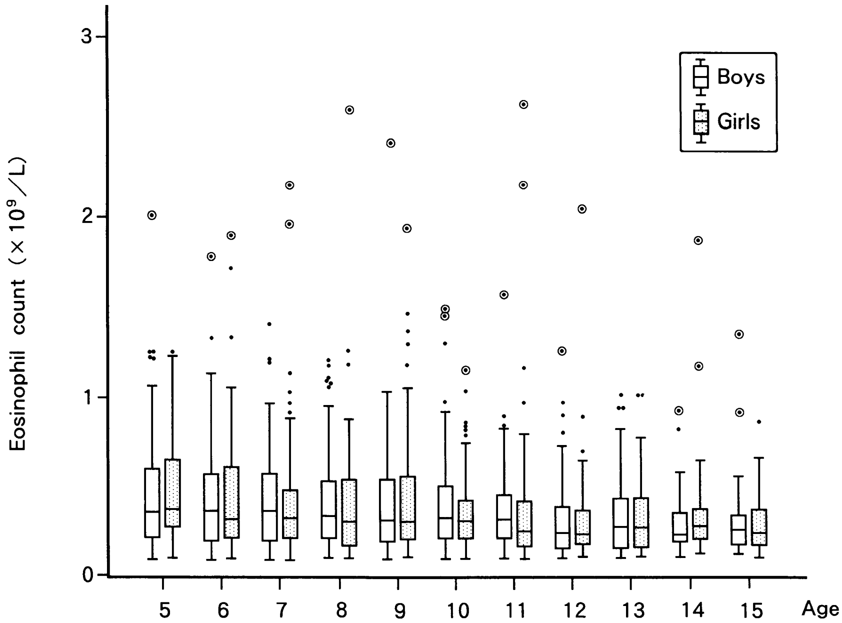

Figure 20. The box-and-whisker plots of eosinophil count by sex and age. See Figure 2 for details.

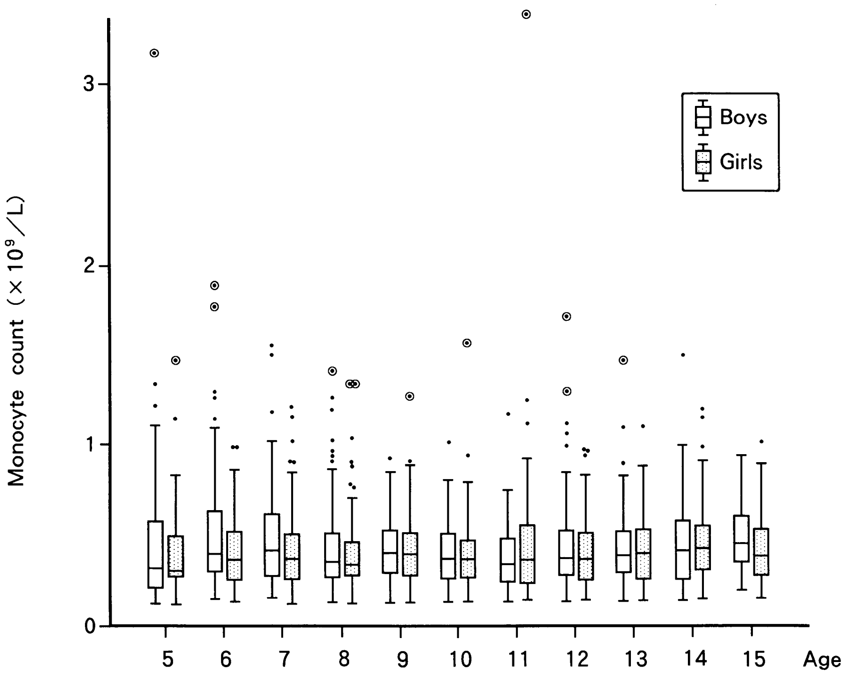

Figure 21. The box-and-whisker plots of monocyte count by sex and age. See Figure 2 for details.

Cs–137 accumulation is influenced not only by external but also by internal supply of radionuclides.

Thyroid abnormality has been noted in the examined children by ultrasound examination and the testing of thyroid function. The highest number of abnormalities was found among children living in Gomelskii rayon. In this rayon, 50.5% of the subjects are children relocated from zones with high contamination density.

Fluctuations in blood parameters, particularly hemogram, have been noted in a considerable number of children.

Because of the small size of the study group we cannot draw any firm conclusions on this matter. It is necessary to increase the number of examinations, to extend the territory under examination, and to investigate the relationship between parameters observed and the presence of various chronic diseases in children.

Results of the Examination of the Health Status of Children in Klincy City and Klintsovskii Rayon

Municipal Children's Hospital of Klincy City

Karyevskaya I. V., Steputin L. A., Kovalev A. I., Aksynov A. S., Ushakova T. I., Ashitok L. M., Troyanova, N. N.

1. Introduction

In the Russian Federation, the laboratory equipment donated by the Sasakawa Memorial Health Foundation is being used in Klincy City of Bryansk Oblast (Province). The objective of the work is the mass examination and the evaluation of the pathologic state of children residing in areas of Bryansk Oblast contaminated as a result of the Chernobyl accident (cf. Appendix A).

2. Materials and Methods

2. 1 Study subjects

The subjects under study are children living in the contaminated areas who were born in the period between 26 April 1976 and 26 April 1986. The examination of the children is carried out by the same techniques and the same equipment as those employed by the other centers.

2. 2 Measurement of whole body Cs-137 concentration

Cs-137 activity in the body was measured with a whole body counter, Model-101, manufactured by Aloka Company. The Cs-137 activity was measured in Bq followed by calculation of the specific activity (per kg of body mass).

2. 3 Thyroid examinations

Thyroid investigation includes the ultrasound scanning of the thyroid gland with automatic measuring of its volume by outlining of each image. An arch-automatic ultrasound instrument (Aloka SSD-520) is being used in this investigation.

To study thyroid function, free thyroid thyroxine (FT_4) and thyroid stimulating hormone (TSH) concentration was determined by the immunometric technique based on enhanced luminescence using the hormone analyzer "Amerlite".

To assay titers of anti-microsome antibodies (AMC) and anti-thyroglobulin antibodies (ATG), the reaction of agglutination by microtitration was conducted (Fujirevio).

Thyroid volume, presence or absence of thyroid abnormalities, nodules, cysts, calcificates, echogenity, as well as the levels of FT_4 and TSH and positive titer of AMC and ATG were taken into consideration in the establishment of all diagnoses.

2. 4 Hematological studies

The peripheral blood test includes the determination of eight parameters using the hemoanalyzer, Model K-1000 of Sysmex. These parameters are: (1) white blood cell count (WBC), (2) red blood cell count (RBC), (3) hemoglobin concentration (Hb), (4) platelet count (PLT), (5) hematocrit (Ht), (6) mean corpuscular volume (MCV), (7) mean corpuscular hemoglobin (MCH), and (8) mean corpuscular hemoglobin concentration (MCHC). The analysis of morphologic leukocyte differentiation was conducted as well using an "Olympus" microscope. Peripheral blood smears were stained by the May-Grünwald-Giemsa method.

3. Results

3. 1 Study subjects

A total of 3,764 children were examined from May 1991 to December 1992. 3,432 of the 3,764 live in areas with a contamination density ranging from 5 to 15 Ci/km^2 (Klincy City), while 242 children live in an area where the contamination density is in the range of 1 to 5 Ci/km^2 (Klintsovskii Rayon) (cf. Figure 1). The quantitative distribution of examined children by sex and place of residence is presented in Table 1.

3. 2 Measurement of whole body Cs–137 concentration

The relationship between Cs–137 specific activity found by measurement of Cs–137 accumulation in the body and the place of residence of children is given in Figure 2. In children living in areas with a low contamination density, the median of Cs–137 specific activity in a body is higher than that in children living in more contaminated areas. This may be attributable to the fact that areas with low contamination densities belong to agricultural zones. Residents of these zones consume food from private plots, unprocessed milk, mushrooms, forest berries, fish from contaminated reservoirs as well as the meat of wild animals. The wider scatter of data on Cs–137 accumulation in children living in Klincy City may be attributable to the same factors.

The relationship between Cs–137 specific activity and age and sex is given in Figure 3. The median of Cs–137 specific activity of about 50 Bq/kg does not correlate with the sex or age of the examined children.

3. 3 Thyroid examinations

The results of the study show that thyroid volume increases with the age of

Figure 1. Cs–137 contamination levels (Ci/km^2) in the rayons of Bryansk oblast.
a. Minimum and maximum levels of contamination.

Table 1. Classification of study subjects by sex and rayon.

Rayon	Boys	Girls	Total
Klintsovskii	116 (7, 9, 12)[a]	126 (8, 9, 12)	242 (7, 9, 12)
Klincy City	1,670 (7, 10, 13)	1,762 (8, 11, 14)	3,432 (8, 11, 14)
Total	1,786 (8, 10, 14)	1,888 (8, 11, 14)	3,674 (8, 10, 14)

a. Each triplet gives the 25th, 50th and 75th sample percentiles of age distribution at the time of examination.

a child. In girls of 12–13 years old the thyroid volume is just above that in boys of the same age (Figure 4).

The prevalence of goiter by sex and residence is shown in Figure 5. The prevalence of goiter is higher in children living in more contaminated areas, and it is higher in boys than in girls. The prevalence of goiter in children living in less contaminated areas does not differ by sex. See Appendix B for details concerning the definition of goiter.

The classification of thyroid abnormality according to sex and place of residence is given in Table 2. Thyroid abnormalities have been found in children living in Klincy City.

The number of children with hyperfunction, i.e. high FT_4 and low TSH levels, and hypofunction, i.e. high TSH and low FT_4 levels, is shown in Table 3 by sex and rayon of residence. In each group there are two children: a boy and a girl in the age range of six to nine years.

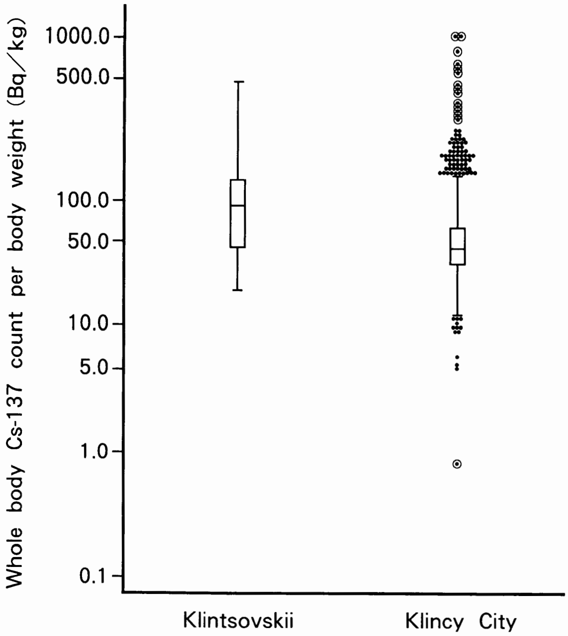

Figure 2. The box-and-whisker plots of whole body Cs-137 count per body weight by rayon. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, which are called "outside" and "far out," respectively.

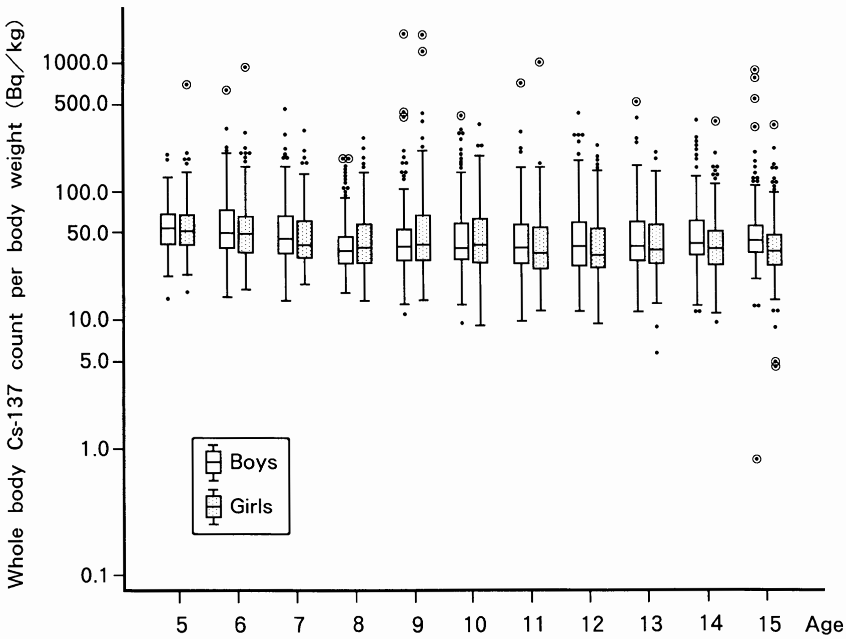

Figure 3. The box-and-whisker plots of whole body Cs-137 count per body weight by sex and age. See Figure 2 for details.

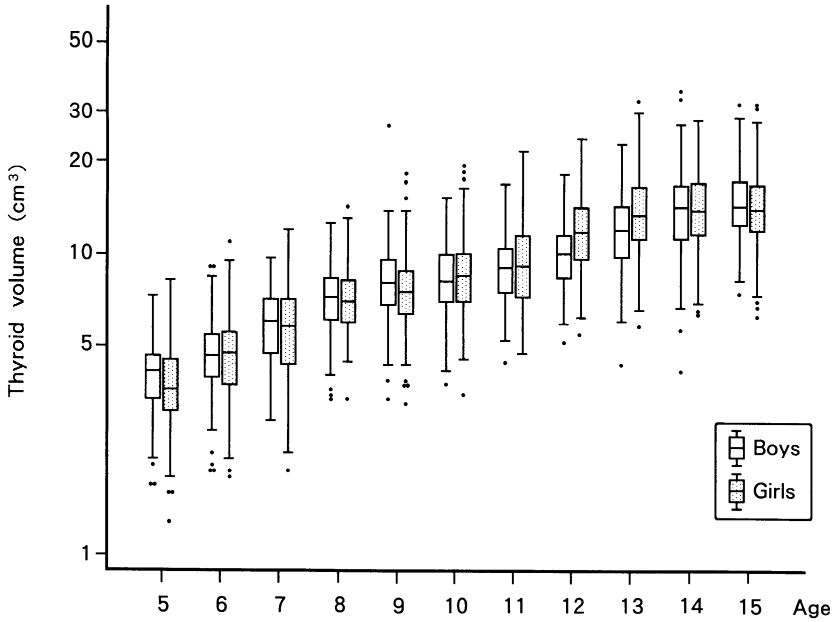

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. See Figure 2 for details.

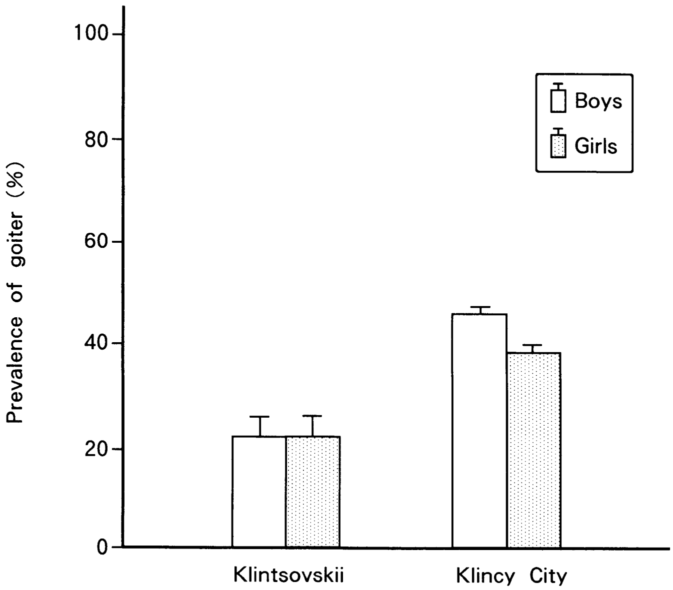

Figure 5. Prevalence of goiter by sex and rayon. The whiskers denote the standard errors. See Appendix B for the definition of goiter.

The distribution of children according to determined ATG and AMC levels is given in Table 4.

3. 4 Hematological studies

The relationship between hemoglobin level and the sex and age of examined

Table 2. Subjects with thyroid abnormalities by sex and rayon.

Rayon	Number of subjects examined		Diagnosis							
			Nodular lesion		Cystic lesion		Abnormal echogenity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Klintsovskii	116	126	0	0	0	0	0	0	0	0
Klincy City	1,670	1,762	5	11	14	10	14	31	1	0
Total	1,786	1,888	5	11	14	10	14	31	1	0

a. B, boys; G, girls.

Table 3. Number of subjects with hypothyroidism or hyperthyroidism by sex and rayon.

Rayon	Number of subjects measured			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Klintsovskii	237	114	123	0	0	0	0	0	0
Klincy City	3,300	1,609	1,691	2	1	1	2	1	1
Total	3,537	1,723	1,814	2	1	1	2	1	1

a. Diagnosed when free $T_4 < 10.0$ pmol/l and TSH > 2.90 μIU/ml.
b. Diagnosed when free $T_4 > 25.0$ pmol/l and TSH < 0.24 μIU/ml.

Table 4. Number of subjects with anti-thyroglobulin and/or anti-microsome antibodies by sex and rayon.

Rayon	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Klintsovskii	237	114	123	3	2	1	1	1	0
Klincy City	3,300	1,609	1,691	37	12	25	92	31	61
Total	3,537	1,723	1,814	40	14	26	93	32	61

children is shown in Figure 6. It is seen that hemoglobin level increases with age.

The relationship between mean corpuscular volume (MCV) and the sex and age of examined children is shown in Figure 7. The median of MCV is within normal limits, and the trend is toward an increase in MCV with age. The median values are slightly lower among boys than among girls in all age groups.

As shown in Figure 8, the median of platelet count (PLT) is within normal limits, and the trend is toward a decrease with age.

The median of white blood cell count (WBC) also shows no correlation with the sex or age of the examined children as shown in Figure 9. The dispersion of data was probably caused by the presence of infections among the children

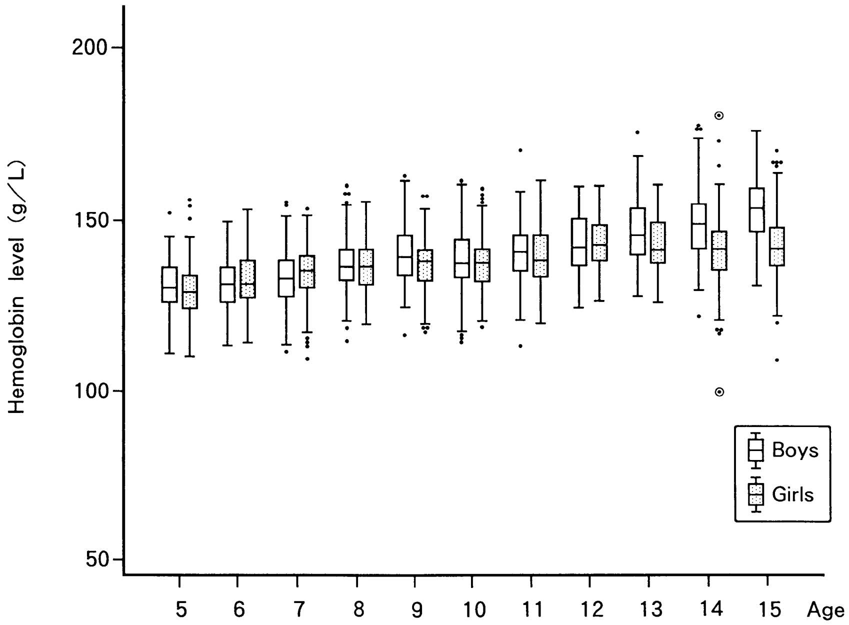

Figure 6. The box-and-whisker plots of hemoglobin level by sex and age. See Figure 2 for details.

