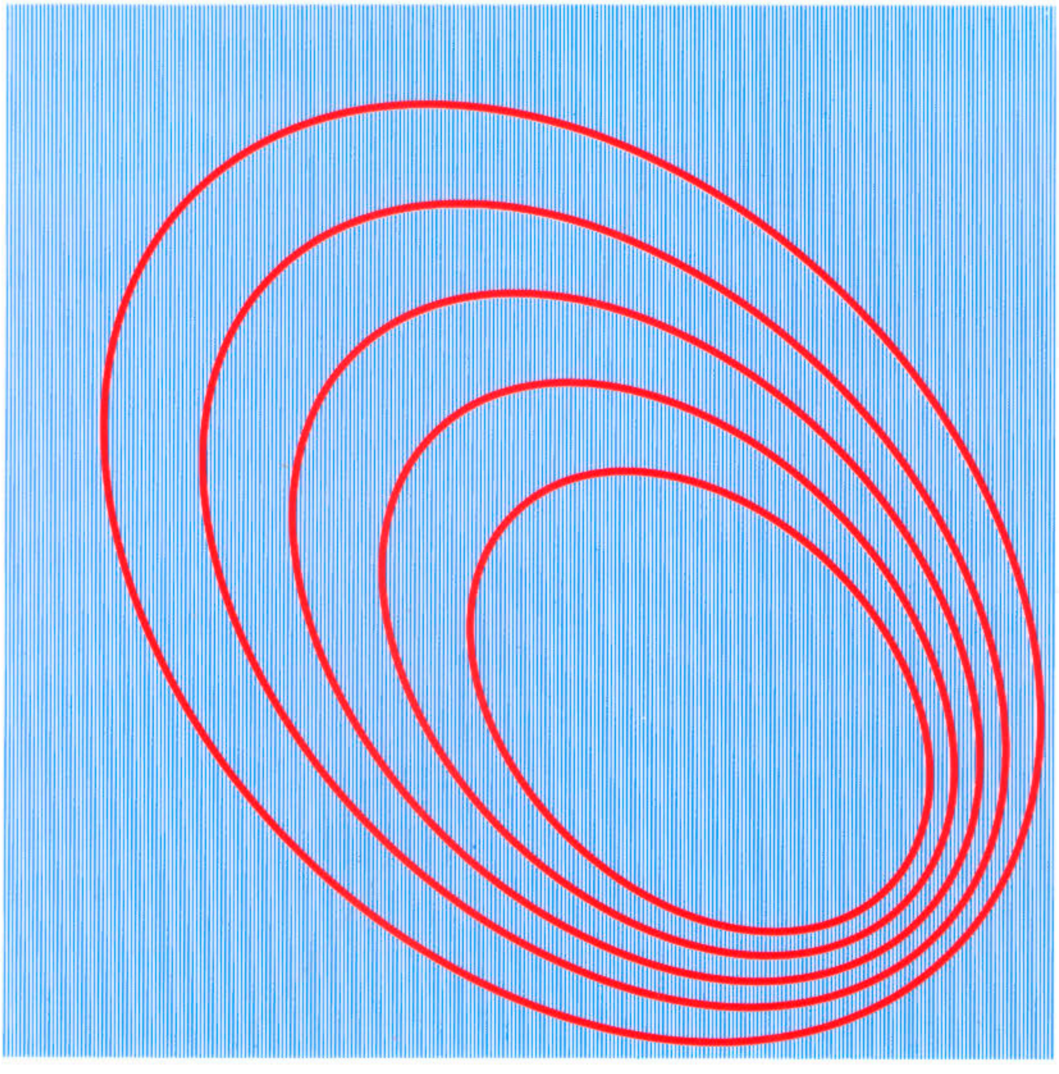
A Report on the 1994 Chernobyl Sasakawa Project Workshop

May 16 – 17, 1994

Moscow



Sasakawa Memorial Health Foundation

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Foreword

Chernobyl Sasakawa Health and Medical Cooperation Project was launched as a five-year plan in May 1991, five years after the Chernobyl Nuclear Power Station accident. The third workshop of the series was held on May 16–17, 1994 in the suburbs of Moscow to mark the completion of the third year of the program and to examine the data accumulated at the five project centers.

Although originally launched by the USSR and Japan as a joint endeavor to help the victims of the Chernobyl disaster, the project became a collaborative work shared by the Republic of Belarus, the Russian Federation, Ukraine and Japan after the political upheaval in the summer of 1991.

As stated previously, the aims of the project can be summarized as follows.

(1) The project aims to be scientific as well as humanitarian. These two principles are not contradictory. On the contrary, it is our fundamental assumption that a truly humanitarian act of this kind needs to have a solid scientific foundation.

(2) The main activity of the project is medical screening of children living in the affected areas. Therefore, we have a responsibility to provide reliable and accurate information on the results of screening to those examined. If any abnormal finding is detected in a child, he/she will receive follow-up examinations until a final diagnosis is made. It is imperative, therefore, that the first screening be carried out with the utmost accuracy and precision.

(3) The data obtained from the screening must be high in quality and reliability to avoid false interpretation. For this purpose, standardization of screening procedures and various examinations are of crucial importance. State-of-the-art medical equipment is employed in the screening. In order to obtain standardized data from the five centers, continuous efforts have been made, by training and quality control, to maintain optimal conditions regarding screening staff, medical equipment, reagents and supplies.

In implementing the project, we strive to ensure that the above three aims are observed. In addition to these three, there is another very important point.

(4) That is the management of data obtained from the screening activities. These data are a valuable asset for the future of humankind. Thus, the analysis of data becomes an important aspect of the project. Comparison and examination of data by characteristics of children (such as age and sex) will be found in the pages of this report. One of our next targets of analysis will be to examine the effects of irradiation at the time of the accident on the health of children.

This publication summarizes the reports made by the five centers at the workshop in May on activities conducted and data obtained during the period between May 1991 and December 1993. We plan to hold the 3rd Chernobyl Sasakawa Medical Symposium in Bryansk, Russia in September 1994 to discuss and analyze the data reported herein, and we hope to enjoy the participation not only of the doctors and specialists involved in the project but also of world experts.

At the symposium entitled "Chernobyl in the Future" held in Nagasaki, Japan in June 1994, the unanimous opinion was that international collaboration and cooperation are indispensable in the effective pursuit of relevant medical cooperation and research programs. In publishing this scientific data, which is the fruit of the cooperation of four nations, we hope to attract constructive and wide-ranging comments and opinions from persons concerned about the impact of the Chernobyl accident. We believe that this vital project will thereby not only benefit the examined children but also contribute to the health and welfare of all the people of the world.

Kenzo Kiikuni
Executive Managing Director
Sasakawa Memorial Health Foundation

June 1994

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Mogilev Regional Medical Diagnostic Center

Yurieva N. D., Rafeenko S. M., Sharipov V. F., Krupnik T. A., Dolbeshkin N. K., Kovalev V. M.