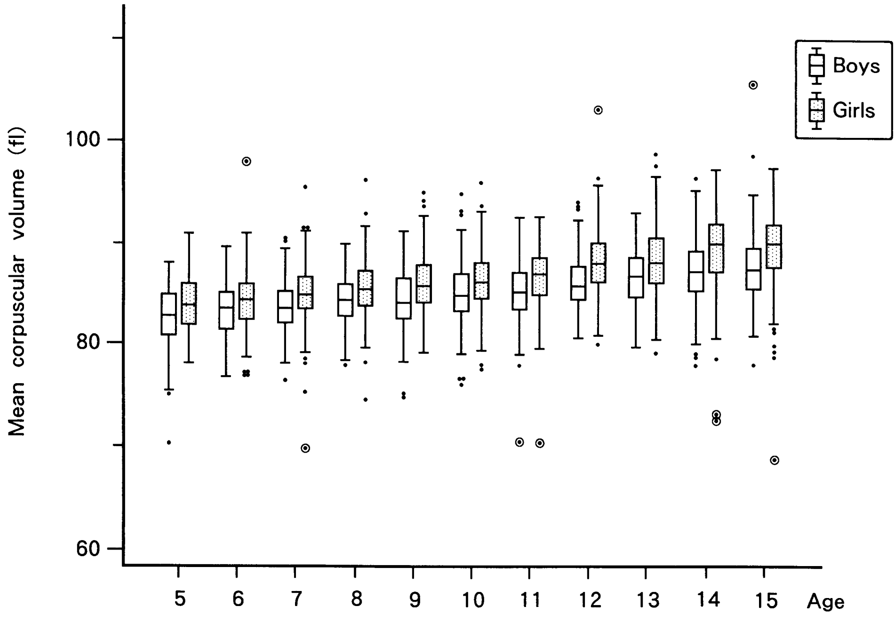

Figure 7. The box-and-whisker plots of mean corpuscular volume by sex and age. See Figure 2 for details.

at the time of the examination, a fact that was confirmed by the data in Figure 10.

Figure 10 shows that the median of neutrophil count is within normal limits and does not correlate with the sex or age of the examined children.

The median of lymphocyte count does not differ by sex, and it decreases

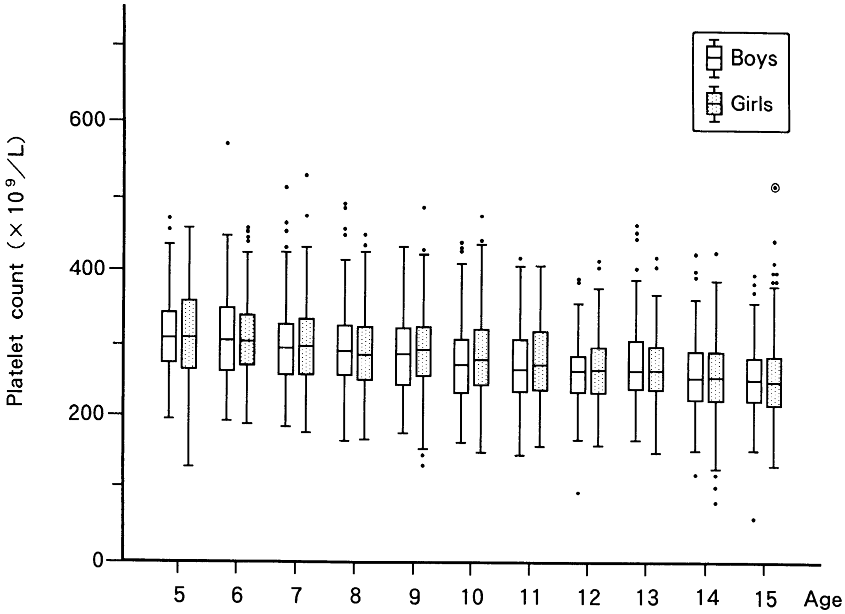

Figure 8. The box-and-whisker plots of platelet count by sex and age. See Figure 2 for details.

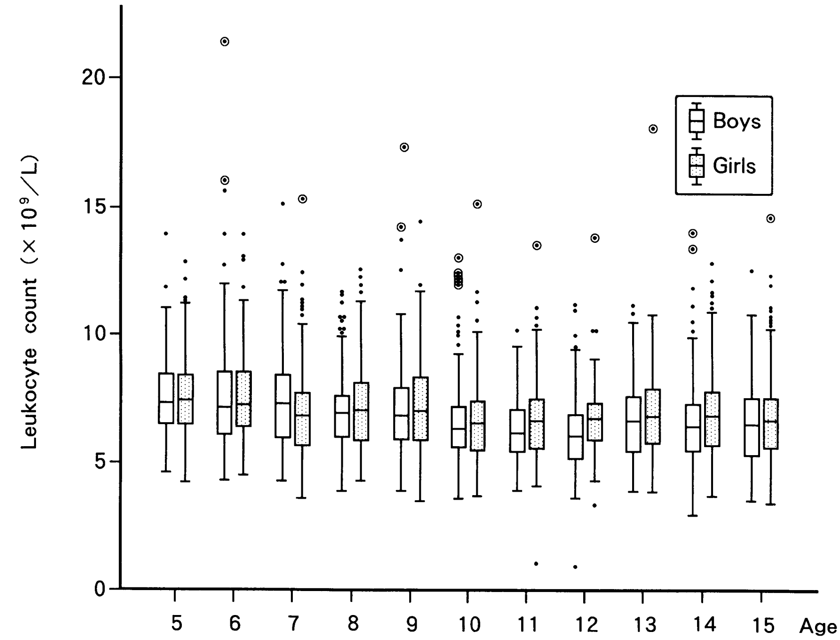

Figure 9. The box-and-whisker plots of leukocyte count by sex and age. See Figure 2 for details.

with age as shown in Figure 11.

The relationship between eosinophil count and sex and age is plotted in Figure 12. The median of eosinophil count is within normal limits. A significant portion of data, however, are beyond the upper limit of normal.

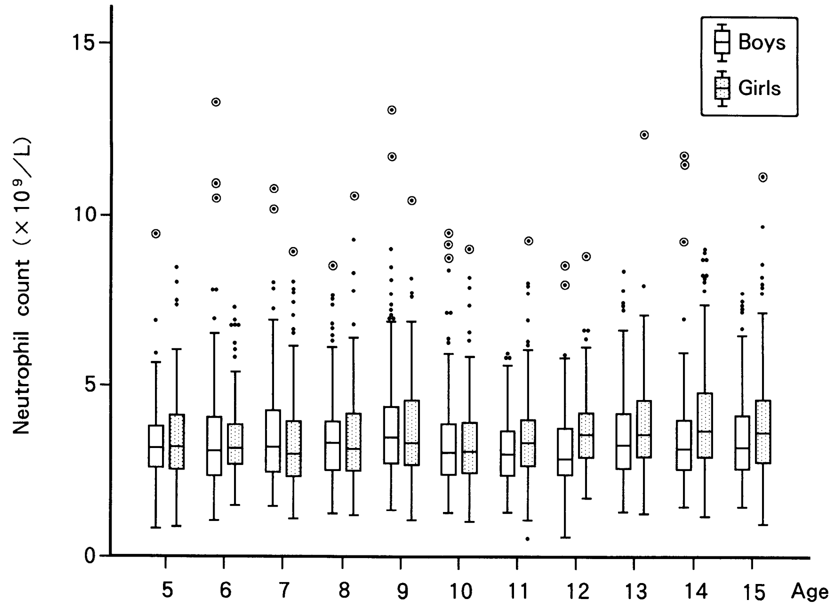

Figure 10. The box-and-whisker plots of neutrophil count by sex and age. See Figure 2 for details.

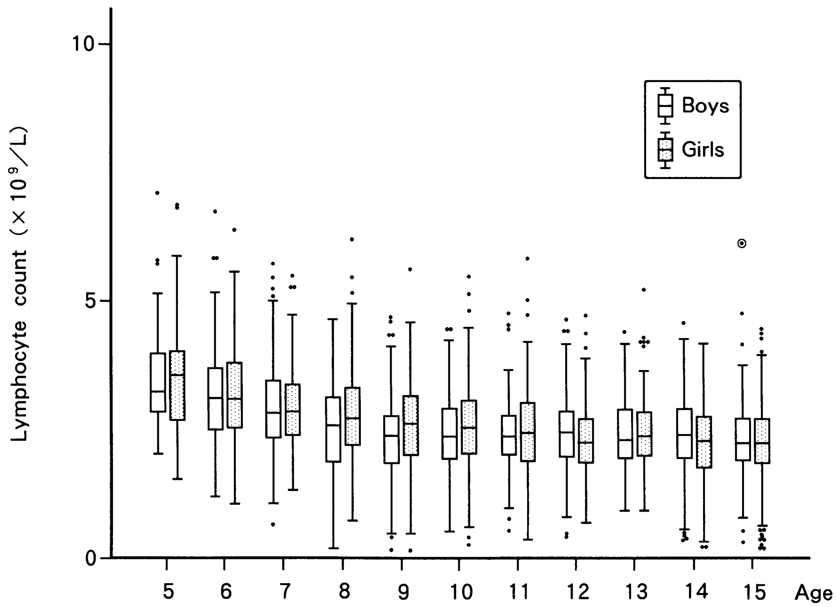

Figure 11. The box-and-whisker plots of lymphocyte count by sex and age. See Figure 2 for details.

The relationship between monocyte count in the peripheral blood and age and sex is given in Figure 13. The median of monocyte count is within normal limits.

The deviation of parameters from the normal range found in blood tests is shown in Table 5 by place of residence of the examined children. A decrease

Table 5. Frequency of subjects with hematological abnormalities by rayon.[a]

Blood analysis		Rayon		Total
Item (unit)[b]	Abnormality criteria	Klintsovskii	Klincy City	
Hb (g/L)	<110[c]			
	>180[c]			
	<110[d]	1 (0.4)	3 (0.1)	4 (0.1)
	>160[d]		11 (0.3)	11 (0.3)
WBC ($\times 10^9$/L)	<3.8[c]		11 (0.3)	11 (0.3)
	>10.6[c]	6 (2.5)	51 (1.5)	57 (1.6)
	<3.6[d]	1 (0.4)	4 (0.1)	5 (0.1)
	>11.0[d]	3 (1.2)	42 (1.2)	45 (1.2)
PLT ($\times 10^9$/L)	<100		5 (0.1)	5 (0.1)
	>440	1 (0.4)	29 (0.8)	30 (0.8)
MCV (fl)	<80	11 (4.5)	124 (3.6)	135 (3.7)
	>100		2 (0.1)	2 (0.1)
Ly ($\times 10^9$/L)	<1.2	1 (0.4)	159 (4.5)	160 (4.4)
	>3.5	76 (29.9)	423 (11.9)	499 (13.6)
Ne ($\times 10^9$/L)	<1.4	6 (2.4)	40 (1.1)	46 (1.3)
	>6.6	4 (1.6)	132 (3.7)	136 (3.7)
Eo ($\times 10^9$/L)	>0.5	67 (26.4)	734 (20.6)	801 (21.8)
Mo ($\times 10^9$/L)	<0.12	5 (2.0)	329 (9.2)	334 (9.1)
	>1.00	10 (3.9)	106 (3.0)	116 (3.2)
Number of children measured		242	3,432	3,674

a. Parenthetic entries refer to the percentage of subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

in the absolute number of lymphocytes occurred in 4.5% of children, i.e. those living in highly contaminated areas, while an increase in the absolute number of lymphocytes occurred in 29.9% of children, i.e. those living in areas with a low contamination density. A decrease in the number of monocytes occurred more often in children living in highly contaminated areas (9.2%). More or less the same prevalence of eosinophilia (21.8%) was found in children living in high and low contamination areas.

The deviations from the normal range in relation to Cs–137 specific activity is shown in Table 6. The prevalence of lymphocytosis increased with the increase in Cs–137 specific activity. Changes of monocyte and eosinophil count do not correlate with Cs–137 specific activity. The percentage of deviations of other blood parameters was not significant.

4. Discussion

The information gained is inadequate to draw any definite conclusions on the morbidity of children living in the contaminated areas. To clarify the reasons for the abnormalities found by the examinations, the work should be continued and carried out in rayons with various contamination densities. To obtain clear-cut data on Cs–137 activity and to study the way of intake of radionuclides in the body, soil and samples of food kept by the families of examined children should be analyzed. To elucidate the peculiarities of hematological changes, the study of iron metabolism in the body should be included in the examination program.

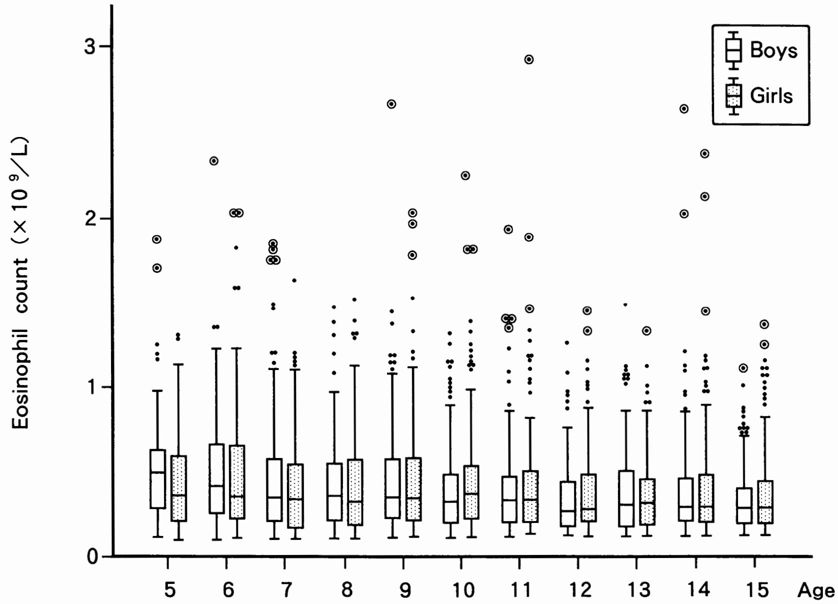

Figure 12. The box-and-whisker plots of eosinophil count by sex and age. See Figure 2 for details.

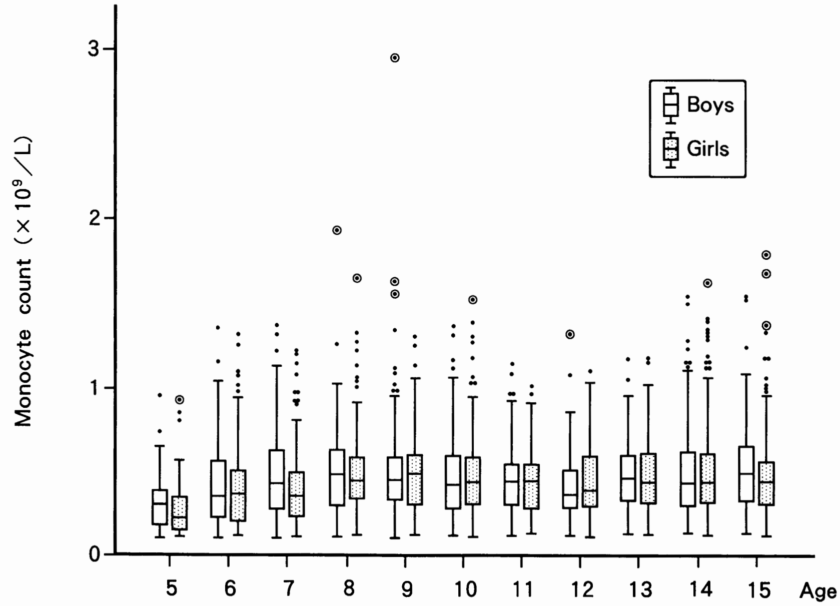

Figure 13. The box-and-whisker plots of monocyte count by sex and age. See Figure 2 for details.

Table 6. Frequency of subjects with hematological abnormalities by Cs-137 level.[a]

Blood analysis		Whole body Cs-137 count per body weight (Bq/kg)					Total
Item (unit)[b]	Abnormality criteria	0–50	50–100	100–200	200–500	≥500	
Hb (g/L)	<110[c]						
	>180[c]						
	<110[d]	3 (0.1)			1 (1.4)		4 (0.1)
	>160[d]	8 (0.3)	3 (0.3)				11 (0.3)
WBC ($\times 10^9$/L)	<3.8[c]	5 (0.2)	4 (0.4)	1 (0.3)	1 (1.4)		11 (0.3)
	>10.6[c]	33 (1.4)	18 (2.0)	2 (0.7)	4 (5.7)		57 (1.6)
	<3.6[d]	3 (0.1)		2 (0.7)			5 (0.1)
	>11.0[d]	32 (1.3)	11 (1.2)	2 (0.7)			45 (1.2)
PLT ($\times 10^9$/L)	<100	4 (0.2)			1 (1.4)		5 (0.1)
	>440	19 (0.8)	9 (1.0)	2 (0.7)			30 (0.8)
MCV (fl)	<80	79 (3.2)	47 (5.2)	7 (2.4)	2 (2.8)		135 (3.7)
	>100		1 (0.1)	1 (0.3)			2 (0.1)
Ly ($\times 10^9$/L)	<1.2	114 (4.6)	30 (3.2)	13 (4.3)	3 (4.2)		160 (4.4)
	>3.5	287 (11.5)	145 (15.6)	50 (16.7)	12 (16.7)	5 (41.7)	499 (13.6)
Ne ($\times 10^9$/L)	<1.4	35 (1.4)	8 (0.9)	3 (1.0)			46 (1.3)
	>6.6	90 (3.6)	39 (4.2)	3 (1.0)	4 (5.6)		136 (3.7)
Eo ($\times 10^9$/L)	>0.5	489 (19.5)	207 (22.2)	84 (28.0)	18 (25.0)	3 (25.0)	801 (21.8)
Mo ($\times 10^9$/L)	<0.12	192 (7.7)	104 (11.2)	26 (8.7)	11 (15.3)	1 (8.3)	334 (9.1)
	>1.00	82 (3.3)	27 (2.9)	5 (1.7)	2 (2.8)		116 (3.2)
Number of children measured		2,422	882	288	70	12	3,674

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

Results of the Examination of Children in Kiev Oblast

Kiev Regional Hospital No. 2
Diagnostic Center "Sasakawa-Chernobyl"

Nikifirova N. V., Grinko V. I., Kochubey S. S., Krivakova E. V.

1. Introduction

Kiev Diagnostic Center carried out the examination of children in 1991 and 1992 as part of the Sasakawa-Chernobyl Project, an undertaking developed in cooperation with Hiroshima and Nagasaki Universities. The collaboration with Japanese scientists made possible the examination of 3,499 children living in Kiev Oblast (Province), an area contaminated with radionuclides as a result of the Chernobyl nuclear power station accident (see Appendix A).

The examinations included the following: (1) inquiry concerning disease history; (2) collection of anthropometric data; (3) hematological studies; (4) determination of serum thyroid hormone levels; (5) blood testing for presence of anti-thyroid autoantibodies; (6) ultrasonography of the thyroid; (7) examination by a pediatrician; and (8) measurement of whole body Cs–137 concentration.

2. Materials and Methods

2. 1 Study subjects

The study subjects are children born between 26 April 1976 and 26 April 1986. The children are residents of Kiev City and the following seven rayons of Kiev Oblast: Polesskii, Irpenskii, Vishgorodskii, Borodyanskii, Ivankovskii, Makarovskii and Kievo-Svyatoshinskii.

2. 2 Measurement of whole body Cs–137 concentration

The whole body Cs–137 concentration was measured using equipment manufactured by Aloka Company and implementing the technique proposed by Japanese specialists. This method involves calibration of gamma-spectrometer at peaks with standard samples of Cs–137 and Co–60, measurement of "blank space" and four phantoms. Duration of the measurement is five minutes.

2. 3 Thyroid examinations

Image study of the thyroid was performed in all children using an arch-automatic ultrasonographic instrument (Aloka–520) followed by data input, output, analysis and storage. The volume of the thyroid was calculated with a computer by the established formula. The following criteria were used to establish a diagnosis: the structure and volume of the thyroid, levels of FT_4

and TSH, positive titers of anti-thyroglobulin (ATG) and anti-microsome (AMC) antibodies in the serum, hemogram and clinical symptoms.

Determination of the presence of ATG and AMC antibodies as well as hormone levels in the blood serum was carried out with an Amerlite analyzer. Standard serum kits were used.

If deviations from normal were found in any of these criteria, the child in question was reexamined with an Aloka–630.

2. 4 Hematological studies

Hematological studies involved the testing of venous blood with a Sysmex K–1000 hemoanalyzer and light microscopic examination of blood smears. Staining of smears was performed by the May-Grünwald-Giemsa technique with the help of a Sakura device. Three smears (two stained and one fixed) were produced for each examined child. Conclusions on hematological studies were drawn on the basis of the laboratory data and the results of the examination of children.

3. Results

3. 1 Study subjects

The distribution of the examined children with regard to sex, age and residence is shown in Table 1. A total of 3,499 children living in Kiev City and the seven rayons of Kiev Oblast contaminated with radionuclides (Polesskii, Irpenskii, Vishgorodskii, Borodyanskii, Ivankovskii, Makarovskii and Kievo-Svyatoshinskii) were examined during the study period. The geographical location of the Kiev Oblast rayons is shown in Figure 1 along with Cs–137 contami-

Table 1. Classification of study subjects by sex and rayon.[a]

Rayon	Boys	Girls	Total
Vishgorodskii	294 (8, 10, 12)[b]	308 (8, 10, 12)	602 (8, 10, 12)
Polesskii	390 (8, 9, 12)	406 (7, 9, 12)	796 (8, 9, 12)
Borodyanskii	168 (7, 8, 10)	197 (7, 8, 10)	365 (7, 8, 10)
Makarovskii	283 (7, 8, 10)	295 (7, 9, 11)	578 (7, 8, 10)
Ivankovskii	403 (7, 8, 10)	380 (7, 8, 10)	783 (7, 8, 10)
Kiev City	15 (8, 11, 13)	17 (8, 10, 12)	32 (8, 10, 12)
Irpenskii	138 (7, 9, 11)	202 (8, 11, 12)	340 (7, 9, 12)
Total	1,691 (7, 9, 11)	1,805 (7, 9, 11)	3,496 (7, 9, 11)

a. Three girls in Kievo-Svyatoshinskii are not included.

b. Each triplet gives the 25th, 50th and 75th sample percentiles of age distribution at the time of examination.

Figure 1. Cs–137 contamination levels (Ci/km^2) in the rayons of Kiev oblast.

nation densities (Ci/km^2). A total of 1,808 girls (51.7% of all examined children) and 1,691 boys (48.3%) were examined. Most of the examined children ranged in age from 6 to 10 years. The proportion of children in other age groups was as follows: 3.9% – 5 years old; 8.7% – 11 years old; 8.0% – 12 years old; 4.9% – 13 years old; 2.0% – 14 years old; and 0.9% – 15 years old. Of the 3,499 examined children, 796 live in the Polesskii rayon, which is recognized as the third zone of radiocontamination.

3. 2 Measurement of whole body Cs–137 concentration

Dosimetric measurement was carried out in 85% of the children by visits of the mobile laboratory to the subjects' place of residence. The staff implemented the techniques proposed by Japanese specialists and used the equipment manufactured by Aloka Company and donated by the Sasakawa Memorial Health Foundation. The updated version of the program for calculation of whole body radioactivity has been used since September 1991.

The distribution of Cs–137 specific activity is shown in Figure 2. The median of the specific activity was 40 Bq/kg, and there was no sex dependency. A slight increase in radioactivity was found in 15 year-old boys. The dispersion of values of specific activity also shows no sex dependency. The maximal value of Cs–137 specific activity was about 3,200 Bq/kg.

The distribution of specific activity in rayons given in Figure 3 shows that a buildup of Cs–137 ranging from 5 to 500 Bq/kg was found in children living in

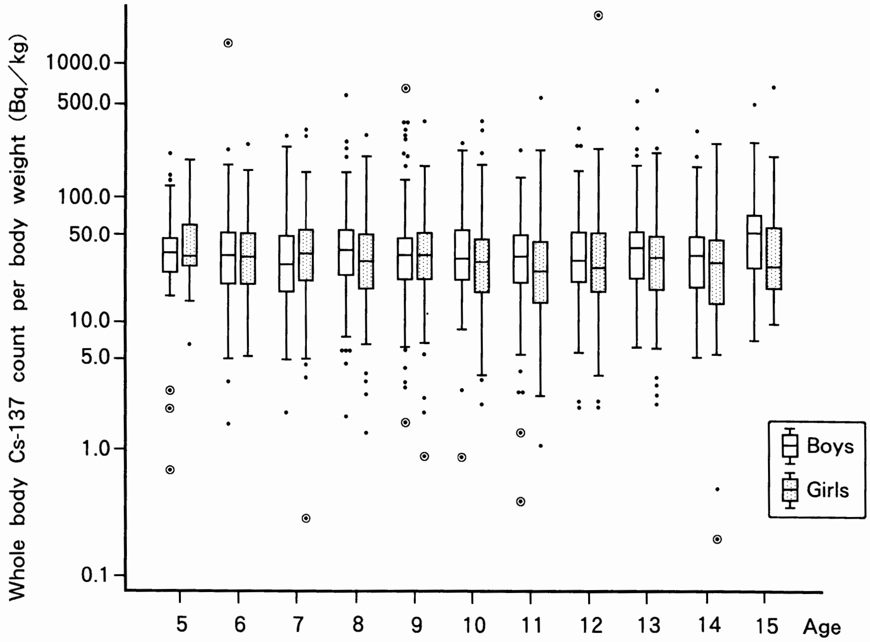

Figure 2. The box-and-whisker plots of whole body Cs-137 count per body weight by sex and age. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, which are called "outside" and "far out," respectively.

the northern rayons of Kiev Oblast adjacent to the Chernobyl zone, that is, Polesskii, Vishgorodskii and Ivankovskii. At the same time, the Cs-137 specific activity found in the southern rayons of Borodyanskii and Makarovskii ranges from 5 to 100 Bq/kg.

3. 3 Thyroid examinations

Thyroid volume

Data on thyroid volume in relation to sex and age are given in Figure 4. There is a direct relationship between thyroid volume and age. No relationship between thyroid volume and sex was observed in any age group.

The limit of permissible thyroid volume was calculated by the formula:

$$LIMIT = 1.7 \times 10^{0.13 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of a child in years at the time of the examination, *height* is the height of a child in cm, and *body weight* is the weight of a child in kg. See Appendix B for details.

A thyroid volume over this limit was recognized as goiter. The prevalence of goiter by rayon is shown in Table 2 and Figure 5. The prevalence of goiter was 59.2%, which was 58.4% in boys and 59.8% in girls. The highest prevalence of goiter (66.8% of all children and 71.4% of all examined girls) was

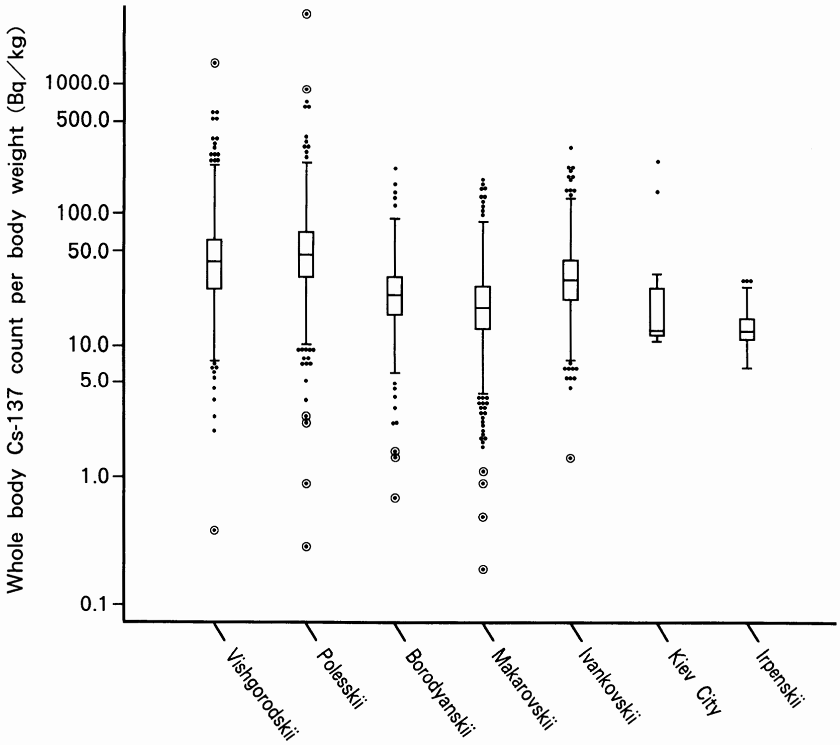

Figure 3. The box-and-whisker plots of whole body Cs-137 count per body weight by rayon. See Figure 2 for details.

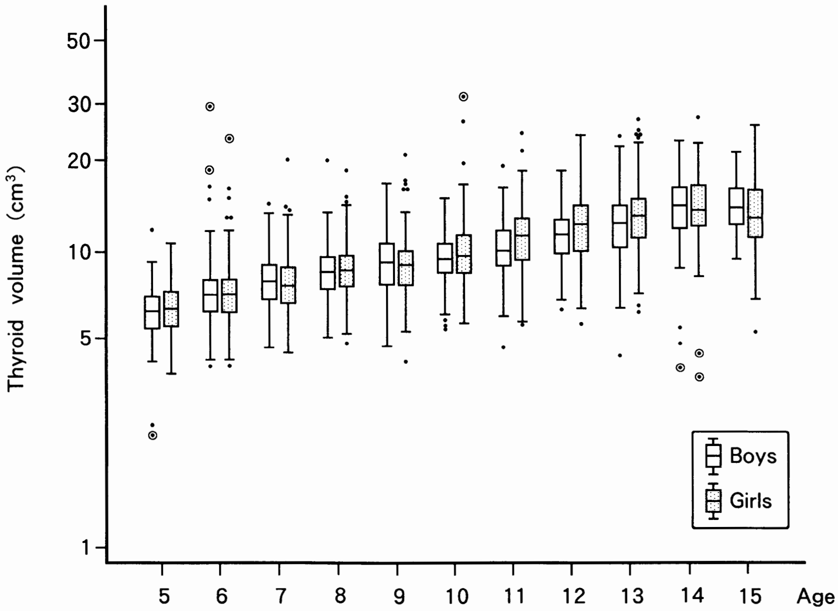

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. See Figure 2 for details.

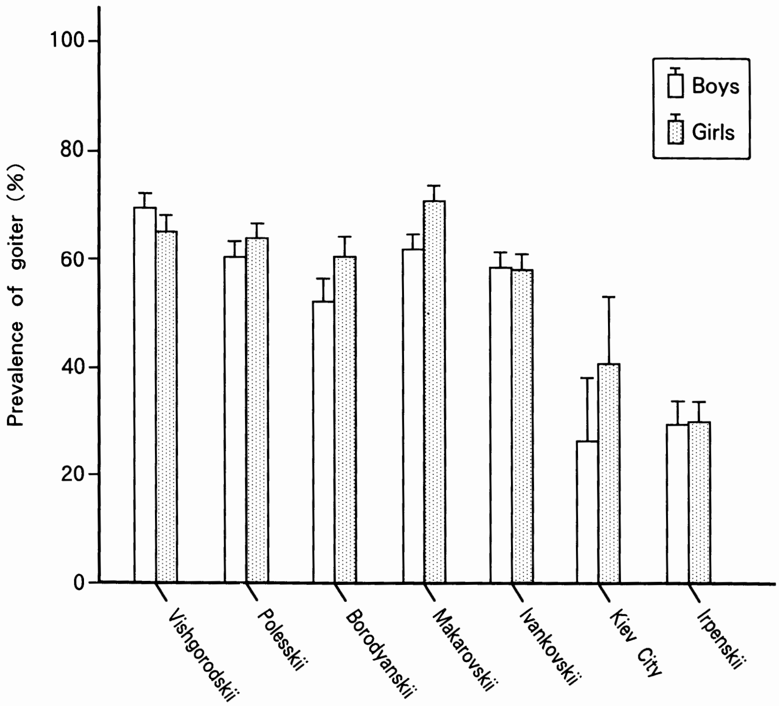

Figure 5. Prevalence of goiter by sex and rayon. The whiskers denote the standard errors. See page 58 for the definition of goiter.

Table 2. Classification of subjects with goiter by sex and rayon.

Rayon	Number of subjects examined			Number of subjects with goiter		
	Boys	Girls	Total	Boys	Girls	Total
Vishgorodskii	294	307	601	205	201	406
Polesskii	354	371	725	216	238	454
Borodyanskii	167	196	363	88	119	207
Makarovskii	281	294	575	174	210	384
Ivankovskii	401	378	779	236	220	456
Kiev City	15	17	32	4	7	11
Irpenskii	138	202	340	41	61	102
Total	1,650	1,765	3,415	964	1,056	2,020

noted among children in the Makarovskii rayon, while the lowest prevalence of goiter (30.0% of all children) was found in the Irpenskii rayon. In other rayons the prevalence of goiter was as follows: Vishgorodskii – 67.6%, Polesskii – 62.6%, Borodyanskii – 57.0%, Ivankovskii – 58.5%, and Kiev City – 33.6%. The prevalence of goiter was higher in girls than in boys.

All thyroid abnormalities found in the examinations are shown in Table 3.

Hormones

An elevated TSH level was found in the blood serum of 55 boys (3.3%) and 83 girls (4.6%), while a decreased TSH level was found in that of seven boys

(0.4%) and four girls (0.2%). Thus the number of children with increased TSH level (4.0%) is higher than the number of children with decreased TSH level (0.3%) (Table 4).

An elevated FT_4 level was found in the blood serum of 33 boys (2.0%) and 34 girls (1.9%), while a decreased FT_4 level was found in that of six boys (0.4%) and 11 girls (0.6%) (Table 4).

Antibodies

A positive ATG titer was found in six boys (0.4%) and nine girls (0.5%), and a positive AMC titer was found in four boys (0.2%) and 16 girls (0.9%) as shown in Table 5.

Diagnosis

Autoimmune thyroiditis was found in 17 children (0.5%), consisting of 12

Table 3. Subjects with thyroid abnormalities by sex and rayon.

Rayon	Number of subjects examined		Diagnosis							
			Nodular lesion		Cystic lesion		Abnormal Echogenity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Vishgorodskii	294	306	0	0	1	0	1	1	0	0
Polesskii	387	402	0	0	0	0	2	3	0	0
Borodyanskii	168	195	0	0	0	0	1	2	0	0
Makarovskii	282	292	0	0	0	0	2	3	0	0
Ivankovskii	401	379	0	0	0	0	0	1	0	0
Kiev City	15	17	0	0	0	0	0	0	0	0
Irpenskii	134	196	0	1	0	0	0	1	0	0
Total	1,681	1,787	0	1	1	0	6	11	0	0

a. B, boys; G, girls.

Table 4. Classification of subjects with high or low level of TSH and free T_4 by sex and rayon.[a]

Rayon	Number of subjects measured			Hormone					
				TSH			Free T_4		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Vishgorodskii	600	294	306	27/1[b]	14/1	13/0	8/0	3/0	5/0
Polesskii	788	387	401	19/6	13/4	6/2	22/3	9/3	13/0
Borodyanskii	363	168	195	18/0	4/0	14/0	14/3	6/0	8/3
Makarovskii	574	282	292	17/2	8/1	9/1	10/8	6/1	4/7
Ivankovskii	780	401	379	30/2	12/1	18/1	12/1	9/0	3/1
Kiev City	32	15	17	2/0	0/0	2/0	0/0	0/0	0/0
Irpenskii	331	134	197	25/0	4/0	21/0	1/2	0/2	1/0
Total	3,468	1,681	1,787	138/11	55/7	83/4	67/17	33/6	34/11

a. High level of TSH: TSH$>$2.90 μIU/ml; low level of TSH: TSH$<$0.24 μIU/ml; high level of free T_4: free $T_4>$25.0 pmol/l; low level of free T_4: free$T_4<$10.0 pmol/l.

b. Total subjects with high level hormone over total subjects with low level hormone.

Table 5. Number of subjects with anti-thyroglobulin and/or anti-microsome antibodies by sex and rayon.

Rayon	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Vishgorodskii	600	294	306	1	0	1	1	0	1
Polesskii	789	387	402	2	2	0	6	3	3
Borodyanskii	363	168	195	1	0	1	3	0	3
Makarovskii	574	282	292	7	3	4	5	0	5
Ivankovskii	780	401	379	2	1	1	1	1	0
Kiev City	32	15	17	1	0	1	1	0	1
Irpenskii	331	134	197	1	0	1	3	0	3
Total	3,469	1,681	1,788	15	6	9	20	4	16

girls and five boys. The diagnosis was established on the basis of the results of multiple examinations including ultrasound examination of the thyroid, determination of hormone levels and positive titers of ATG and AMC antibodies in the blood serum, and physical examination.

Hypothyroidism was found in one of the children, Juli R. (an eight year-old girl with an FT_4 level of 9.76 pmol/l and a TSH level of 30.9 μIU/ml), at the primary examination. At the next examination a year later, FT_4 level was 6.37 pmol/l, TSH level was 56.6 μ IU/ml, and AMC and ATG titers were 1:6,400 and 0 respectively.

Multiple nodules in the thyroid were found in a nine year-old girl, Katya M. The serum level of hormones was within normal limits, and no antibodies were found in the blood serum. A diagnosis of thyroid cancer was established on the basis of a further examination. Surgery was performed and follicular thyroid cancer was confirmed histologically.

Thyroid cyst 0.5 cm $\times$ 0.6 cm in size was observed in a seven year-old girl, Sveta K. The serum level of thyroid hormones was within normal limits. No positive titers of ATG and AMC were detected. The child is presently under the observation of an endocrinologist.

3. 4 Hematological studies

As shown in Figure 6, most of the hemoglobin levels lie within normal limits. No relationship was observed between hemoglobin level and place of residence but there was a trend toward an increase in hemoglobin level with age (Figure 7). A reduction in hemoglobin level was found in 14–15 year-old girls as compared to boys of the same age. We consider the cause of these changes to be hormonal changes during puberty. In seven boys (0.2%) and seven girls (0.2%) the hemoglobin level was below the normal range (Table 6). Changes in hemoglobin level related to thyroid disorders and accumulation of CS-137 in the body were not found (Table 7).

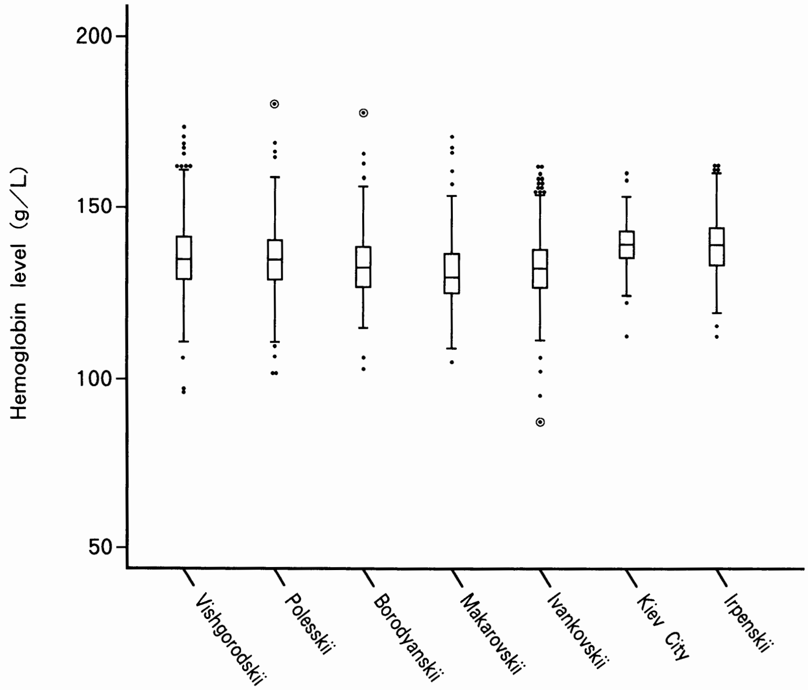

Figure 6. The box-and-whisker plots of hemoglobin level by rayon. See Figure 2 for details.

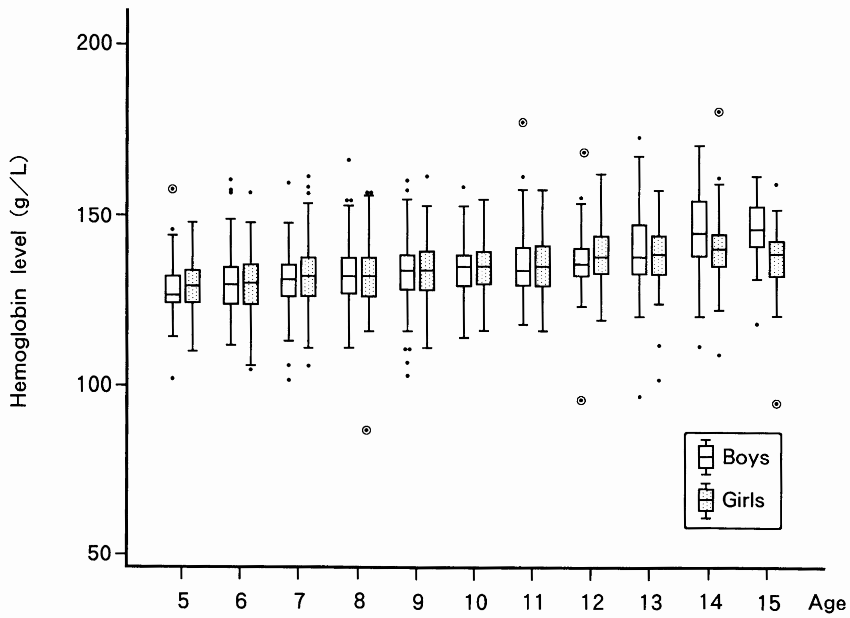

Figure 7. The box-and-whisker plots of hemoglobin level by sex and age. See Figure 2 for details.