1. Introduction

The Chernobyl disaster caused an unfavorable medical situation in the Mogilev Oblast (Province). The territory of 10 400 km^2 comprising 1159 settlements with 186 600 residents including 46 400 children was exposed to ^{137}Cs radiation contamination exceeding 1 Ci/km^2. More than 10 000 residents of areas recognized as unfavorable for habitation (15 Ci/km^2 or higher) have been resettled to uncontaminated areas.

Under these conditions a long-term program for the medical examination and study of the health status of children renders inestimable assistance to health care bodies and to the population of the oblast. The program is financed mainly by the Sasakawa Memorial Health Foundation with the participation of prominent Japanese scientists.

The Sasakawa Chernobyl Project in our oblast is implemented by the Mogilev Regional Diagnostic Center, which has an adequate material base and skilled medical and technical staff.

The examination of children and collection of information is carried out with a mobile diagnostic laboratory and with a set of stationary equipment installed in the center.

The course of examination includes the following: (1) collection of disease history and biographical information; (2) anthropometric data; (3) registration of gamma radiation from the body of the child; (4) ultrasonography of the thyroid; (5) peripheral blood count; (6) determination of thyroid hormones and antibodies in the blood serum; (7) determination of iodine and creatinine in the urine; and (8) examination by a pediatrician, a hematologist and by other specialists if required.

The information thus obtained is processed at the center and then entered into a database. Parents are informed in writing of the results of the examination.

If abnormalities are found, the children in question are invited to visit the center for a comprehensive examination, professional consultation 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 from May 15, 1991 to December 31, 1993. Only one record of results obtained during the examination of each child was used for data analysis.

2.2 Measurement of whole body ^{137}Cs concentration

To determine the ^{137}Cs concentration in children's bodies, direct spectrometry of radionuclide activity was performed. This method is based on the registration of gamma radiation from the body. The Whole Body Counter-101 manufactured by the Aloka Company (Japan) was used.

2.3 Thyroid examinations

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

Diagnosis of thyroid disease was established on the basis of the following criteria of thyroid images: (1) position, (2) structure, (3) echogenity, (4) presence of nodules and cysts, and (5) 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 following formula:

$$LIMIT = 1.7 \times 10^{0.013 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of the child in years at the time of the examination, *height* is the height of the child in cm; *body weight* is the weight of the child in kg. See Appendix B in *A Report on the 1993 Chernobyl Sasakawa Project Workshop*, 1993 for details.

The serum free thyroid thyroxine (FT_4) and thyroid stimulating hormone (TSH) levels were determined with an Amerlite hormone analyzer using the immunometric technique based on enhanced luminescence. Studies were 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) were determined by the reaction of indirect hemagglutination (Fujirevio).

Determination of iodine and creatinine content in the urine was carried out with a BRAN+LUBBE automatic Analyzer II.

2.4 Hematological studies

Hematological studies were conducted with K-1000 and NE-7000 hemoanalyzers manufactured by the Sysmex Company 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).

The differential leukocyte count was determined using an Olympus BH-2 biological microscope and NE-7000 analyzer.

3. Results

3.1 Study subjects

From May 15, 1991 to December 31, 1993, 12 356 children (6049 boys and 6307 girls) were examined. Ranging in age from 5 to 17 years, these children were residing in 12 rayons of the Mogilev Oblast (Slavgorodskii, Klimovichskii, Chausskii, Krichevskii, Bykhovskii, Mogilevskii, Kostyukovichskii, Krasnopolskii, Cherikovski, Klichevski, Bobruiskii and Glusskii) and Mogilev City (Table 1). Belynichskii, Goretskii, Osipovichiskii and Bobruisk City were not included in the table because less than 10 children were examined in these areas. The triplets give the 25th, 50th and 75th sample percentiles of age distribution at the time of the examination in each group.

Figure 1 shows the rayons where ^{137}Cs contamination levels (Ci/km^2) were measured. The highest level of contamination was registered in Krasnopolskii Rayon (up to 105.8 Ci/km^2), Cherikovskii Rayon (up to 65.7 Ci/km^2) and Kostyukovichskii Rayon (up to 57.6 Ci/km^2). The triplet on the map of

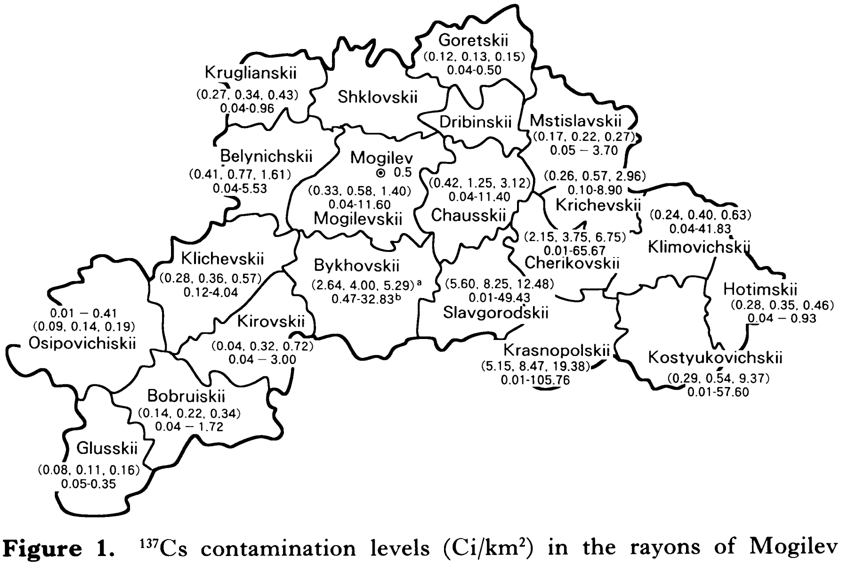

Figure 1. ^{137}Cs contamination levels (Ci/km^2) in the rayons of Mogilev Oblast as measured in 1992.

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

[b] Minimum and maximum levels of contamination.

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

Place of residence	Boys	Girls	Total
Slavgorodskii	178 (7, 9, 12)[b]	193 (7, 10, 12)	371 (7, 9, 12)
Klimovichskii	46 (7, 8, 10)	41 (7, 8, 10)	87 (7, 8, 10)
Chausskii	666 (8, 10, 11)	728 (8, 10, 12)	1394 (8, 10, 11)
Krichevskii	133 (6, 7, 8)	147 (6, 7, 8)	280 (6, 7, 8)
Bykhovskii	712 (9, 11, 14)	719 (9, 11, 14)	1431 (9, 11, 14)
Mogilev City	2603 (8, 11, 13)	2734 (8, 11, 13)	5337 (8, 11, 13)
Mogilevskii	1109 (9, 11, 13)	1078 (9, 11, 13)	2187 (8, 11, 13)
Kostyukovichskii	197 (9, 12, 13)	231 (10, 12, 13)	428 (9, 12, 13)
Krasnopolskii	159 (9, 10, 13)	166 (9, 10, 12)	325 (9, 10, 12)
Cherikovskii	145 (10, 11, 13)	171 (10, 12, 13)	316 (10, 11, 13)
Klichevskii	61 (9, 10, 12)	54 (8, 10, 12)	115 (9, 10, 12)
Bobruiskii	7 (7, 8, 11)	15 (9, 11, 11)	22 (8, 10, 11)
Glusskii	27 (9, 11, 11)	24 (10, 11, 13)	51 (9, 11, 12)
Total	6049 (8, 10, 13)	6307 (8, 11, 13)	12 356 (8, 11, 13)

[a]Subjects in the following rayons are not shown because the number wes less than 10: Belynichskii, Goretskii, Osipovichiskii and Bobruisk City.

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

Mogilev Oblast indicates the 25th, 50th and 75th percentiles of the distribution of the ^{137}Cs contamination level in each rayon. The two numbers are the minimum and maximum contamination levels in each rayon.

3.2 Measurement of whole body ^{137}Cs concentration

Figure 2 shows the distribution of specific ^{137}Cs concentration in the bodies of children examined by sex and age. Children of 5–6 years of age accumulate ^{137}Cs more intensively than older children. It should be noted that the process of ^{137}Cs accumulation is more intensive in 14 to 16 year-old boys than in girls of the same age. The largest ^{137}Cs accumulation values lay in the range from 10 to 80 Bq/kg.

Figure 3 shows the distribution of specific ^{137}Cs concentration in the bodies of children examined by place of residence. A high level of ^{137}Cs accumulation was observed in Klichevskii Rayon (contamination level of the territory is

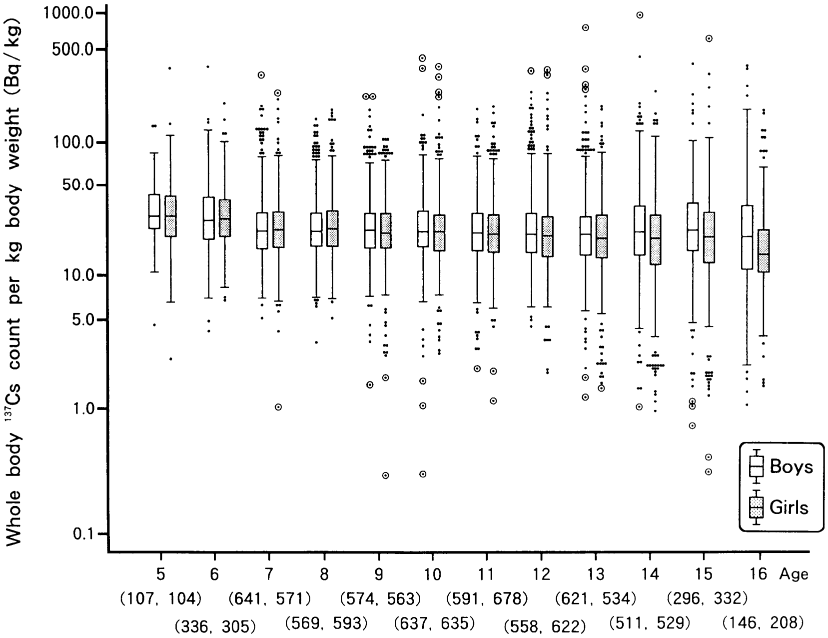

Figure 2. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by sex and age. Each pair presents the number of examined boys and girls. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, called "outside" and "far out," respectively.

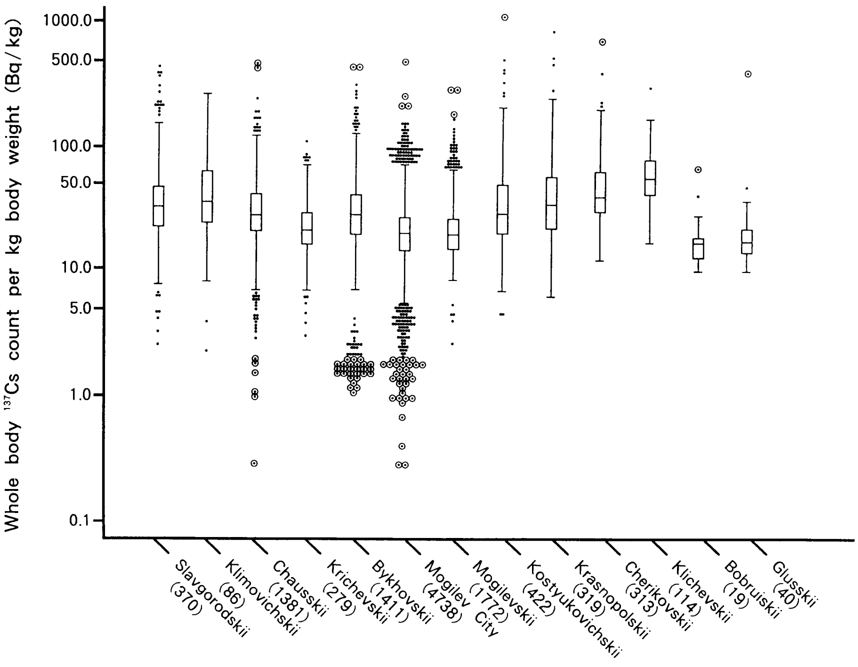

Figure 3. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by place of residence. The parenthetic entries refer to the number of examined children. See Figure 2 for details.