The analysis of data on MCV grouped according to sex and age (Figure 8) revealed an increase with age, the more pronounced increase being found in girls. A reduction in MCV was found in 112 children (3.2%) (Table 6). No statistically significant relationship was observed between MCV and rayon of residence (Figure 9).

Table 6. Frequency of subjects with hematological abnormalities by rayon.[a]

Blood analysis		Rayon[b]							Total
Item (unit)[c]	Abnormality criteria	VYS	POL	BOR	MAK	IVN	KIE	IRP	
Hb (g/L)	<110[d]	2 (0.3)	2 (0.3)	1 (0.3)		2 (0.3)			7 (0.2)
	>180[d]								
	<110[e]	1 (0.2)	1 (0.1)	1 (0.3)	2 (0.3)	2 (0.3)			7 (0.2)
	>160[e]	1 (0.2)	1 (0.1)	1 (0.3)		1 (0.1)		1 (0.3)	5 (0.1)
WBC ($\times 10^9$/L)	<3.8[d]		1 (0.1)			1 (0.1)		1 (0.3)	3 (0.1)
	>10.6[d]	17 (2.8)	37 (4.6)	10 (2.7)	13 (2.2)	27 (3.4)		5 (1.5)	109 (3.1)
	<3.6[e]					1 (0.1)		2 (0.6)	3 (0.1)
	>11.0[e]	17 (2.8)	32 (4.0)	7 (1.9)	9 (1.6)	24 (3.1)		4 (1.2)	93 (2.7)
PLT ($\times 10^9$/L)	<100				1 (0.2)			1 (0.3)	2 (0.1)
	>440	15 (2.5)	20 (2.5)	14 (3.8)	12 (2.1)	12 (1.5)		2 (0.6)	75 (2.1)
MCV (fl)	<80	15 (2.5)	23 (2.9)	18 (4.9)	24 (4.1)	23 (2.9)	1 (3.1)	8 (2.3)	112 (3.2)
	>100								
Ly ($\times 10^9$/L)	<1.2	11 (1.8)	9 (1.1)	2 (0.5)	18 (3.1)	9 (1.1)		8 (2.3)	57 (1.6)
	>3.5	68 (11.2)	173 (21.3)	50 (13.3)	76 (12.9)	192 (23.7)	9 (28.1)	43 (12.5)	611 (17.5)
Ne ($\times 10^9$/L)	<1.4	6 (1.0)	2 (0.2)	1 (0.3)	5 (0.9)	2 (0.2)	2 (6.3)	7 (2.0)	25 (0.7)
	>6.6	45 (7.4)	53 (6.5)	13 (3.5)	31 (5.3)	49 (6.1)		15 (4.3)	206 (5.9)
Eo ($\times 10^9$/L)	>0.5	108 (17.8)	189 (23.3)	97 (25.8)	185 (31.5)	180 (22.2)	7 (21.9)	49 (14.2)	815 (23.3)
Mo ($\times 10^9$/L)	<0.12	47 (7.7)	129 (15.9)	84 (22.3)	43 (7.3)	190 (23.5)	3 (9.4)	19 (5.5)	515 (14.7)
	>1.00	33 (5.4)	24 (3.0)	9 (2.4)	17 (2.9)	8 (1.0)	1 (3.1)	6 (1.7)	98 (2.8)
Number of children measured		602	796	365	578	783	32	340	3,496

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. VYS, Vishgorodskii; POL, Polesskii; BOR, Borodyanskii; MAK, Makarovskii; IVN, Ivankovskii; KIE, Kiev City; IRP, Irpenskii.

c. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

d. Criteria for boys.

e. Criteria for girls.

Table 7. Frequency of subjects with hematological abnormalities by Cs-137 level.[a]

Blood analysis		Whole body Cs-137 count per body weight (Bq/kg)					Total
Item (unit)[b]	Abnormality criteria	0–50	50–100	100–200	200–500	≥500	
Hb (g/L)	<110[c]	6 (0.2)	1 (0.2)				7 (0.2)
	>180[c]						
	<110[d]	4 (0.2)	2 (0.3)		1 (2.2)		7 (0.2)
	>160[d]	4 (0.2)		1 (0.5)			5 (0.1)
WBC ($\times 10^9$/L)	<3.8[c]	2 (0.1)		1 (0.5)			3 (0.1)
	>10.6[c]	79 (3.0)	18 (2.8)	10 (5.4)	2 (4.4)		109 (3.1)
	<3.6[d]	2 (0.1)	1 (0.2)				3 (0.1)
	>11.0[d]	71 (2.7)	18 (2.8)	4 (2.2)			93 (2.7)
PLT ($\times 10^9$/L)	<100	2 (0.1)					2 (0.1)
	>440	60 (2.3)	12 (1.8)	2 (1.1)	1 (2.2)		75 (2.1)
MCV (fl)	<80	85 (3.2)	23 (3.5)	3 (1.6)	1 (2.2)		112 (3.2)
	>100	1 (0.0)					1 (0.0)[e]
Ly ($\times 10^9$/L)	<1.2	42 (1.6)	14 (2.1)	1 (0.5)			57 (1.6)
	>3.5	448 (16.8)	120 (18.2)	35 (18.5)	6 (13.3)	2 (20.0)	611 (17.5)
Ne ($\times 10^9$/L)	<1.4	21 (0.8)	1 (0.2)	2 (1.1)	1 (2.2)		25 (0.7)
	>6.6	158 (5.9)	35 (5.3)	12 (6.3)	1 (2.2)		206 (5.9)
Eo ($\times 10^9$/L)	>0.5	636 (23.9)	132 (20.0)	37 (19.6)	9 (20.0)	3 (30.0)	817 (23.3)[f]
Mo ($\times 10^9$/L)	<0.12	367 (13.8)	99 (15.0)	36 (19.0)	12 (26.7)	1 (10.0)	515 (14.7)
	>1.00	62 (2.3)	21 (3.2)	10 (5.3)	3 (6.7)	2 (20.0)	98 (2.8)
Number of children measured		2,610	649	185	45	10	3,499[g]

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

e. One girl in Kievo-Svyatoshinskii is included.

f. Two girls in Kievo-Svyatoshinskii are included.

g. Three girls in Kievo-Svyatoshinskii are included.

The number of platelets (PLT) was within normal limits in most of the examined children (Figure 10). A PLT count below 100×10^9/L without development of hemorrhage syndrome was found in two children in Makarovskii and Irpenskii rayons where the Cs-137 specific activity ranges from 0 to 50 Bq/kg (Table 6). An abnormally high PLT count was found in 75 children (most often in 5–8 year-old children) living in Polesskii, Vishgorodskii and Borodyanskii rayons. When compared among subjects grouped according to sex and age, the PLT count showed a trend toward reduction with age (Figure 11).

With regard to WBC, the number in most of the children was within the normal range (Figure 12). However, an increase in WBC was observed in all age groups both in boys (109 persons; 3.1%) and in girls (93 persons; 2.7%), as shown in Figure 13 and Table 6. With regard to place of residence, such an

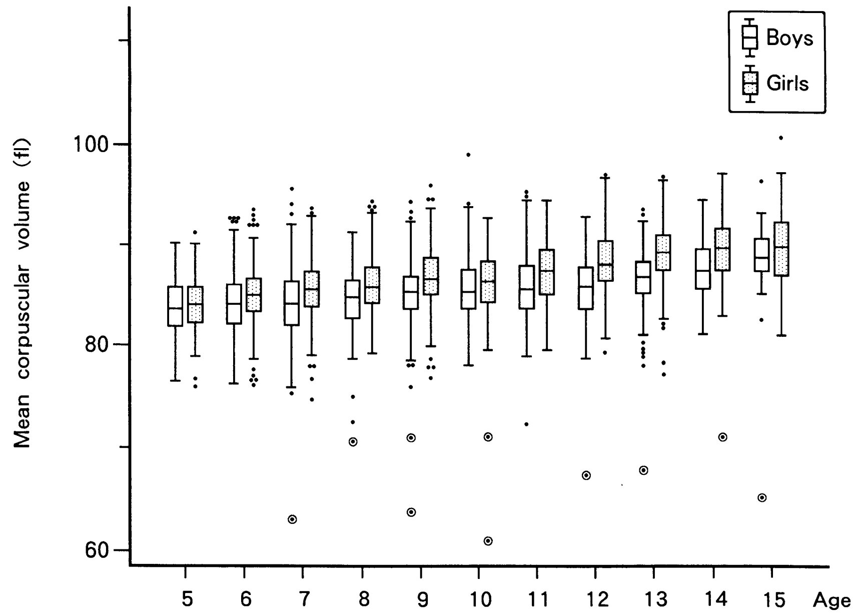

Figure 8. The box-and-whisker plots of mean corpuscular volume by sex and age. See Figure 2 for details.

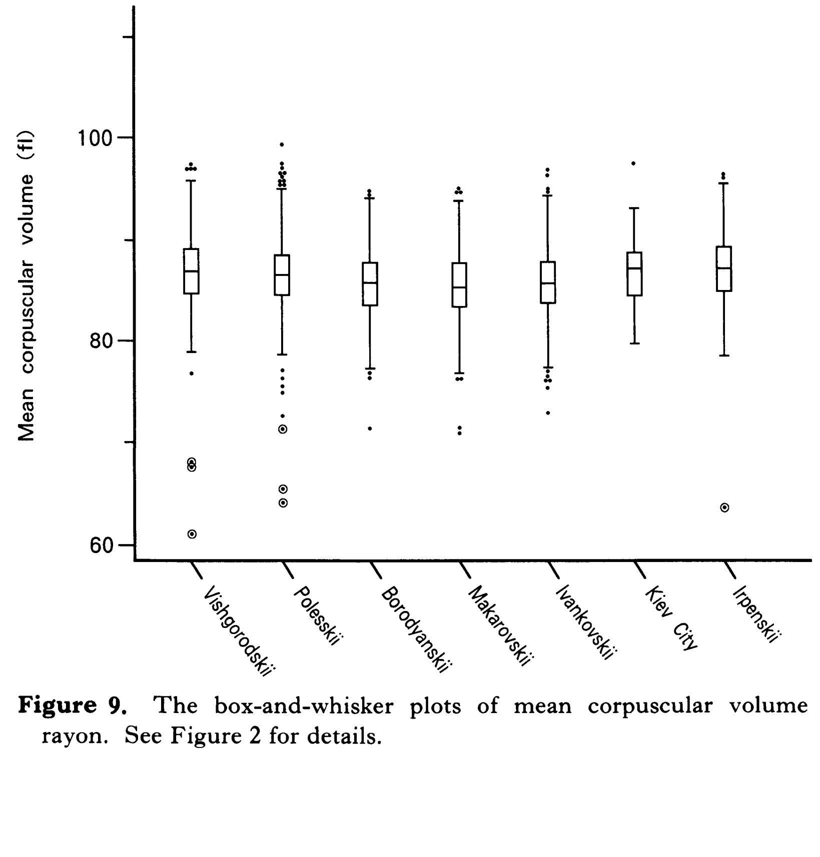

Figure 9. The box-and-whisker plots of mean corpuscular volume by rayon. See Figure 2 for details.

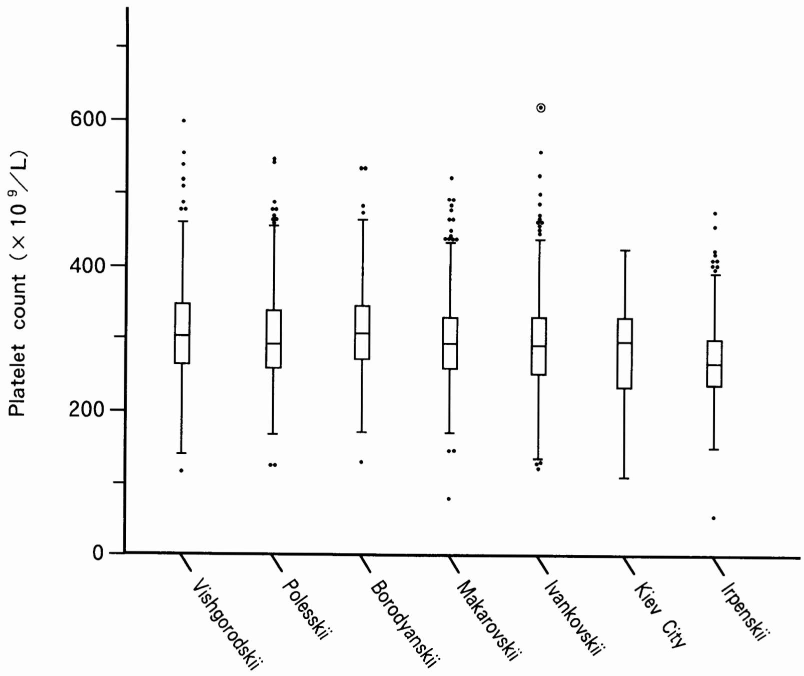

Figure 10. The box-and-whisker plots of platelet count by rayon. See Figure 2 for details.

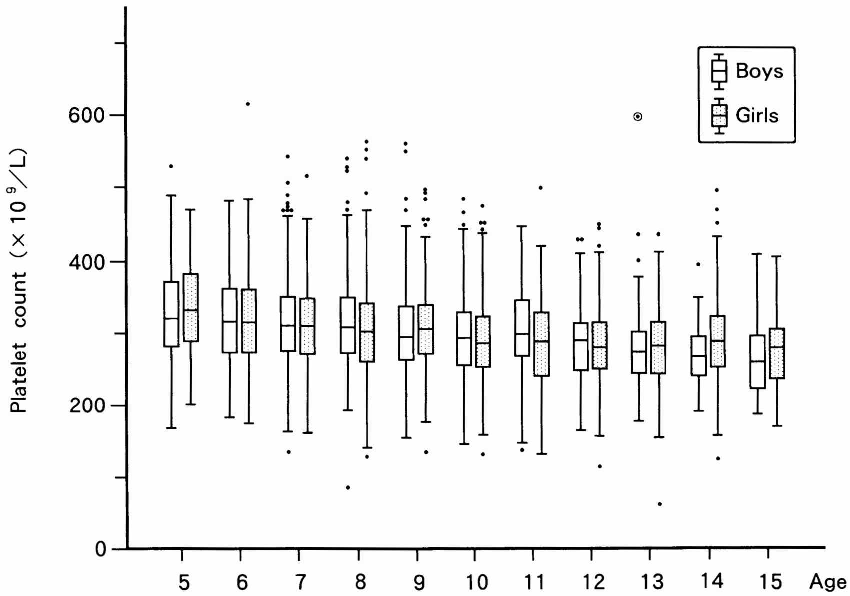

Figure 11. The box-and-whisker plots of platelet count by sex and age. See Figure 2 for details.

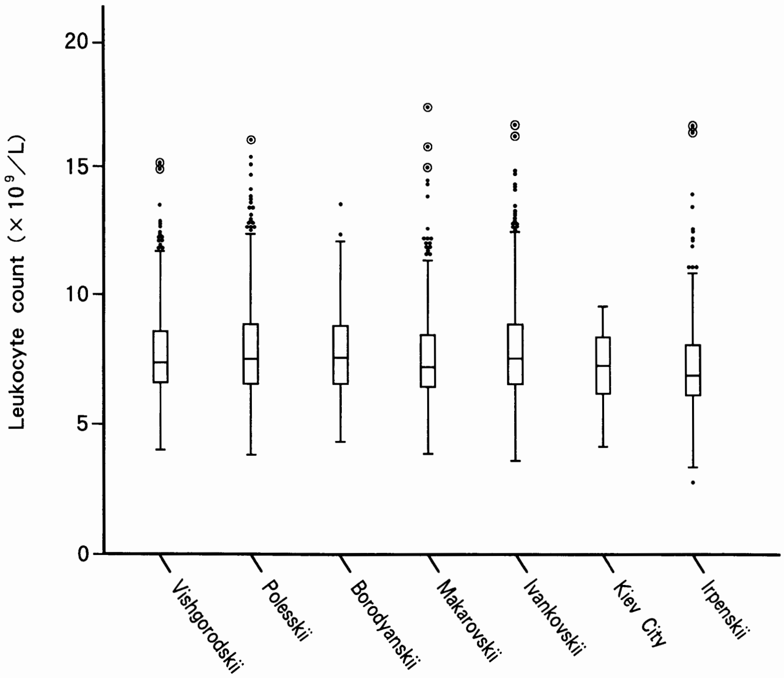

Figure 12. The box-and-whisker plots of leukocyte count by rayon. See Figure 2 for details.

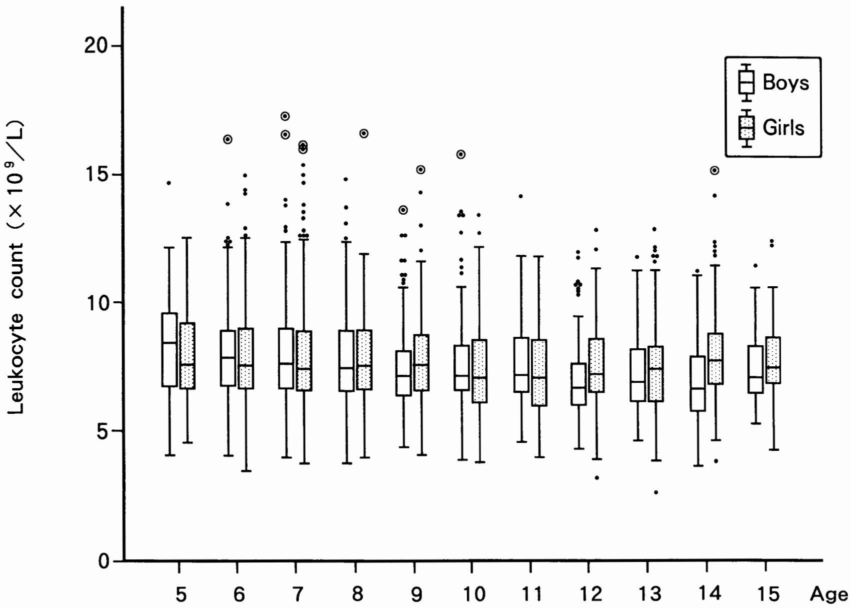

Figure 13. The box-and-whisker plots of leukocyte count by sex and age. See Figure 2 for details.

increase was observed mainly in Ivankovskii and Polesskii rayons. In subjects grouped according to Cs–137 specific activity, the leukocytosis was observed in 150 children in the range between 0 and 50 Bq/kg, in 36 children in the range between 50 and 100 Bq/kg, in 14 children in the range between 100 and 200 Bq/kg, and in two children in the range between 200 and 500 Bq/kg. A reduction in WBC to levels below normal was found in six children (three boys and three girls).

Considerable fluctuations in lymphocyte count were found (Figure 14). A lymphocyte count above normal was observed in 611 children (17.5%), including 192 (23.7%) in Ivankovskii and 173 (21.3%) in Polesskii rayon, and the finding was most prominent in 5–8 year-old children. Children with increased lymphocyte count were distributed practically uniformly with regard to Cs–137 specific activity. In 57 children (1.6%) a reduction in lymphocyte count to levels below normal was found. There is no significant correlation between lymphocyte count and sex, residence or Cs–137 specific activity (Figures 14 and 15 and Tables 6 and 7).

An increase in the neutrophil count was observed in 206 children (5.9%) (Table 6). The most pronounced fluctuations in neutrophil count were noted in 6–10 year-old children (Figure 16). A reduction in neutrophil count to levels below normal was found in 25 children (0.7%) (Table 6). No correlation was observed between neutrophil count and rayon of residence or Cs–137 specific activity (Figure 17 and Table 7).