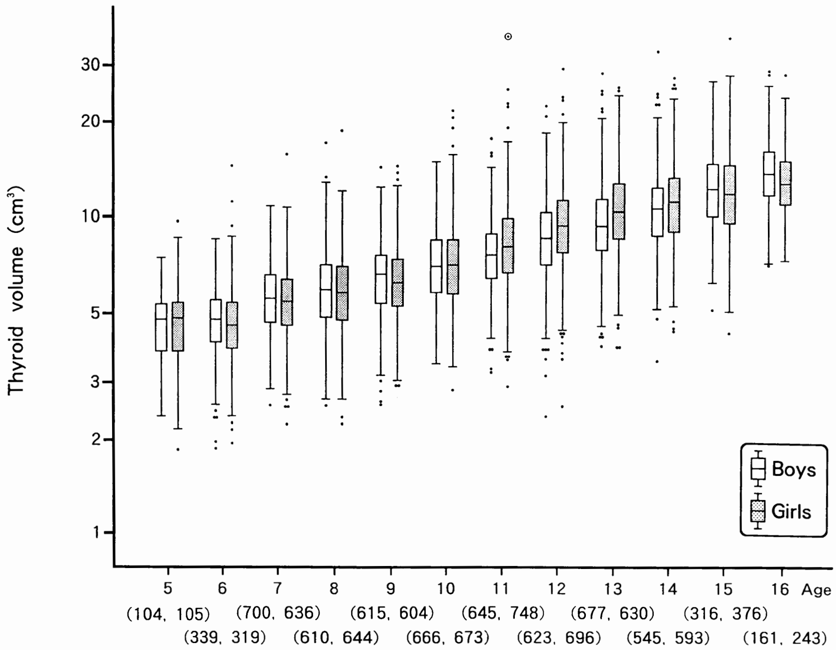

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

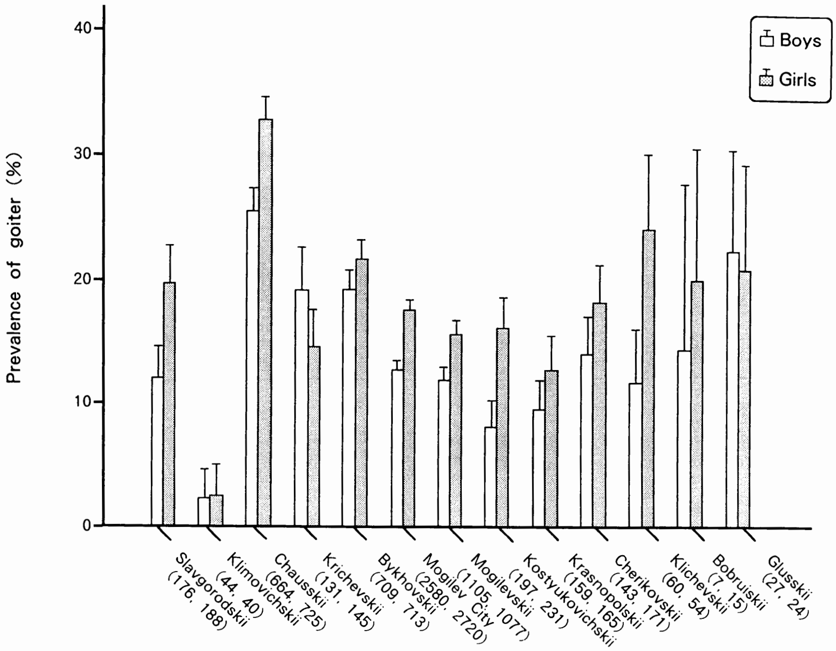

Figure 5. Prevalence of goiter by sex and place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

Table 2. Subjects with thyroid abnormalities by sex and place of residence.

Place of residence	Number of subjects examined		Diagnosis							
			Nodular lesion		Cystic lesion		Abnormal echogenity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Slavgorodskii	176	188	0	0	0	0	0	4	2	0
Klimovichskii	44	40	0	0	0	0	1	0	2	2
Chausskii	664	725	0	1	0	1	4	5	1	2
Krichevskii	131	145	0	0	0	0	0	0	0	0
Bykhovskii	709	714	0	0	0	1	0	2	1	1
Mogilev City	2581	2721	4	4	8	7	11	41	7	8
Mogilevskii	1105	1077	1	1	1	1	9	13	0	0
Kostyukovichskii	197	231	0	0	0	0	0	1	2	1
Krasnopolskii	159	165	0	0	0	0	0	0	3	3
Cherikovskii	143	171	0	0	0	0	1	1	0	0
Klichevskii	60	54	0	0	0	0	0	0	1	0
Bobruiskii	7	15	0	0	0	0	0	0	0	0
Glusskii	27	24	0	0	0	0	0	0	0	0
Total	6009	6276	5	6	9	10	26	68	19	17

[a] B, boys; G, girls.

0.12–4.0 Ci/km^2), in Cherikovskii (0.01–65.7 Ci/km^2), in Klimovichskii (0.04–41.8 Ci/km^2), in Slavgorodskii (0.01–49.4 Ci./km^2) and in Krasnopolskii Rayons (0.01–105.8 Ci/km^2).

3.3 Thyroid examinations

Figure 4 shows the relationship between thyroid volume and sex and age. The trend was towards 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. The highest prevalence of goiter among boys and girls was found in Chausskii Rayon.

Table 2 shows the prevalence of thyroid abnormalities by sex and place of residence. An abnormality in thyroid echogenity was found in 94 children (68 girls), while autoimmune thyroiditis was diagnosed in 51 children (43 girls). Nodules were found in 11 children (6 girls) and cysts in 19 children (10 girls). Hypoplasia was found in 36 children (17 girls).

A positive titer of ATG was observed in 73 children including 53 girls. A positive titer of AMC was found in 160 children including 125 girls. A positive titer of both ATG and AMC was found more frequently in girls than in boys (Table 3).

As shown in Table 4, an increase in serum TSH level with a simultaneous decrease in serum FT_4 level was found in 10 children (6 girls). Seven children were re-examined and the data of the first examination were confirmed in 2 girls. A decreased level of TSH with a simultaneous increase in FT_4 was

Table 3. Prevalence of positive ATG (anti-thyroglobulin antibody) and AMC (anti-microsome antibody) titers by sex and place of residence.[a]

Place of residence	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Slavgorodskii	362	176	186	2 (0.6)	0	2 (1.1)	9 (2.5)	1 (0.6)	8 (4.3)
Klimovichskii[b]									
Chausskii	621	299	322	1 (0.2)	1 (0.3)	0	2 (0.3)	2 (0.7)	0
Krichevskii	273	129	144	2 (0.7)	0	2 (1.4)	1 (0.4)	0	1 (0.7)
Bykhovskii	1317	659	658	11 (0.8)	5 (0.8)	6 (0.9)	26 (2.0)	7 (1.1)	19 (2.9)
Mogilev City	4071	1993	2078	34 (0.8)	10 (0.5)	24 (1.2)	72 (1.8)	15 (0.8)	57 (2.7)
Mogilevskii	2155	1094	1061	17 (0.8)	4 (0.4)	13 (1.2)	37 (1.7)	8 (0.7)	29 (2.7)
Kostyukovichskii	406	189	217	1 (0.2)	0	1 (0.5)	4 (1.0)	1 (0.5)	3 (1.4)
Krasnopolskii	246	119	127	2 (0.8)	0	2 (1.6)	5 (2.0)	1 (0.8)	4 (3.1)
Cherikovskii	301	139	162	1 (0.3)	0	1 (0.6)	2 (0.7)	0	2 (1.2)
Klichevskii	111	60	51	1 (0.9)	0	1 (2.0)	1 (0.9)	0	1 (2.0)
Bobruiskii	12	3	9	0	0	0	0	0	0
Glusskii	43	23	20	1 (2.3)	0	1 (5.0)	1 (2.3)	0	1 (5.0)
Total	9930	4890	5040	73 (0.7)	20 (0.4)	53 (1.1)	160 (1.6)	35 (0.7)	125 (2.5)

[a] Number of subjects with percentages in parentheses.
[b] No subjects were measured their antibodies because reagents were unavailable at the time of examination.

observed in 8 children (5 girls). Five of these children were re-examined, but the data of the previous examination could not be confirmed.

No relationship was observed between the prevalence of goiter and the contamination in the territory of residence (Figure 6).

It is difficult to determine the relationship between the prevalence of goiter and ^{137}Cs specific activity in the body since the number of children with ^{137}Cs specific activity exceeding 200 Bq/kg was very small (Figure 7).

It was not possible to establish any relationship between the prevalence of a positive titer of ATG and ^{137}Cs specific activity in the body (Figure 8). The prevalence of a positive titer of ATG was 1% in girls and 0.4% in boys. No relationship was observed between the prevalence of a positive titer of AMC and ^{137}Cs specific activity in the body (Figure 9). The prevalence of a positive titer of AMC was 2.4% in girls and 0.7% in boys.

Table 4. Number of subjects with hypothyroidism and hyperthyroidism by sex and place of residence.

Place of residence	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	80	42	38	0	0	0	0	0	0
Chausskii	621	299	322	0	0	0	1	1	0
Krichevskii	273	129	144	1	0	1	0	0	0
Bykhovskii	1317	650	657	0	0	0	2	0	2
Mogilev City	5269	2575	2694	2	0	2	1	1	0
Mogilevskii	2160	1098	1062	3	2	1	4	1	3
Kostyukovichskii	406	189	217	1	1	0	0	0	0
Krasnopolskii	246	119	127	0	0	0	0	0	0
Cherikovskii	301	139	162	0	0	0	0	0	0
Klichevskii	111	60	51	0	0	0	0	0	0
Bobruiskii	12	3	9	0	0	0	0	0	0
Glusskii	43	23	20	0	0	0	0	0	0
Total	11 213	5518	5695	10	4	6	8	3	5

[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.

The relationship between urinary iodine content and serum FT_4 and TSH levels, and the residual of thyroid volume after adjustment for age, height and weight was studied (Figures 10–12). A statistically significant correlation was observed between urinary iodine content and serum FT_4 and TSH levels but the respective correlation coefficients were small: 95% confidence interval of the correlation coefficient was $-0.11 < \rho < -0.01$ for urinary iodine content and serum FT_4 level; and $0.04 < \rho < 0.13$ for urinary iodine content and serum TSH level. No significant correlation was observed between urinary iodine content and the residual thyroid volume: 95% confidence interval of the correlation coefficient was $-0.01 < \rho < 0.08$.

Similar analysis was conducted for ^{137}Cs specific activity in the body and serum FT_4 and TSH levels, and the residual thyroid volume (Figures 13–15). A statistically significant correlation was observed in three cases but the respective correlation coefficients were small: 95% confidence interval of the correlation coefficient was $-0.04 < \rho < -0.003$ for ^{137}Cs specific activity and serum FT_4 level; $0.03 < \rho < 0.07$ for ^{137}Cs specific activity and serum TSH level; and $-0.09 < \rho < -0.05$ for ^{137}Cs specific activity and residual thyroid volume.

3.4 Hematological studies

The relationship between hemoglobin level and age and sex is shown in Figure 16. Most of the Hb levels were within normal limits in all age groups. A trend towards an increase in hemoglobin level with age was noted. The median of hemoglobin level was higher in boys than in girls, and the difference

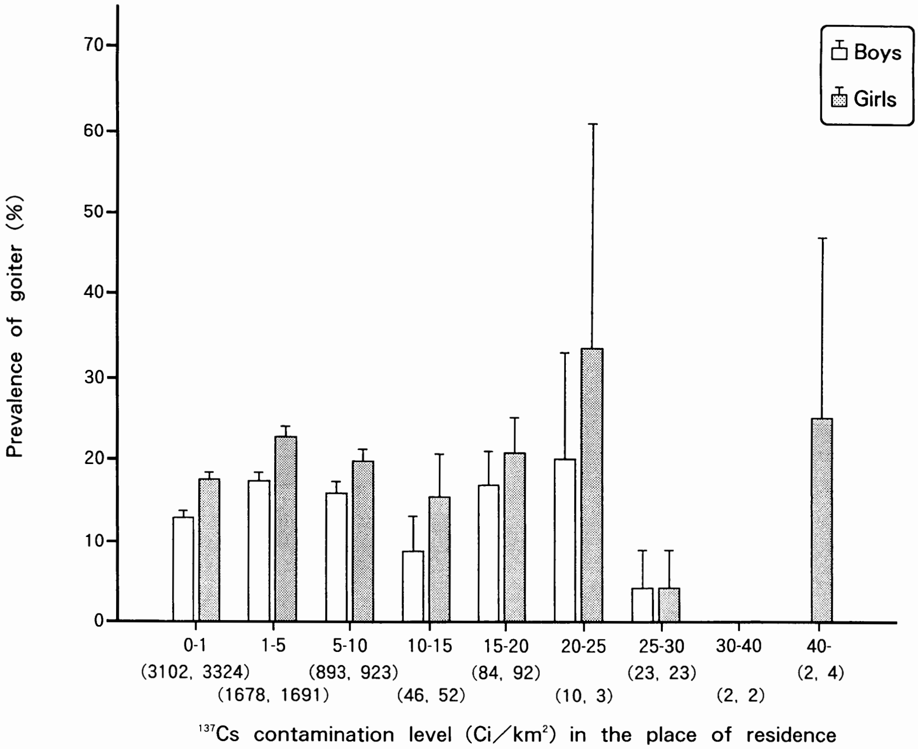

Figure 6. Prevalence of goiter by sex and contamination level (Ci/km^2) in the place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

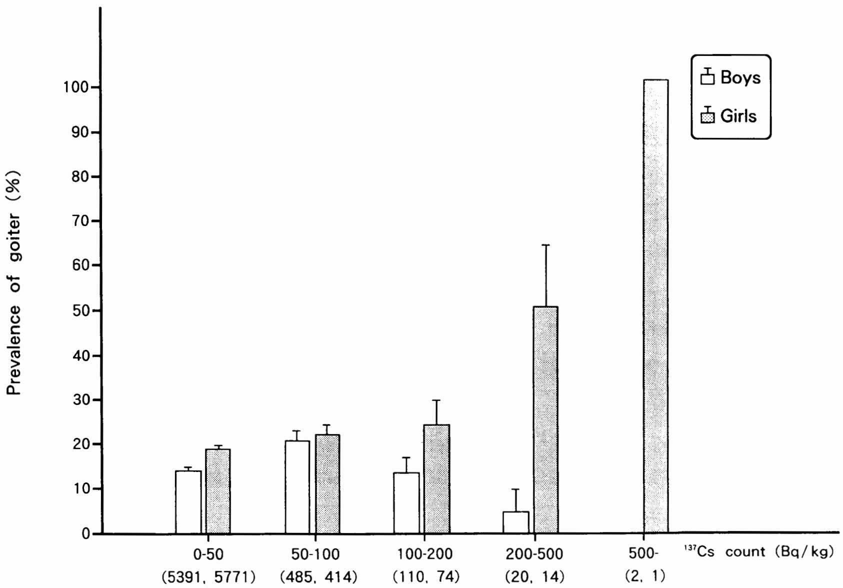

Figure 7. Prevalence of goiter by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