The most pronounced deviations from the normal range were those observed in eosinophil count (Tables 6 and 7). An increase in eosinophil count

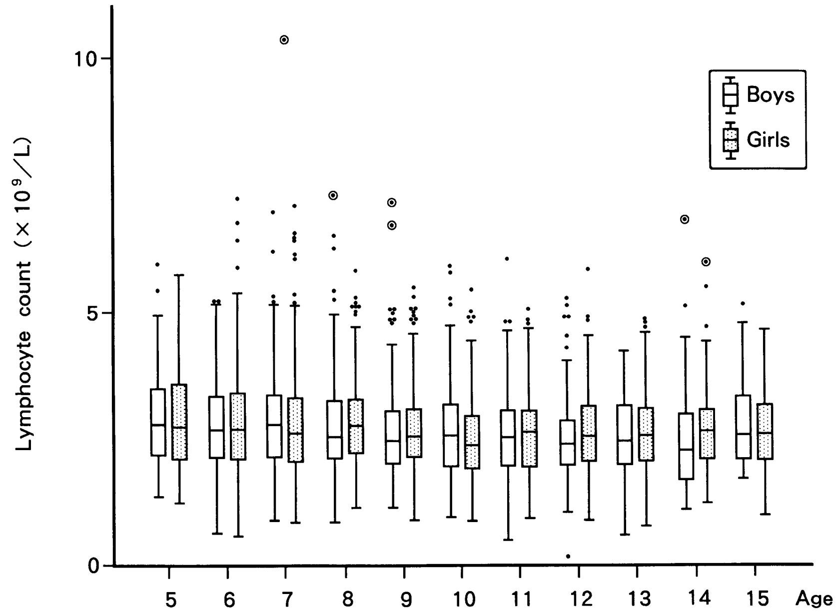

Figure 14. The box-and-whisker plots of lymphocyte count by sex and age. See Figure 2 for details.

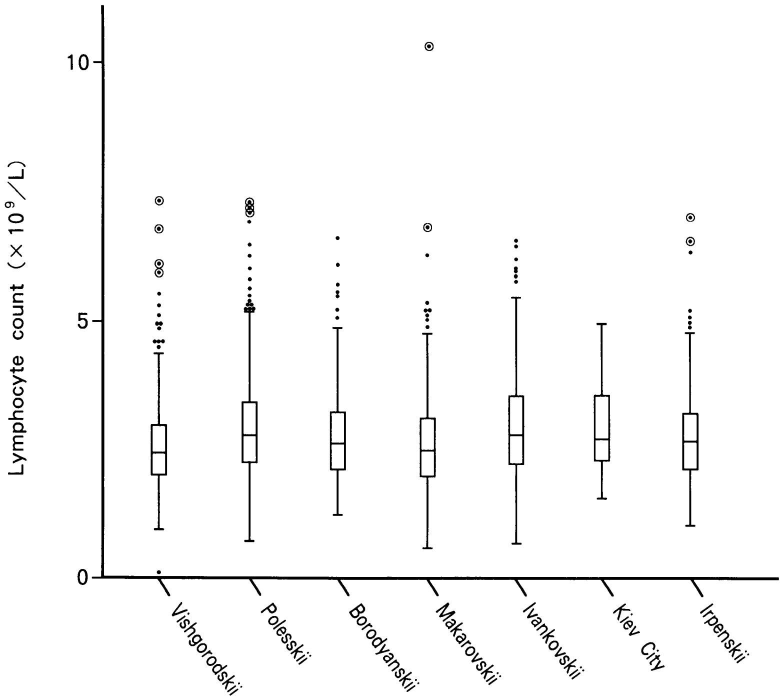

Figure 15. The box-and-whisker plots of lymphocyte count by rayon. See Figure 2 for details.

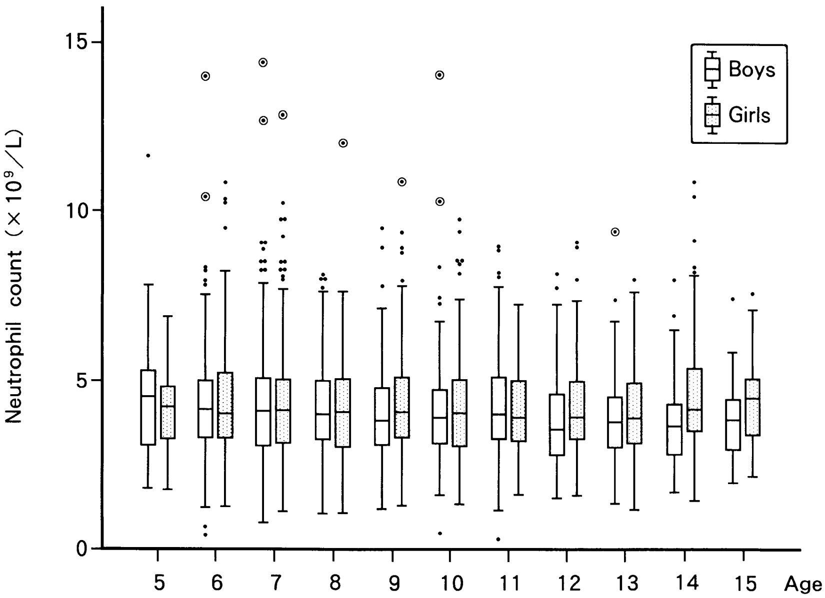

Figure 16. The box-and-whisker plots of neutrophil count by sex and age. See Figure 2 for details.

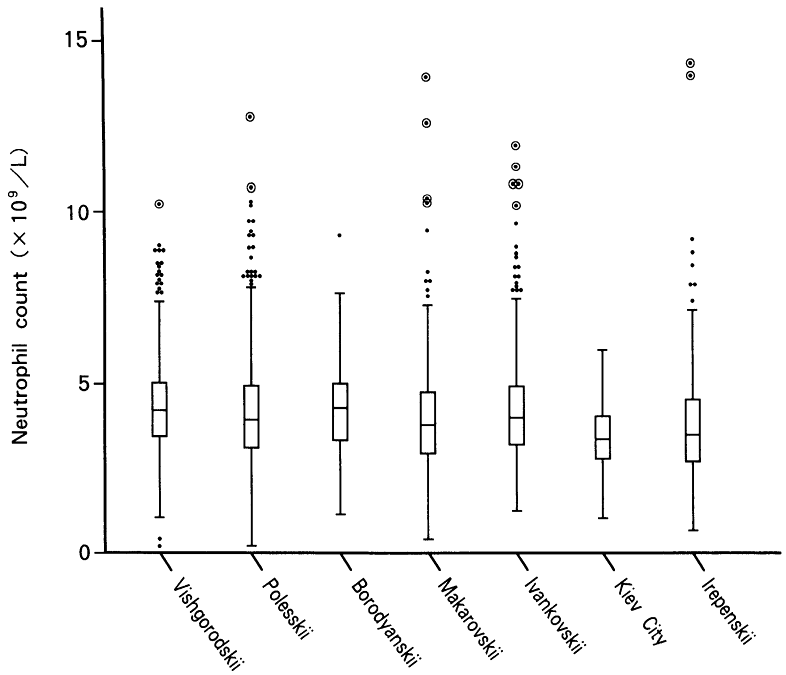

Figure 17. The box-and-whisker plots of neutrophil count by rayon. See Figure 2 for details.

was observed in 817 of the 3,499 examined children (23.3%) (Table 7). The increase occurred most commonly in Makarovskii (31.5%), Borodyanskii (25.8%), Polesskii (23.3%) and Ivankovskii (22.2%) rayons (Table 6). No correlation was observed between Cs–137 specific activity and the increase in eosinophil count (Table 7). We associate this finding with the fact that most of the examined children live in agricultural areas. The residents use food from private plots, and the number of children with worm invasion and infection with protozoa is large. An allergic disease history has been observed in a considerable portion of the children.

A reduction in monocyte count to levels below normal was found in 515 children (14.7%), a finding that is particularly pronounced in Ivankovskii, Borodyanskii and Polesskii rayons (Table 6). An increase in monocyte count to levels above normal was found in 98 children (2.8%). There was no correlation between monocyte count and place of residence (Table 6), and no clear-cut correlation was observed between monocyte count and Cs–137 specific activity in the body (Table 7).

4. Discussion

Since only 3,499 of the approximately 250,000 children living in the contaminated areas in Kiev Oblast have been examined in 1991 and 1992, it is too early to draw final conclusions on either the state of health in children or the effects of low-dose irradiation. We consider it important that this work be continued.

Results of the Examination of Children Living in the Northern Rayons of Zhitomir Oblast

Korosten Interrayon Medical Diagnostic Center

Saiko A. S., Danilyuk V. V., Stotskaya L. P., Sokolovskii I. N.

1. Introduction

The examination of children of the northern rayons of Zhitomir Oblast (Province) affected by the Chernobyl accident has been carried out in Korosten City by means of the mobile diagnostic laboratory "Chernobyl-Sasakawa" (cf. Appendix A).

The course of the examination includes the following: (1) inquiry concerning disease history and filling in of questionnaires; (2) anthropometric data; (3) measurement of Cs-137 activity in the body; (4) ultrasonography of the thyroid; (5) hormonal status and positive titers of antithyroid autoantibodies in the blood serum; and (6) blood testing.

2. Materials and Methods

2. 1 Study subjects

The subjects under study are children born in the period from 26 April 1976 to 26 April 1986 and currently five to 15 years old.

2. 2 Measurement of whole body Cs-137 concentration

The technique of direct spectrometry of radionuclide activity based on the registration of gamma radiation of a body is used. The spectrometry is carried out with the whole body counter Model-101 manufactured by Aloka Company.

The following parameters are measured at the time of examination: specific activity; overall activity; body mass; size of chest; and average radiation rate at the height of 1 m from the ground.

2. 3 Thyroid examinations

This study is carried out with an ultrasonography unit (arch-automatic type Aloka SSD-520). By the technique of automatic scanning at 5 mm, 11 cross sections of the thyroid gland are obtained.

To establish a diagnosis for each child, the following criteria are used: thyroid structure; echogenity; thyroid volume; laboratory data (general blood count, hormonal status, positive titers of anti-microsome antibodies (AMC) and anti-thyroglobulin antibodies (ATG)); physical data (height, mass and age); and functional examination (ECG).

The criterion for goiter is a thyroid volume exceeding the volume calculated by the following formula:

$$LIMIT = 1.7 \times 10^{0.13 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of a child in years at the time of the examination; *height* is the height of a child in cm; and *body weight* is the weight of a child in kg. See Appendix B for details.

Free thyroxine (FT_4) and thyroid stimulating hormone (TSH) levels in serum are assayed with the Amerlite analyzer system using the immunometric method based on enhanced luminescence. Titers of AMC and ATG are assayed by the reaction of indirect hemagglutination.

2. 4 Hematological studies

Blood testing is conducted with a Sysmex K-1000 hemoanalyzer to determine the following eight parameters: (1) white blood cell count (WBC); (2) red blood cell count (RBC); (3) hemoglobin (Hb); (4) hematocrit (Ht); (5) mean corpuscular volume (MCV); (6) mean corpuscular hemoglobin (MCH); (7) mean corpuscular hemoglobin concentration (MCHC); and (8) platelet count (PLT). Hemogram is analyzed with a BH-2 "Olympus" microscope.

3. Results

3. 1 Study subjects

During the period between May 1991 and 31 December 1992, 5,265 children (2,367 boys and 2,898 girls) residing in 11 rayons (Korostenskii, Luginskii, Olevskii, Malinskii, Emilchinskii, Ovruchskii, Narodichskii, Novograd-Volinskii, Volodar-Volinskii, Brusilovskii, Radomishliskii) and Korosten City of Zhitomir Oblast were examined (Table 1). The greatest proportion of examined children are residents of Korosten City, Korostenskii, Malinskii and Volodar-Volinskii rayons.

The Cs-137 contamination levels of the northern rayons of Zhitomir Oblast are shown in the map (Figure 1). The most contaminated rayons are Narodichskii (15 to 40 Ci/km^2), Ovruchskii (15 to 40 Ci/km^2) and Korosten City (5 to 15 Ci/km^2). The contamination levels in the other rayons lie in the range between 1 and 5 Ci/km^2.

3. 2 Measurement of whole body Cs-137 concentration

The distribution of Cs-137 activity in children's bodies by place of residence is shown in Figure 2. The maximal activity was registered in residents of Olevskii, Luginskii, Ovruchskii and Narodichskii rayons, while the minimal activity was registered in residents of Volodar-Volinskii rayon. In individual cases the Cs-137 specific activity ranged from 500 to 1,000 Bq/kg.

Distribution of data on Cs-137 specific activity by sex and age is given in

Table 1. Classification of study subjects by sex and rayon.

Rayon	Boys	Girls	Total
Korosten City	661 (8, 11, 13)[a]	771 (8, 11, 14)	1,432 (8, 11, 13)
Korostenskii	236 (9, 10, 13)	244 (9, 10, 13)	480 (9, 10, 13)
Luginskii	156 (8, 9, 13)	176 (8, 9, 13)	332 (8, 9, 13)
Olevskii	64 (9, 10, 12)	74 (9, 10, 12)	138 (9, 10, 12)
Malinskii	223 (8, 9, 11)	315 (8, 10, 11)	538 (8, 10, 11)
Emilchinskii	195 (8, 10, 12)	267 (9, 10, 12)	462 (9, 10, 12)
Ovruchskii	172 (8, 10, 12)	243 (8, 10, 12)	415 (8, 10, 12)
Narodichskii	111 (9, 10, 13)	176 (8, 11, 13)	287 (8, 11, 13)
Novograd-Volinskii	164 (8, 10, 12)	222 (9, 11, 13)	386 (9, 10, 12)
Volodar-Volinskii	245 (8, 10, 12)	276 (9, 11, 13)	521 (9, 10, 12)
Brusilovskii	127 (9, 11, 12)	116 (8, 11, 13)	243 (8, 11, 13)
Radomishliskii	13 (9, 12, 13)	18 (8, 11, 13)	31 (8, 12, 13)
Total	2,367 (8, 10, 12)	2,898 (8, 10, 13)	5,265 (8, 10, 13)

a. Each triplet gives the 25th, 50th and 75th sample percentiles of age distribution at the time of examination.

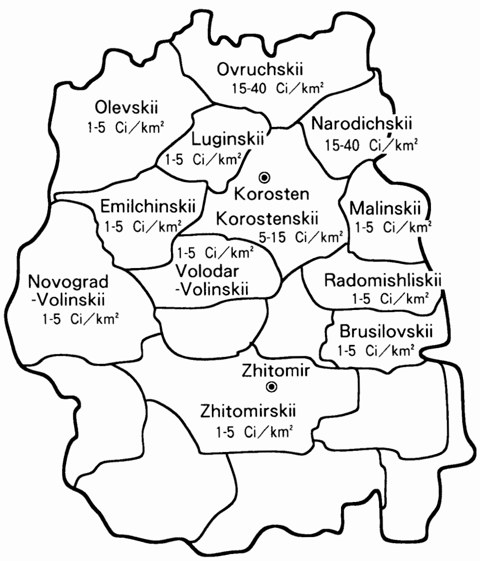

Figure 1. Cs–137 contamination levels (Ci/km^2) in the rayons of Zhitomir oblast.

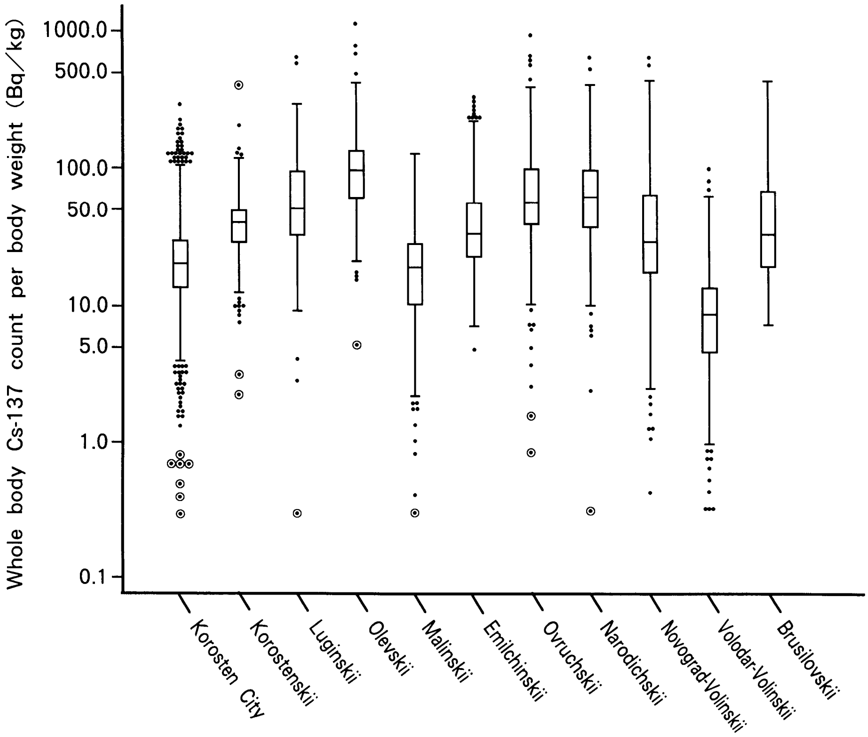

Figure 2. The box-and-whisker plots of whole body Cs–137 count per body weight by rayon. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, which are called "outside" and "far out," respectively.

Figure 3. The median of Cs–137 specific activity lies between 20 and 50 Bq/kg. The median of Cs–137 specific activity in children from 6 to 14 years old and in girls of 15 years old was virtually at the same level. The median was slightly higher in children of 5 years old and boys of 15 years old. Cs–137 specific activity from 500 to 1,000 Bq/kg was observed in some children of 9, 11, 13 and 15 years old.

3. 3 Thyroid examinations

The relationship between thyroid volume and sex and age is plotted in Figure 4. An increase in thyroid volume with age was observed. The increase was more pronounced in girls from 9 to 15 years old than in boys of the same age.

As shown in Figure 5, the number of cases of goiter is higher among girls than among boys with the exception of children in Emilchinskii rayon, where the inverse relationship was observed.

The following thyroid disorders were found in children during the given period: (1) autoimmune thyroiditis – 18 cases (0.34%), consisting of two boys (0.08%) and 16 girls (0.55%); (2) thyroid cysts – 24 cases (0.46%), consisting of

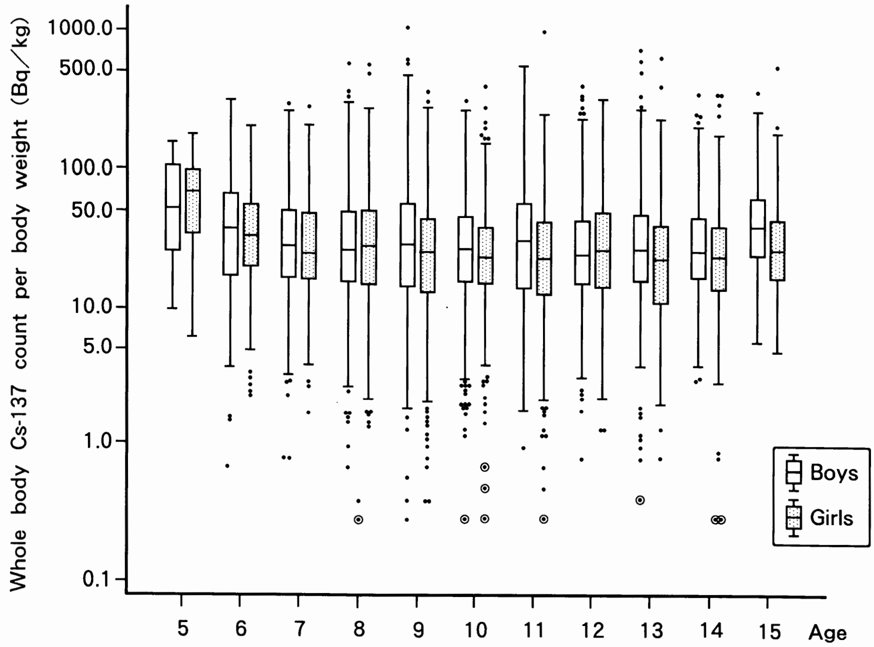

Figure 3. The box-and-whisker plots of whole body Cs-137 count per body weight by sex and age. See Figure 2 for details.

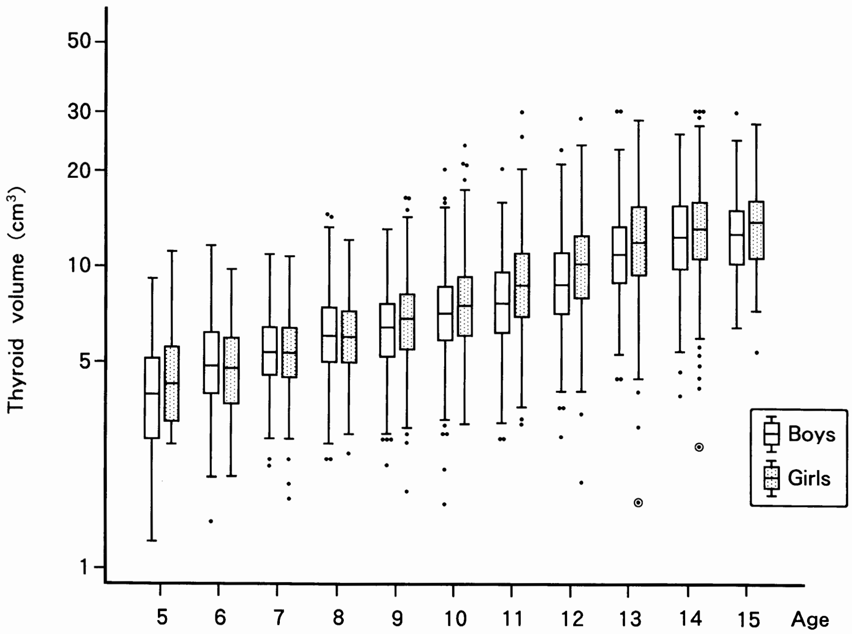

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. See Figure 2 for details.

five boys (0.21%) and 19 girls (0.66%); (3) nodular goiter – six girls (0.21%); and (4) hypoplasia of the thyroid – 11 cases (0.21%), consisting of seven boys (0.30%) and four girls (0.14%).

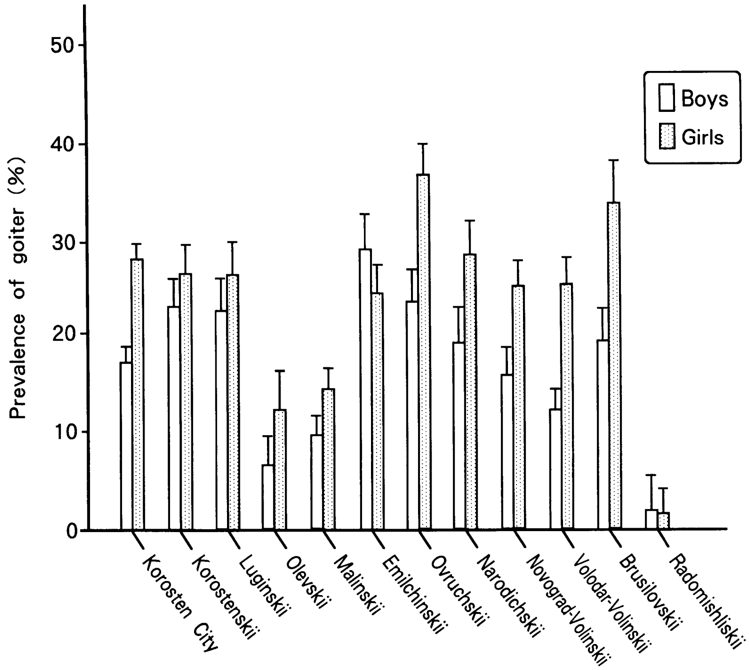

Figure 5. Prevalence of goiter by sex and rayon. The whiskers denote the standard errors. See page 73 for the definition of goiter.

Table 2 presents data on FT_4 level in the blood of children. An increase in FT_4 level was found in 57 children (21 boys and 36 girls). A decrease in FT_4

Table 2. Classification of subjects with high or low level of TSH and free T_4 by sex and rayon.[a]

Rayon	Number of subjects measured			Hormone					
				TSH			Free T_4		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Korosten City	1,402	649	753	93/8[b]	25/1	68/7	19/24	8/8	11/16
Korostenskii	452	224	228	58/3	28/3	30/0	7/6	3/2	4/4
Luginskii	332	156	176	14/1	4/0	10/1	4/4	3/1	1/3
Olevskii	137	63	74	15/1	8/0	7/1	3/0	1/0	2/0
Malinskii	536	223	313	17/2	8/1	9/1	6/7	0/5	6/2
Emilchinskii	457	191	266	21/1	7/0	14/1	2/15	0/5	2/10
Ovruchskii	403	168	235	40/2	19/1	21/1	5/6	2/2	3/4
Narodichskii	285	111	174	22/0	8/0	14/0	1/0	0/0	1/0
Novograd-Volinskii	375	159	216	15/4	4/1	11/3	5/3	3/1	2/2
Volodar-Volinskii	513	239	274	133/1	58/0	75/1	3/3	0/0	3/3
Brusilovskii	242	126	116	4/0	3/0	1/0	2/3	1/3	1/0
Radomishliskii	31	13	18	4/1	0/0	4/1	0/0	0/0	0/0
Total	5,165	2,322	2,843	436/24	172/7	264/17	57/71	21/27	36/44

a. High level of TSH: TSH$>$2.90 μIU/ml; low level of TSH: TSH$<$0.24 μIU/ml; high level of free T_4: free $T_4>$25.0 pmol/l; low level of free T_4: free $T_4<$10.0 pmol/l.

b. Total subjects with high level hormone over total subjects with low level hormone.

Table 3. Number of subjects with anti-thyroglobulin and/or anti-microsome antibodies by sex and rayon.

Rayon	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Korosten City	861	396	465	49	19	30	42	12	30
Korostenskii	313	159	154	20	10	10	33	12	21
Luginskii	228	101	127	23	10	13	9	3	6
Olevskii[a]									
Malinskii	390	161	229	3	0	3	11	4	7
Emilchinskii	275	125	150	0	0	0	0	0	0
Ovruchskii	115	47	68	18	4	14	22	10	12
Narodichskii	200	85	115	36	16	20	26	11	15
Novograd-Volinskii	261	116	145	0	0	0	0	0	0
Volodar-Volinskii	495	232	263	3	1	2	13	3	10
Brusilovskii	242	126	116	12	3	9	6	2	4
Radomishliskii[a]									
Total	3,380	1,548	1,832	164	63	101	162	57	105

a. No subjects were measured their antibodies because reagents were unavailable at the time of examination.

level was found in 71 children (27 boys and 44 girls). Data on TSH level in the blood of children are also presented. An increase in TSH level was found in 436 children (172 boys and 264 girls), while a decrease in TSH level was found in 24 children (7 boys and 17 girls).

Table 3 presents data on the ATG level in the blood by sex and place of residence. An increase in ATG titer is observed in 164 children (63 boys and 101 girls). Data on the AMC level in the blood by sex and place of residence are also presented. An increase in AMC titer was registered in 162 cases (57 boys and 105 girls).

On the basis of these data we can infer that thyroid abnormality, changes in hormonal status and positive ATG and AMC titers occur more often in girls than in boys.

3. 4 Hematological studies

The results of testing of children grouped by sex, age, and rayon of residence are given in the form of graphs. Deviations in blood parameters from the normal limits were found in 3,194 or 60% of the 5,265 examined children.

Figure 6 shows the relationship between hemoglobin level (Hb) and sex and age. The median of Hb was within normal limits in all groups. The trend was toward an increase in Hb with age. The Hb level was higher in boys than in girls among children 12 to 15 years of age. The relationship between Hb and place of residence is shown in Figure 7. The median of Hb is at virtually the same level in all rayons under study.

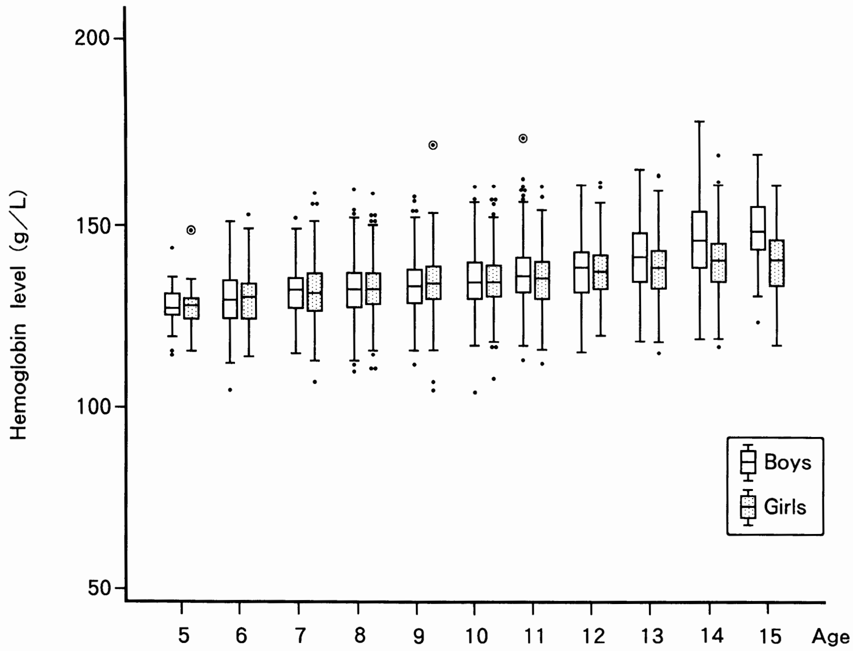

Figure 6. The box-and-whisker plots of hemoglobin level by sex and age. See Figure 2 for details.

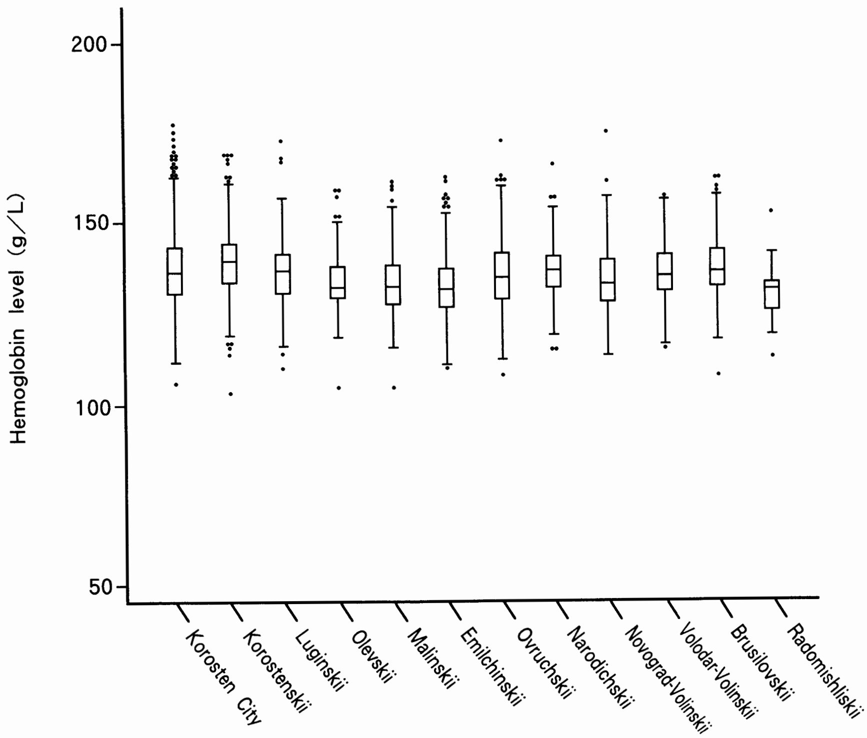

Figure 7. The box-and-whisker plots of hemoglobin level by rayon. See Figure 2 for details.

The relationship between white blood cell count (WBC) and sex and age is given in Figure 8. The median of WBC was within normal limits at all ages. Leukocytosis was established in 233 children (cf. Table 4, page 83). The fact that 70% of the cases were established in autumn suggests that this disorder may be caused by acute respiratory illness or other somatic diseases.

The relationship between platelet count (PLT) and age and sex is given in Figure 9. The median of PLT was within normal limits at all ages. There was a trend toward a decrease in PLT with age. Figure 10 shows the relationship between PLT and place of residence. The median of PLT was within normal limits in all rayons under study. The maximal number of children with thrombocytosis was registered in Korosten City and Malinskii rayon.

Figure 11 shows the relationship between MCV and sex and age. The median of MCV was within normal limits at all ages. In all age groups MCV is higher in girls than in boys. Figure 12 shows the relationship between MCV and place of residence. The median of MCV was within normal limits in all rayons under study. Individual cases of deviation in MCV from the normal range were observed in Korosten City.

As shown in Table 4, the following disorders were found among the 5,265 children examined: anemia – seven children including three boys; and leukopenia – 10 children including seven boys.

The relationship between lymphocyte count and sex, age and place of residence is shown in Figures 13 and 14. The following abnormalities were found

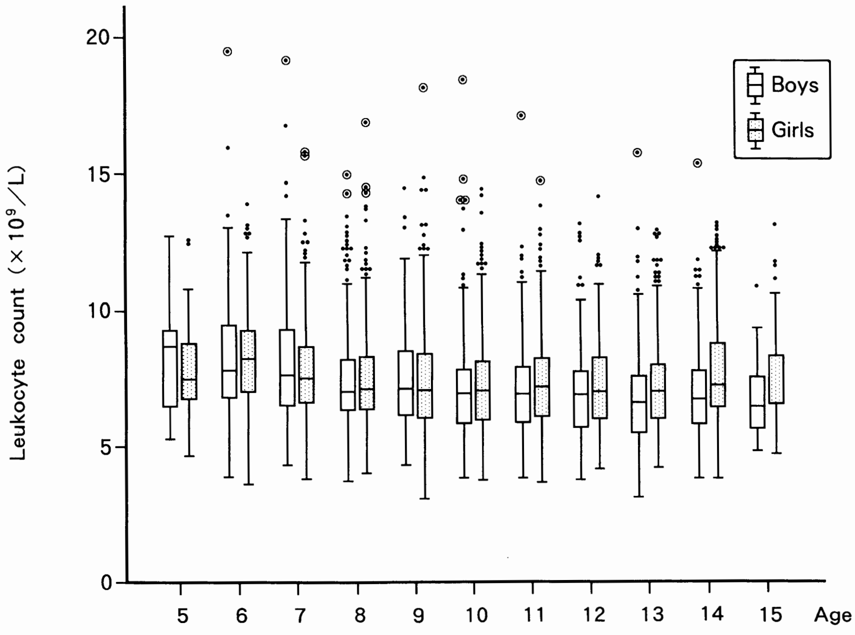

Figure 8. The box-and-whisker plots of leukocyte count by sex and age. See Figure 2 for details.

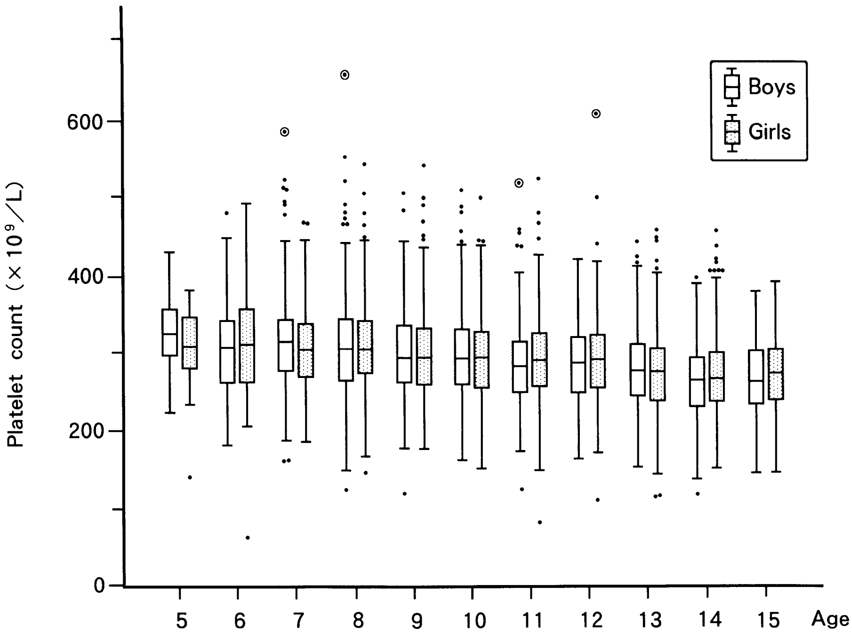

Figure 9. The box-and-whisker plots of platelet count by sex and age. See Figure 2 for details.

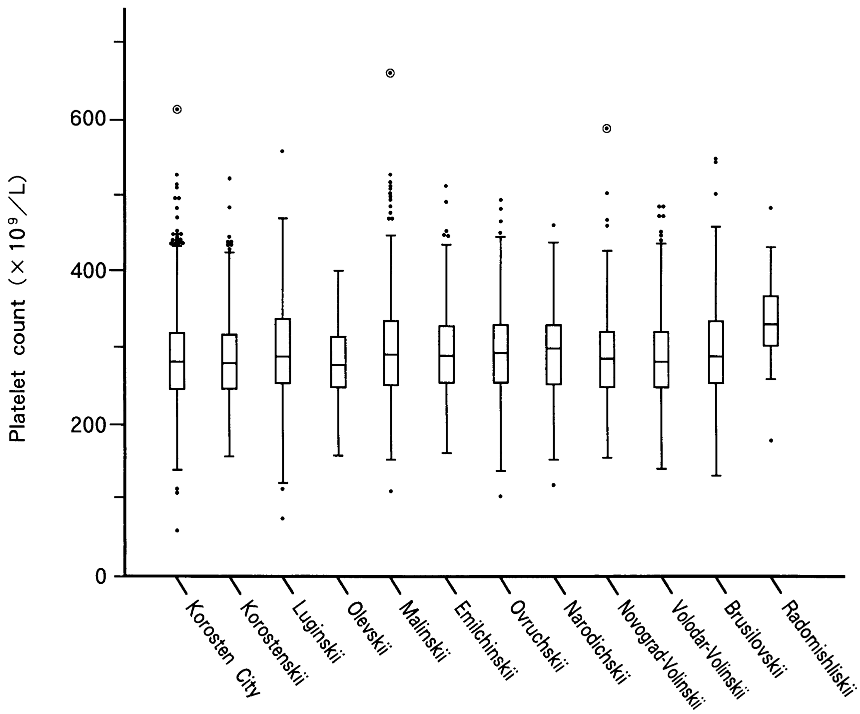

Figure 10. The box-and-whisker plots of platelet count by rayon. See Figure 2 for details.

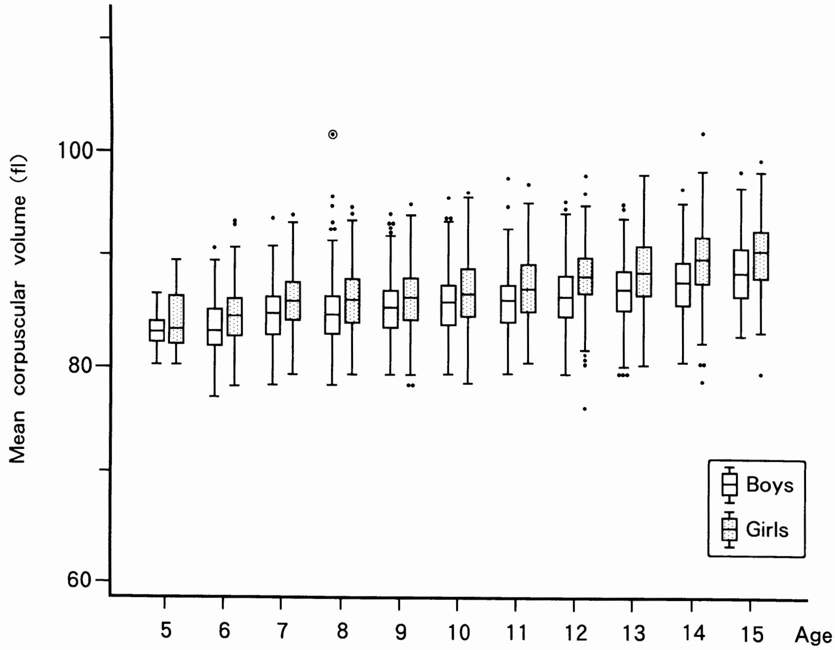

Figure 11. The box-and-whisker plots of mean corpuscular volume by sex and age. See Figure 2 for details.

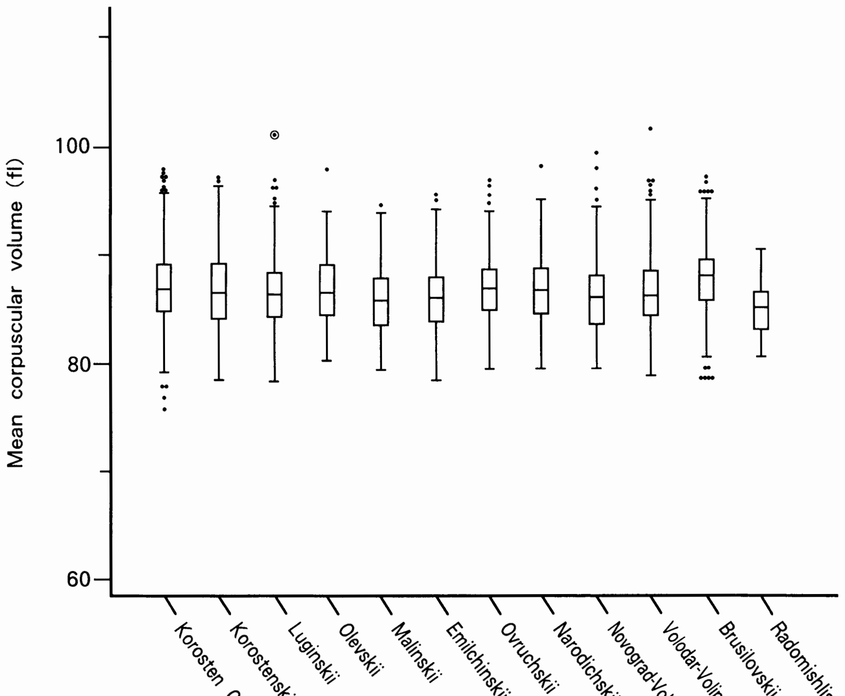

Figure 12. The box-and-whisker plots of mean corpuscular volume by rayon. See Figure 2 for details.