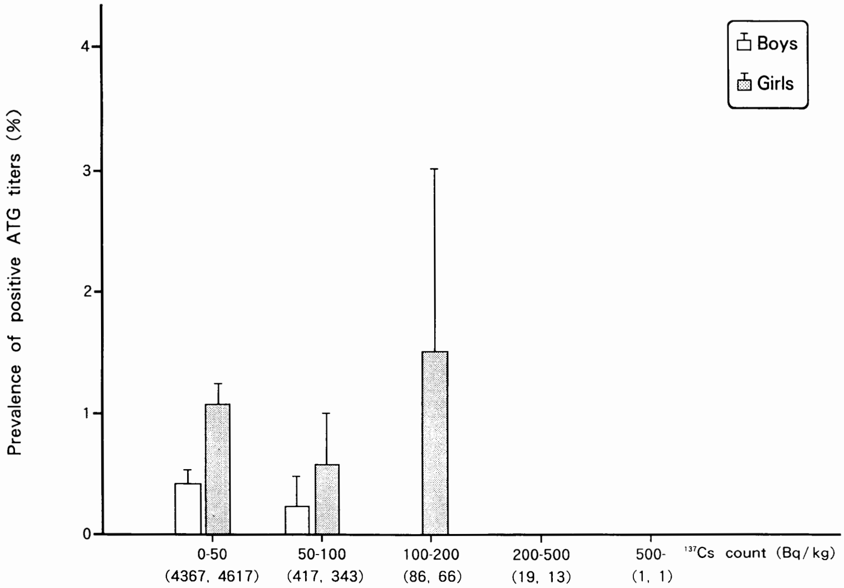

Figure 8. Prevalence of positive ATG titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

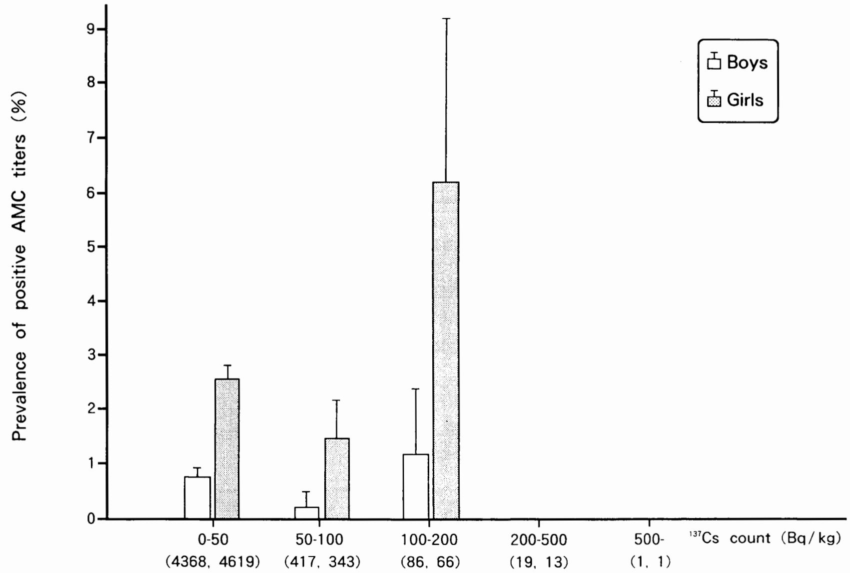

Figure 9. Prevalence of positive AMC titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

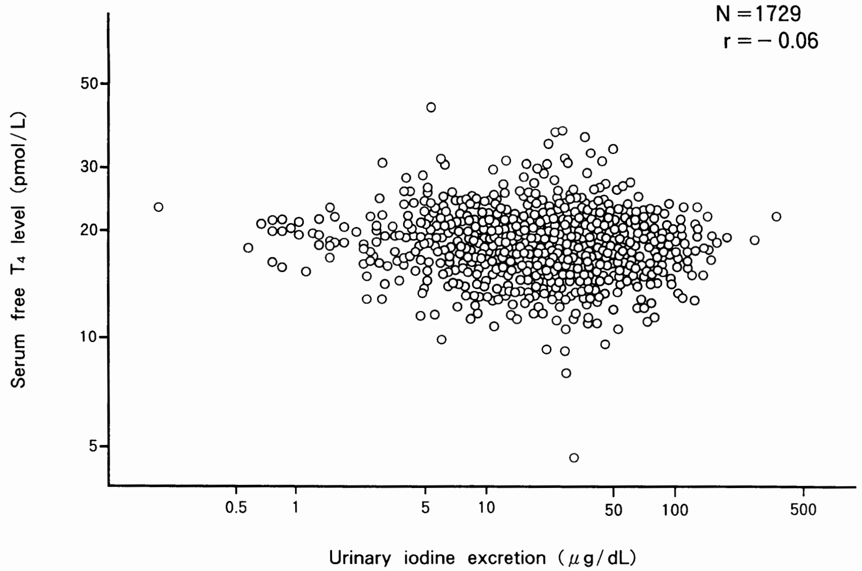

Figure 10. Scatter plots of urinary iodine excretion and serum free T_4 level.

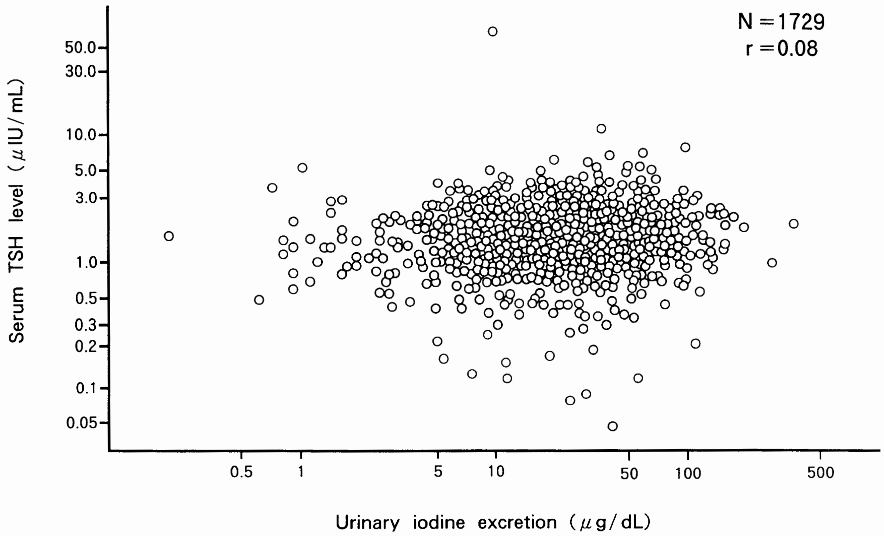

Figure 11. Scatter plots of urinary iodine excretion and serum TSH level.