Table 4. Frequency of subjects with hematological abnormalities by Cs-137 level.[a]

Blood analysis		Whole body Cs-137 count per body weight (Bq/kg)					Total
Item (unit)[b]	Abnormality criteria	0–50	50–100	100–200	200–500	≥500	
Hb (g/L)	<110[c]		1 (0.1)	2 (0.6)			3 (0.1)
	>180[c]						
	<110[d]	4 (0.1)					4 (0.1)
	>160[d]	7 (0.2)	2 (0.3)		1 (1.0)		10 (0.2)
WBC ($\times 10^9$/L)	<3.8[c]	5 (0.1)	1 (0.1)	1 (0.3)			7 (0.1)
	>10.6[c]	88 (2.1)	16 (2.2)	10 (3.1)	9 (8.7)	1 (8.3)	124 (2.4)
	<3.6[d]	3 (0.1)					3 (0.1)
	>11.0[d]	76 (1.8)	22 (3.1)	8 (2.5)	3 (2.9)		109 (2.1)
PLT ($\times 10^9$/L)	<100		2 (0.3)				2 (0.0)
	>440	61 (1.5)	8 (1.1)				69 (1.3)
MCV (fl)	<80	45 (1.1)	6 (0.8)	5 (1.6)	2 (1.9)		58 (1.1)
	>100	2 (0.0)					2 (0.0)
Ly ($\times 10^9$/L)	<1.2	59 (1.4)	10 (1.4)	5 (1.5)	3 (2.9)	1 (8.3)	78 (1.5)
	>3.5	480 (11.5)	91 (12.7)	45 (14.1)	16 (15.5)	1 (8.3)	633 (12.0)
Ne ($\times 10^9$/L)	<1.4	21 (0.5)	5 (0.7)				26 (0.5)
	>6.6	194 (4.6)	37 (5.6)	10 (3.1)	7 (6.8)	1 (8.3)	249 (4.7)
Eo ($\times 10^9$/L)	>0.5	967 (23.2)	192 (26.9)	87 (27.2)	36 (35.0)	4 (33.3)	1,286 (24.4)
Mo ($\times 10^9$/L)	<0.12	300 (7.2)	55 (7.7)	25 (7.8)	5 (4.9)	1 (8.3)	386 (7.3)
	>1.00	117 (2.8)	18 (2.5)	6 (1.9)	3 (2.9)	1 (8.3)	145 (2.8)
Number of children measured		4,116	714	320	103	12	5,265

a. Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.

b. Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

c. Criteria for boys.

d. Criteria for girls.

(Table 4): lymphopenia – 78 cases (1.5%); and lymphocytosis – 633 cases (12.0%). There was no obvious relationship between deviations in lymphocyte count from the normal range and place of residence.

The relationship between neutrophil count and sex, age and place of residence is shown in Figures 15 and 16. The following disorders were found (Table 4): neutropenia – 26 cases (0.5%); and neutrophilia – 249 cases (4.7%).

The examination data (see Figures 17 and 18 and Table 4) show that eosinophilia was found in 1,286 children (24.4%) and monocytosis was found in 145 (2.8%). The group of children with a Cs-137 specific activity in the range of 0 to 50 Bq/kg was the largest (4,116 children). The highest number of deviations in studied parameters from the normal range was registered precisely in this group. Because of the small size of the other groups it is difficult to compare the obtained data. Severe non-malignant hematological disease and leukemia have not been found.

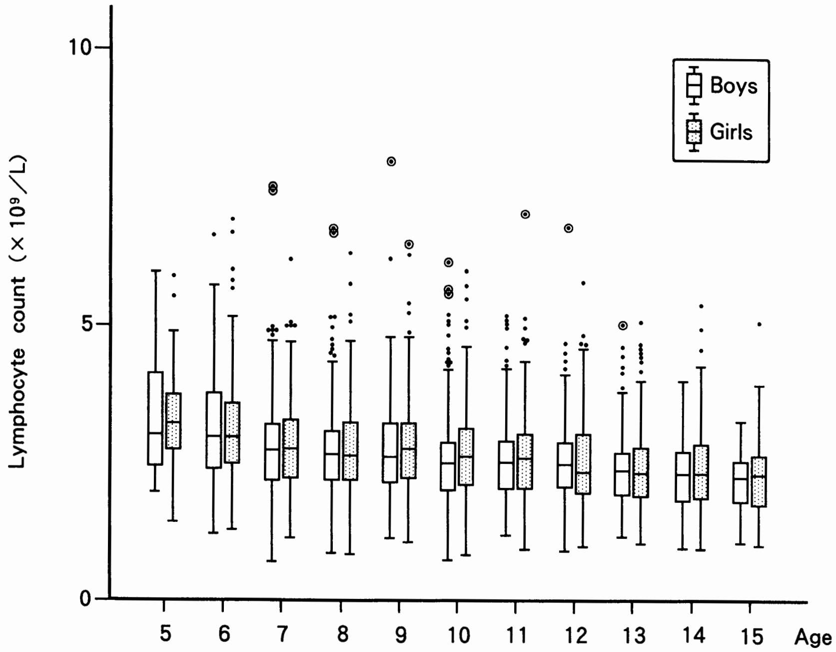

Figure 13. The box-and-whisker plots of lymphocyte count by sex and age. See Figure 2 for details.

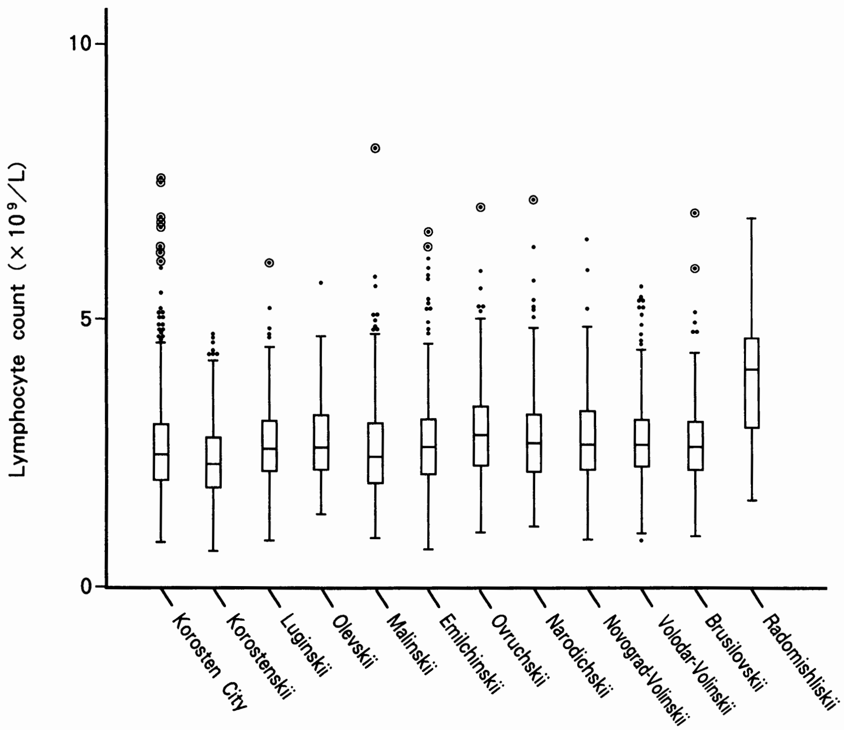

Figure 14. The box-and-whisker plots of lymphocyte count by rayon. See Figure 2 for details.

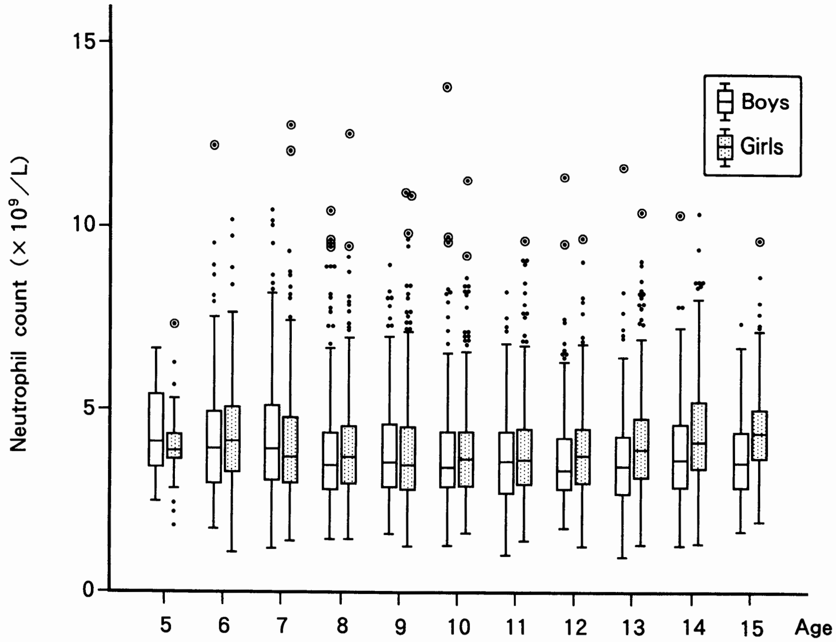

Figure 15. The box-and-whisker plots of neutrophil count by sex and age. See Figure 2 for details.

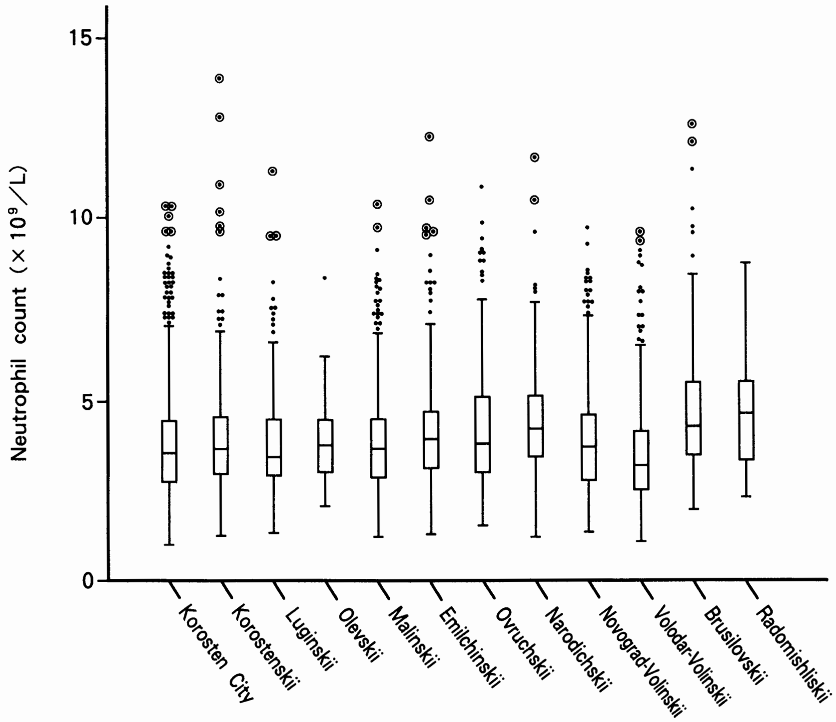

Figure 16. The box-and-whisker plots of neutrophil count by rayon. See Figure 2 for details.

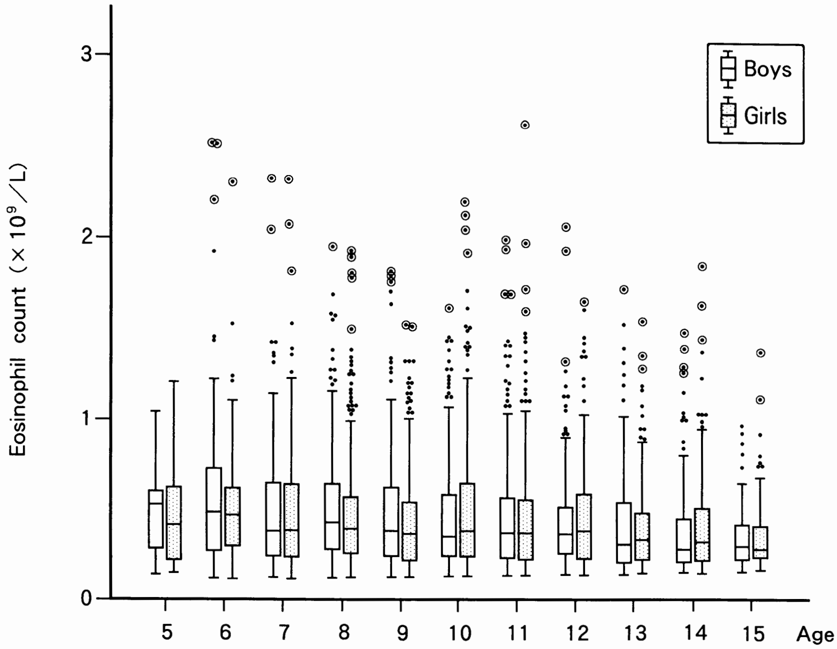

Figure 17. The box-and-whisker plots of eosinophil count by sex and age. See Figure 2 for details.

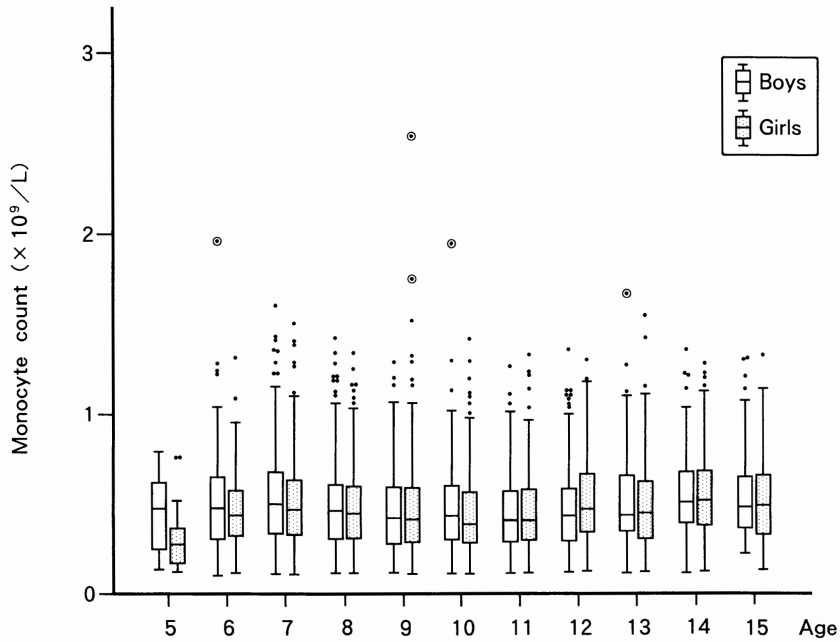

Figure 18. The box-and-whisker plots of monocyte count by sex and age. See Figure 2 for details.

II. Comments by Japanese Scientists

Comments on Thyroid-related Examinations and the 1993 Workshop Presentations

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I. Examinations in the second year

Examinations at five centers entered into their second year in May 1992. The past examinations were conducted mainly on buses but today they are more efficiently carried out at base centers using their instruments. Learning from the trial-and-error experience of the first year, a support system has been established considering the actual conditions of each center. Examination skills of staff members have improved dramatically. Unfortunately, however, the pending issue of conducting high quality examinations rather than merely increasing the number of examinations has not been resolved smoothly. The centers have not yet been able to hold a weekly general meeting to provide opportunities for staff members to learn from each other. Further efforts are needed to establish a more effective examination system and increase our contributions to children, mothers and the local community. These call for solution of problems within each center as well as developing smooth communications with Health Bureau and the Ministry. At present, the content and level of activities differ greatly from center to center, depending on the number and quality of staff and resourcefulness of the director. There is room for improvement. Notwithstanding these organizational problems, the five centers are doing a remarkably good job under difficult political and economic circumstances.

In the field of thyroid-related examinations, a laser disc thyroid imaging analyser has been introduced. A single laser disc can now record and store images of 1,000 subjects. A newly introduced automatic urinary iodine analyzer at the Mogilev and the Kiev centers are contributing greatly to differentiation and diagnosis of iodine deficiency goiters. In response to the request of the centers, a new instrument 'Aloka 630' has been installed providing ultrasonography for outpatients and special examinations. In the third year, assistance will be given to the pathological diagnosis department for establishing cytology by useing 'Aloka 630'. The level of medical screening has improved steadily with the dedicated efforts and commitments of each center and achievements for the second year have been greater. The following is a report on thyroid-related examinations during the year.

(1) Mogilev

Given the high quality of their examinations, it seems appropriate for the Mogilev center to serve as a leader for the five centers. Examinations at the center in the second year have improved greatly over the first. The center has a new data input system and skilled engineers in information processing and statistics engaged in the development of new software. Quality control of individual data, however, must be handled with care. The imaging diagnosis of thyroid gland went well. So far no case of thyroid cancer has been identified. The center examined normal boys and girls with no iodine deficiency in Mogilev City to determine the normal range of thyroid volume by age. The formula is used to analyze the frequency of goiter at other centers. Measurement of blood hormone and antibody titers is also proceeding well.

(2) Gomel

The doctor in charge of thyroid ultrasonography at the Gomel center changed frequently and as a result, numerous problems occurred with regard to the transfer of authority. Also, there were problems concerning storage and management of data in reexamining ultrasonograms. The center will need to find better ways of inputting and processing individual data correctly, and clarify the relationship between radiation disorder and thyroid cancer which has been detected frequently in children in the region. The center has reported a high incidence of subjects positive for thyroid autoantibody, at 3–5 percent in the first year, but at 1.1–2.6 percent in the second year.

(3) Kiev

The center has been relocated from the First Regional Hospital to the Second Hospital and examiniations based on this program have been conducted by staff led by Director Dr. Elagin. Imaging diagnosis of thyroid is proceeding well since Ms. Yelena and other staff members who received training from the start fortunately remained on the team and moved to the new location. Measurement of urinary iodine and hormone levels is going well, providing important data in an iodine-deficient region. The center has reported no case of thyroid cancer at present.

(4) Korosten

After conducting examinations on a bus in the first year, the Korosten center started using laser discs at the base center in winter. Regrettably, the center cannot conduct two examinations at the same time in winter due to the shortage of staff and lack of garage with heating system. However, the commitment of the director and staff is exceptional among the five centers.

(5) Klincy

Imaging diagnosis of thyroid at this center has identified many cases of chronic thyroiditis and multinodular goiter. The center will need to refer patients to hospitals specialized in thyroid where cytological diagnosis may be available. No case of thyroid cancer has been reported so far but it will be necessary to conduct further examinations. With the use of heated garage in winter and a larger number of staff, examinations at the center are going well.

II. Comments on Presentations at the 1993 Workshop

Presentations at the 1993 workshop were prepared by using a software developed by Mr. Kovalev and other staff at the Mogilev center, and presented with the help of overhead projector. It was an innovative attempt incorporating the incidence of disease by region. Presentations, lasting about 15 minutes each, were given in Russian by the representatives of each center. We believe they enjoyed a certain level of positive response.

(1) Mogilev

Normal range of thyroid volume of children aged 5 to 15 years was established by age and sex. The standard value was then used to evaluate the incidence of goiter at each center. The standard value and its scientific basis used will be summarized in a paper at a later date. The centers will need to establish a standard for diagnosing various thyroid disorders. The incidence of subjects showing positive thyroid autoantibody at this center is around 0.1 percent. Since many subjects in Mogilev City have normal urinary iodine levels, the region can be used as a control. The incidence of goiter is between 5–15 percent with little regional differences. These are the most reliable data among the five centers. Furthermore, they will be able to perform by themselves aspiration biopsy of the thyroid which will enable them to conduct cytological diagnosis in the near future.

(2) Gomel

At the Gomel center, cases that have not been image diagnosed are classified as anomaly, and accurate classification of ectopia and hypoplasia is unknown. Therefore, a reexamination of data is necessary. In other words, anomalies reported by the Gomel center can be interpreted as those incapable of image analysis. The nodular lesions in this area were observed about one percent, though the definite diagnosis was not performed. The details of the children with thyroid cancer should be analyzed. Although the frequency of thyroid autoantibody is high, there is no correlation with the level of soil contamination. Further and more detailed investigation on area of residence and individual background is needed. The Gomel center has received low recognition in the past, but in spite of mounting difficulties arising from the need for integration of numerous unorganized support systems, the center is moving toward the better, thanks to the dedicated efforts of the Dutch team. The Gomel center is expected to accumulate more accurate data with a larger number of staff.

(3) Kiev

Unlike other centers, the Kiev center reported a high incidence of goiter, at 50–60 percent, making it an 'endemic goiter' region caused by iodine deficiency. The incidence of subjects positive to thyroid autoantibody is low. One apparent case of hypothyroidism and one case of thyroid cancer were reported recently. Histologically, the cancer was papillary. Measurement of urinary iodine showed that most of the subjects are at levels below 10 $\mu g/dl$.

(4) Korosten

One needs to exercise caution in interpreting abnormal values of TSH or FT_4 as data on blood thyroid hormone levels vary widely. However, the center's diagnosis of thyroid image anomalies is extremely accurate. So far, Hashimoto's disease and multinodular goiter have been detected at the center. The incidence of subjects positive to thyroid autoantibody is high, at 5 percent. Further investigation is needed in this point.

The center plans to hold an examination of cytological thyroid diagnosis of subjects with abnormal findings. It is expected to produce an accurate report on the correlation between thyroid-related diseases and soil contamination. Furthermore, measurement of urinary iodine will be conducted at the Kiev center.

(5) Klincy

The Klincy center reported the results of examinations of 3,432 subjects at two locations — 5–15 Ci/km^2 of Klincy City (CLC) and 1–5 Ci/km^2 of Klincy Region (CLR). The center manages and reports data and conducts elaborate operations with great accuracy. The incidence of subjects positive to thyroid autoantibody at this center is high, at 2–3 percent. An accurate diagnosis of thyroid abnormalities is made. However, a system of transporting specimen to the Mogilev center for unriary iodine measurement has not yet been established. Measurement at the Klincy center is reliable in general. In the future the center must select a control region and study the relationship between thyroid-related diseases and the degree of contamination or radiation doses. This center needs further support from Health Ministry and Public Health Bureau.

The second presentations by the representatives of each center reflected a great progress made in the second year, while a need for better quality control remains. The centers are sharing information with local residents and carrying out publicity activities in the community. All in all examinations are carried out with the understanding and cooperation of the parties concerned. Efforts should be continued to clarify the the state of radiation disorder while maintaining a basic humanitarian perspective. The centers are called on to improve the storage of recorded data and the resident I.D. follow-up system. Experience of the past two years should be utilized to build a system of cooperation and support by drawing up a long-term vision of the role and direction of each center.

Comments on the Activities at the Five Centers of Sasakawa Project

— Blood examination, in particular —

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Shizuyo Kusumi
Radiation Effects Research Foundation

I. Comments commonly applicable to the five centers

1. Fluctuation within the normal range observed in blood examination
   1) Fluctuation in erythroid values by age within the normal range

      The Hb level of boys increases gradually from age 5 and rapidly particularly after 11. The Hb level of girls, on the other hand, increases gradually from age 5, but tends to reach a plateau after 11. In general, MCV of girls is higher than that of boys, and the difference becomes more remarkable after age 10.

   2) Fluctuation in the values of the leukocyte system by age within the normal range

      Fluctuation by age is not clear in both sexes. In terms of leukocyte differentiation, lymphocyte counts are relatively large at the ages of 5 and 6, but tend to be fixed after around 7. Little change by age in the actual neutrophil count is observed.

   3) Fluctuation by age in the platelet count within the normal range

      Almost the same numbers are observed in both sexes. They tend to decrease gradually with age.

Considering the above, it is thought that numerical changes in the levels of leukocytes and platelets are not different from the previously observed changes.

As for Hb, difference caused by the development of the endocrine system might be reflected in the sex difference of the Hb level. However, it is interesting that MCV of girls over age 11 is markedly higher than that of boys. Although the cause is not clear, boys might have potential iron deficiency accompanying hyper-erythropoiesis due to an increase of male hormone secretion such as androgen. In any case, it is necessary to designate certain centers to measure iron in serum, TIBC, ferritin, and erythropoietin.

Except for the contaminated areas it should be possible to develop a table of standard Hb values as the first step by collecting from the populations without any abnormal cases in which no abnormality was found in the blood examination. To this end, it is proposed that the Mogilev area, which is less contaminated, be used as a model.

No difference was observed in the amount of cesium in bodies and 50% value of Box & Whisker Plot of blood examination by area (Rayon).

2. Outlying values in blood examination

No difference except a decrease of monocytes ($<0.12\times10^9$/L) was observed in the frequency of outlying values in the blood examinations at the four centers excluding Gomel. This suggests that the selection of the subjects for examination did not influence the blood examinations, that is, it is possible that there is no significant difference in the daily life, living environment, and the degree of contamination after the accident between each center, and that the examination power at each center is almost the same. The problem is the contents of the abnormal cases and detection of tumor of the hematopoietic organ, if any, in the abnormal cases observed by follow-up. No apparent abnormal case such as leukemia has been observed, but some cases, two cases in Kiev for example, need to be followed up and be treated depending on further findings.

The two cases showed the following abnormalities;

Case No. 0301036201 13-year-old girl
Hb 11.2 g/dl, WBC 2500/μl (Ly 57%), platelet 5.6/μl

Case No. 0301023661 8-year-old boy
Hb 13.1 g/dl, WBC 6100/μl, platelet 8.2/μl

In any case, even if the frequency of abnormalities observed in the blood examinations is not high, individual cases with abnormalities merit a comprehensive hematological interpretation, elucidation of the causes, and follow-up examinations. This is a problem which the project is facing. As has been pointed out, this is because the weight of the financial burden (of the patients side) and the medical importance of the examinations are not well appreciated by the physicians and examinees.

For correction of this point, the consciousness of the physicians need to be alerted and also the services of specialized physicians should be enlisted in the future. In developing a medical network, it might be helpful if the physicians at supporting hospitals are called to participate in the project and also if training by the hematologists at supporting hospitals is held. Eosinophilia ($>0.5\times10^9$/L) was observed in 20 to 24% of the cases at each center pursuant to the previous examinations. Parasite and allergy have been pointed out as the cause of this, but examination procedures to clarify the conditions of the disease should be added. For example, examination for parasite eggs should be performed for eosinophilia patients to identify parasites as the cause. As for allergy, it is necessary to obtain the patients' anamnesis again and also measure IgE in serum.

Prevention of computer input errors is important for the purpose of reconfirmation of the outlying values. Sysmex has been requested to develop a system by which examination instruments are connected online to the centralized computer.

As a whole, no correlation has been observed between the frequency of hematological abnormalities, and the level of cesium in the body by age, area, and degree of contamination. For the purpose of producing a firm conclusion, it is proposed that a greater number of cases be accumulated and studied further.

II. Conditions at each center

1. Mogilev

At Bykhovski and Krichevski, the frequencies of neutrophilia ($>76.6\times 10^9/L$) and leukocytosis ($>11.0\times 10^9/L$) are high, 8.1–19.0% and 5.4–5.8% respectively. Reportedly, there are many infectious diseases. There are cases which encourage exchange of information on epidemic infectious diseases with local physicians.

2. Gomel

Recalculation has been made since some problems in the amassing of data came to attention. It was found that the data were almost the same as those of other centers, and that there were no striking features. It is reported that the relationship between eosinophilia and parasite, and the lymphocyte subsets by age using some cases are being examined at this institute. We requested them to continue the examination and to include the data obtained in the report since it is a very interesting point. As four children of the people who were engaged in cleaning activities after the accident have been observed to suffer from leukemia (both are under 5 years old), it has been decided to amass the cases.

3. Klincy

A comparison is being made with the contaminated areas. There are more Klincy City (CLc) cases in the moderately contaminated area than the Klincy Rayon (CLR) cases in the low contaminated area. This makes it difficult to make a statistical comparison. It is assumed that many of the leukocytosis and neutrophilia cases were caused by tonsillitis.

4. Kiev

There are some cases of neutrophilia at age 10 and below, which seem to be caused by infection. The above mentioned two cases will be followed up.

5. Korosten

Although the highly contaminated areas are included, no relationship with any abnormal hematological levels has been observed as of now.

III. From the report meeting of the five centers

The representatives of the centers reported the state of the examinations conducted between May 1991 and December 1992 (20 minutes each). Concerning blood examinations, Director Rumyantsev, Research Institute of Hematology of Russian Federation pointed out the following. (We were able to visit this institute. This is an excellent institute equipped with BMT, aseptic room, etc. the level of which is comparable to those of any A-class Japanese hospitals. We were able to meet many of the younger people in the staff. This institute provides treatment for pediatric hematopoietic organ tumor, solid tumor, and intractable hematological diseases on the same level as Japan. The level of research is high in terms of morale. I received an impression that cooperation could be obtained rather easily.)

1. Is one-time examination enough?
2. Is there no seasonal change in the blood examination values?
3. Questions concerning normal values.

To these points, we explained that the purpose of this examination is being defined and that the follow-up system with respect to patients with outlying level is being establislied, and requested them to establish a system which allows contact with the supporting hospitals. As for seasonal change, since the seasons when children can undergo examinations are limited, it is difficult to detect the seasonal effects immediately. However, it is thought that a fixed number of people in certain areas should be examined to determine the seasonal effects. Concerning the normal values, we explained that figures were quoted from the textbook of Wintrobe, and emphasized the necessity of establishing standard values by age of children in the future. Also lymphocyte subsets and the significance of the decrease of monocytes and lymphocytes were discussed. Both parties agreed to cooperate and study the problems further as subjects of future discussions.

Report and Comments on the Workshop of the Sasakawa Health and Medical Cooperation Project

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I. Introduction

It has been two years since the start of the five-year Chernobyl Sasakawa Health and Medical Cooperation Project. As in the last year, a workshop was held in Moscow this year to review accomplishments and to consider directions for the future. This report contains a comment on the measurement of ^{137}Cs by chair-type counters reported at the workshop. Last year, soil and food were collected as part of the pilot study. A full-scale collection of soil and food conducted this year will also be contained in this report.

II. Workshop on radiation dose

On the first day of the workshop (June 30), representatives from each center met to coordinate presentations scheduled for July 2. On the second day (July 1), there were separate workshop meetings where important issues were discussed for presentation. With regard to radiation dose, each center had two types of data summarizing their measurement of the whole body levels of ^{137}Cs per unit of body weight (Bq/kg): one showed distribution by region and the other, by age and sex. The results were basically the same as those of last year. Noticeably, there was no difference by region except for Gomel nor by age or sex. Details of the results appear in the reports prepared by each center.

One question frequently asked by the centers in the cession was: "We know current whole body levels of ^{137}Cs are the result of Chernobyl accident, but how dangerous is it?" In an attempt to provide an answer to the question, I lectured on the hazards of radiation to human body. The natural radiation dose per year is considered to be about 1 mSv: this corresponds to the whole body ^{137}Cs level of approximately 1000 Bq/kg (using conversion formula 500 Bq/kg=0.43 mSv=43 mrem for the exposure dose per year). Hardly any resident presently in the region has been exposed to an annual dose of 1000 Bq/kg. A comparison with an annual dose is the simplest way to explain questions about radiation.

Environmental radioactiviry of the residential areas was also discussed. Results from the last year's survey were shared suggesting a possible correlation between the contamination of soil and the whole body ^{137}Cs levels. Soil had been collected this year in Mogilev, Gomel and Klincy in the week preceding the Moscow workshop. Each center collected soil samples from approximately fifty homes in about ten locations (total of about 1500 locations). It was agreed that food samples will be collected in the future. (Food from Gomel has already been collected). Collection will be completed before the end of this year and an analysis will be conducted by the Mogilev center acting as the coordinating center. Urine of the children from the same families was also collected in order to determine the iodine content.

It is important to inform the residents of the results of the pilot study on soil and food samples collected last year. For this purpose, we gave reports to the persons in charge to be given to the residents concerned.

III. On workshops

Workshops were joined by participants from Russia. Each center reported on developments of the past year. Questions raised were mainly concerned with management of the program, such as cooperation with the Russian side. Participants were also interested to know the normal levels of items examined. The significance of soil collection was explained in regard to radiation dose. This is to say, it is necessary to estimate radiation dose relative to the total exposure and, of course, appropriate measures should be taken to avoid exposure by, for example, decontamination. The Russian Federation offered to provide data of soil contamination measured by themselves. These data will be useful for our future analyses.

IV. On soil collection

We arrived at Mogilev in the early morning of June 23 and explained the purpose of our visit. (Dr. Takatsuji and Dr. Nanba were in Gomel collecting samples.) The person in charge of measuring dose was explained some important points when collecting samples of soil, food, and urine. We had written to the center in advance so that they could select about fifty subjects (the same was done for Gomel and Klincy). As we were scheduled to go on to Gomel the following day, we collected three soil samples to show how it was done. With the collaborators from the center we visited the homes of the subjects to explain what is to be done.

The following day, instructions were given on how to use drier incinerator and blender which will be used to process collected food samples.

On June 25, we visited the Klincy center, and explained the purpose of our visit. We also obtained a consent to conduct measurements in Mogilev. Later, samples were collected by our collaborator at Klincy. The collection of soil was continued in Klincy until June 29.

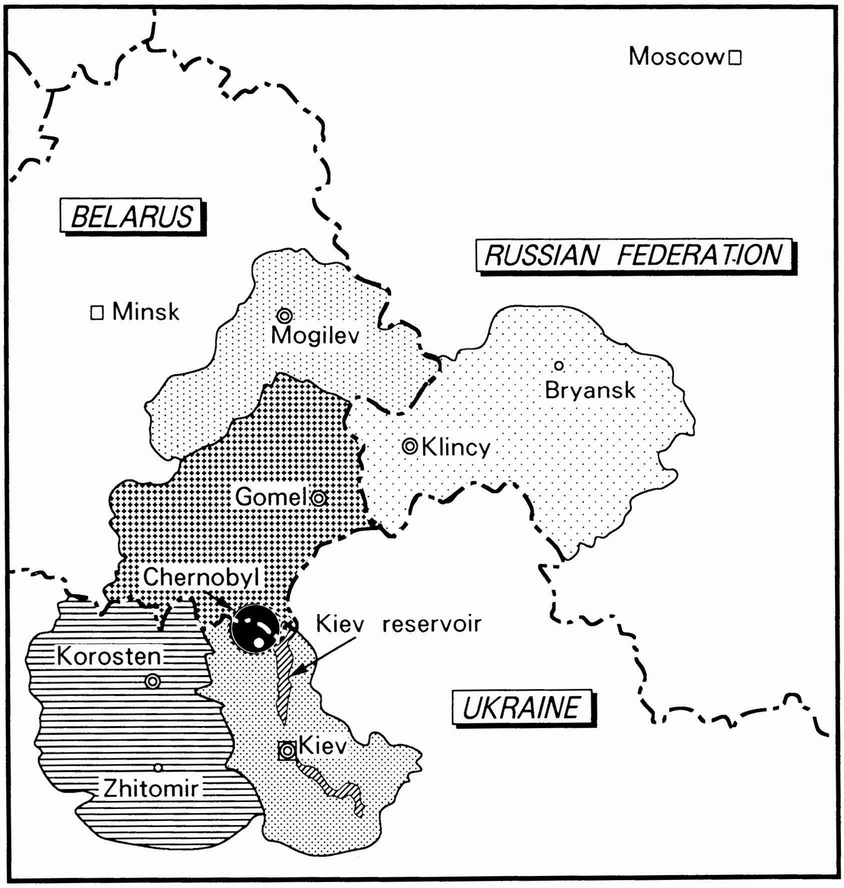
V. Conclusion

All workshops were concluded without any troubles. Soil samples were collected as planned. After a Ge detector is installed to the Mogilev center in the future, measurements will be done there. It is expected that the results of these determinations will lead to a more quantitative understanding of the relationship between soil contaminartion and the level of body intake. Once we understand the transport of ^{137}Cs from contaminated soil to human body, we believe that possibilities will open up for studying not only ^{137}Cs but other nuclides as well.

III. Appendix

Appendix A

Location of the Five Cooperative Centers



Map showing the five oblasts. The locations of the five cooperative centers are shown with double circles.

Appendix B

Determination of the Standard Thyroid Volume in Children

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The arch scanning technique described by Yokoyama et al. (J. Nucl. Med. 27, 1475–9, 1986) has been used at each of the five centers to determine the thyroid volume and also to detect structural abnormalities. The superiority of the technique over the conventional methods in estimating the thyroid volume has been suggested. Thyroid volume is known to vary with a variety of factors such as age and body weight, and therefore these factors should be taken into account when setting the limit of the standard thyroid volume.

The standard thyroid volume described in the reports was determined on the basis of findings in children who were examined at the Mogilev Regional Medical Diagnostic Center and who:

(1) were 5 to 15 years of age at the time of examination;
(2) were living in areas that are not iodine deficient (urinary iodine level being over 10 μg/dl) and where ^{137}Cs contamination level is less than 1 Ci/km^2;
(3) had a whole body ^{137}Cs count less than 50 Bq/kg;
(4) had levels of TSH and free T_4 within normal ranges, i.e., $0.24 \leq \text{TSH} \leq 2.90$ μIU/ml and $10.0 \leq \text{free } T_4 \leq 25.0$ pmol/l;
(5) had neither anti-thyroglobulin antibody nor anti-microsome antibody; and
(6) had no thyroid abnormalities revealed by ultrasonography.

A total of 801 children (386 boys and 415 girls) were selected.

The standard thyroid volume was determined by multiple regression analysis, which usually assumes the normality of the continuous variables involved in the model. Hence appropriate transformations of thyroid volume, age, height and body weight are desirable to achieve approximately normal distributions. These transformations can be obtained by means of the Box-Cox transformation technique and the normal probability plots.

For the thyroid volumes (cm^3) and body weights (kg), the base 10 logarithm was found to be the most appropriate way to achieve normal distributions. The heights (cm) and ages (year), however, were found to be normally distributed. With the criterion of Mallows' C_p, we selected the most appropriate linear regression model which expresses the $\log_{10}$(thyroid volume) as a linear function of sex, age, height and $\log_{10}$(body weight). The selected model was:

$$\log_{10}(\text{thyroid volume})=\beta_0+\beta_1(\text{age})+\beta_2(\text{height})+\beta_3\log_{10}(\text{body weight})+\varepsilon,$$

where ε is a random variable normally distributed with mean 0 and unknown variance σ^2. We defined the limit of the standard thyroid volume as the point where the normalized residual ε/σ exceeds the 95th standard normal percentile. By substituting the estimates of the parameters in the above model, we obtained the limit of the standard thyroid volume described in the reports:

$$\text{LIMIT}=1.7\times10^{0.013\times\text{age}+0.0028\times\text{height}}\times(\text{body weight})^{0.15}.$$

Postscript

The second workshop was held in Moscow from June 30 to July 2, 1993 and provided an opportunity for staff members and representatives of the five centers to engage in active discussions in all areas of concern. This document is a compilation of the unedited reports from the centers.

This time, the method of selecting subjects and data processing was standardized. Also, in describing data, a method was chosen with the intention of minimizing loss of information. As no existing software was available, staff members at the Mogilev Regional Medical Diagnostic Center worked day and night to develop the necessary software and to process the data accumulated by the five centers. This greatly contributed to the success of the workshop.

Data from 25,000 children examined by the end of 1992 were analyzed. While certain problems remain in each area, the results are impressive. Representatives of the five centers presented the results of their examinations on the final day before an audience of Russian experts and officials of the Health Ministry and Public Health Bureau. The representatives earned high praise and a positive response to the content and logical format of their presentations. The next step will be to prepare a scientific paper based on a more detailed analysis of the data.

Assistance for the second year has been provided effectively in accordance with the needs of each center. Improvements have been made including the introduction of new equipment. In the future, assistance must be directed to software and not just to hardware needs. We are determined to continue the project in the spirit of mutual collaboration and understanding and with a constant focus on feedback to local residents.

The interpreters and staff at the Sasakawa Foundation Moscow Office have dedicated themselves to the project and have been a source of strength in promoting this international medical cooperation project even in the midst of political and economic turmoil.

Finally, we would like to thank the experts and the many other people in Japan for their generous support.

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