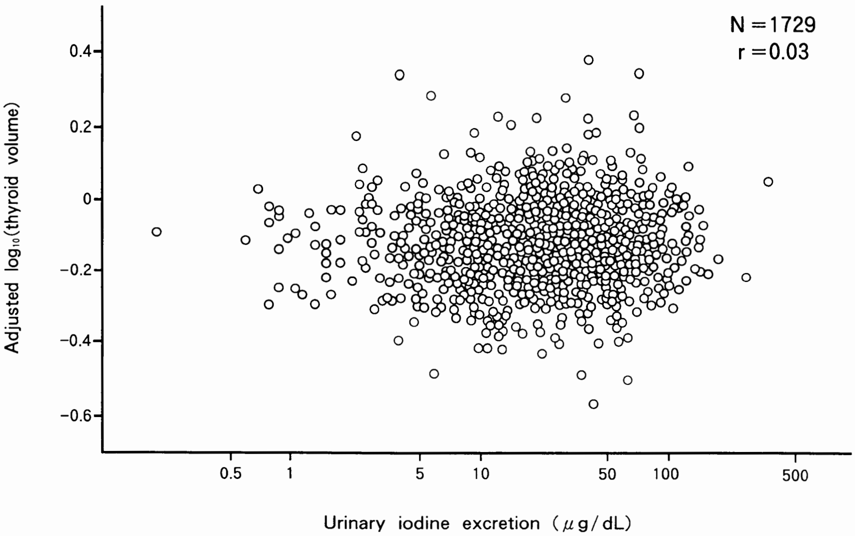

Figure 12. Scatter plots of urinary iodine excretion and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

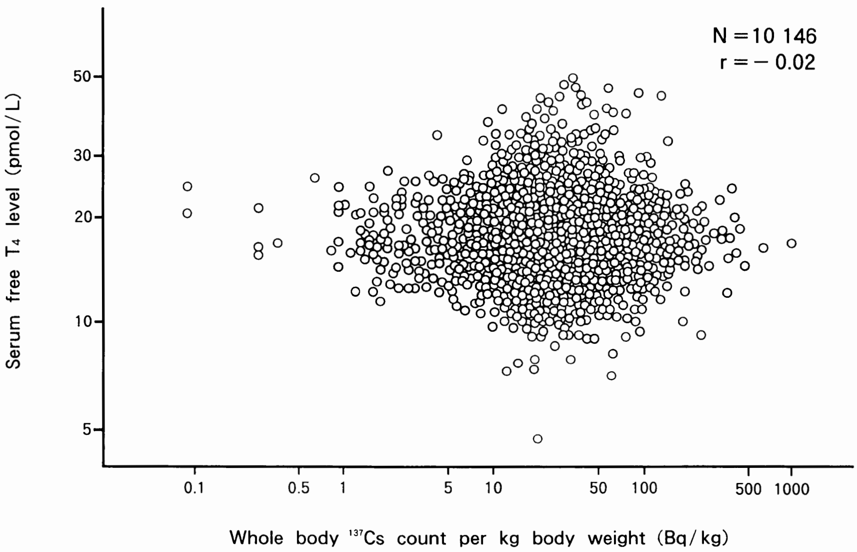

Figure 13. Scatter plots of whole body ^{137}Cs count per kg body weight and serum free T_4 level.

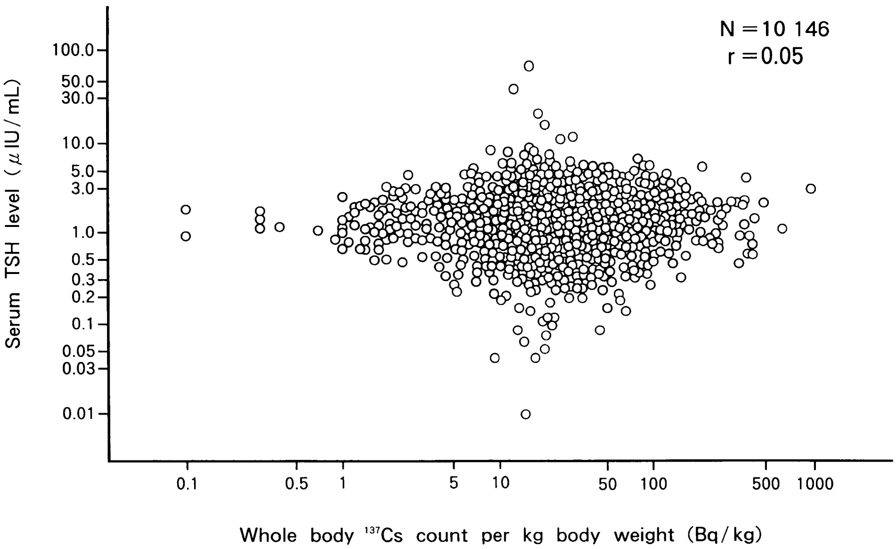

Figure 14. Scatter plots of whole body ^{137}Cs count per kg body weight and serum TSH level.

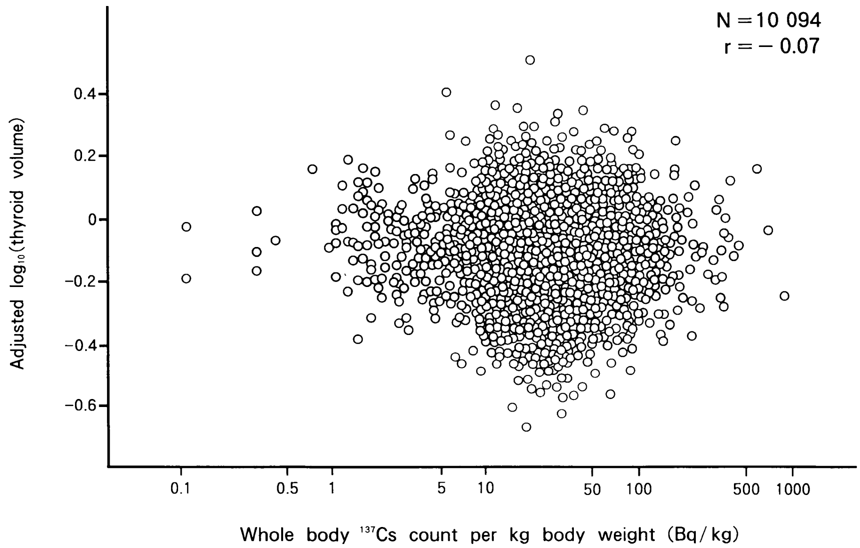

Figure 15. Scatter plots of whole body ^{137}Cs count per kg body weight and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

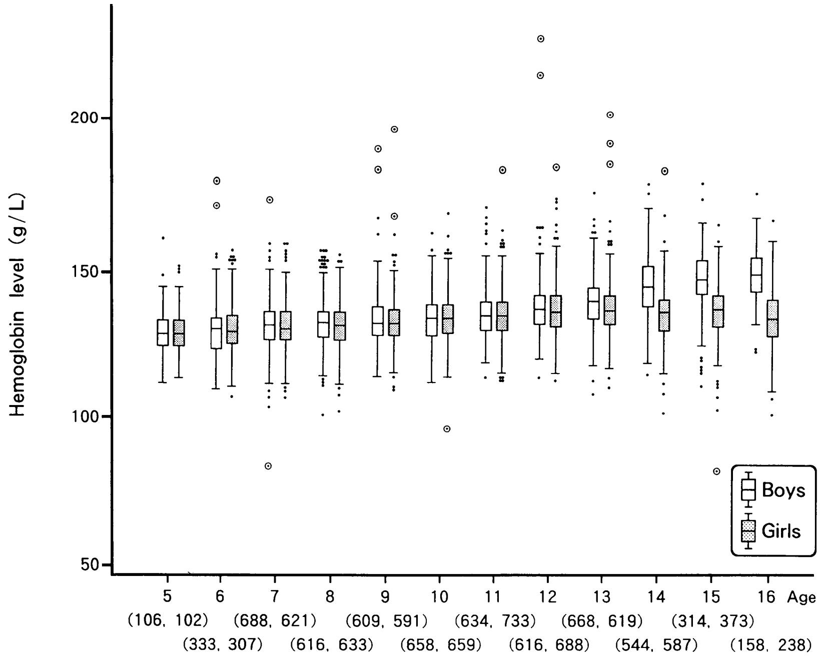

Figure 16. The box-and-whisker plots of hemoglobin level by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

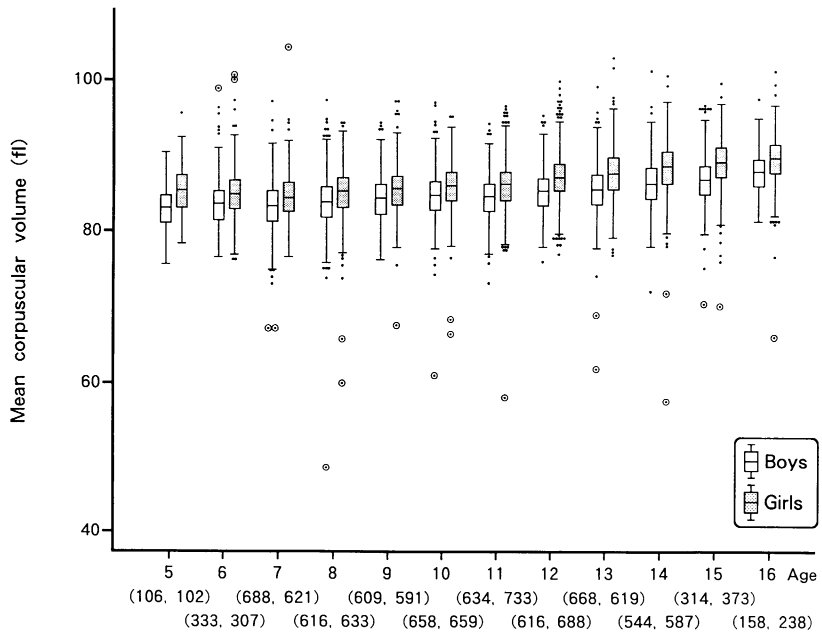

Figure 17. The box-and-whisker plots of mean corpuscular volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

was more pronounced from 12 years of age.

The relationship between MCV and age and sex is shown in Figure 17. The median of MCV was within normal range in all age and sex groups. The trend was toward an increase in MCV with age. MCV was higher in girls than in boys at all ages. A decrease in MCV level was registered in 476 children, while anemia was found in only 9 children.

Figure 18 shows the relationship between platelet count in the blood and age and sex. Most of the levels and the median of PLT were within normal range at all ages. The trend was toward a decrease in PLT with increasing age in both girls and boys.

Figure 19 shows the relationship between WBC and age and sex. The median of WBC was within normal limits at all ages and no relationship was found between WBC and age and sex.

Tables 5A and 5B show the frequency of deviations from normal in the hemograms of boys and girls in relation to the place of residence, respectively. The leukogram was examined precisely by microscopic analysis.

The results of the general blood count in 5951 boys show the following hematological abnormalities: anemia-7 boys (0.1%) living in Mogilev City and Mogilevskii Rayon; leukopenia-39 boys (0.7%), 27 of whom live in Mogilev City; thrombocytopenia-3 boys (0.1%), 2 of whom are from Mogilev City; lymphopenia-545 boys (9.2%); neutropenia-15 boys (0.3%); eosinophilia-898 boys (15.1%). The highest frequency of leukocytosis in boys (14.4%) was registered in Krichevskii Rayon and the lowest in Mogilev City (1.6%).

The Pelger anomaly of neutrophils was found in 4 boys (families).

The most remarkable deviations from normal range were noted in eosinophil count. The highest frequency of eosinophilia was in boys residing in Krichevskii (40.2%), Klimovichskii (40.0%), Slavgorodskii (29.8%) and Cherikovskii (26.8%) Rayons, while the lowest frequency was observed in Mogilev City (10.8%). Most of the people residing in the rayons consume food from private farms, thus giving rise to a high incidence of parasitic and allergic diseases.

Of the 6160 girls undergoing examinations by general blood count, 14 girls (0.2%) were shown to have anemia, or twice as many cases as in boys, and 8 of them live in Mogilev; 21 girls (0.3%) had leukopenia or half the number of cases in boys, and 16 live in Mogilev City; 8 (0.1%) had thrombocytopenia, and 3 live in Mogilev City; 529 (8.6%) had lymphopenia; 14 girls (0.2%) had neutropenia; and 830 girls (13.5%) had eosinophilia.

One girl aged 9 (Krichevskii Rayon) showed a leukemoid reaction of the lymphocytic type, and one girl aged 11 from Mogilev had a thrombocytopenic purpura.

The highest frequency of leukocytosis in girls (11.0%) was registered in Krichevskii Rayon and the lowest in Mogilev City (1.1%). Most of the children with a high WBC showed clinical symptoms such as acute respiratory dis-

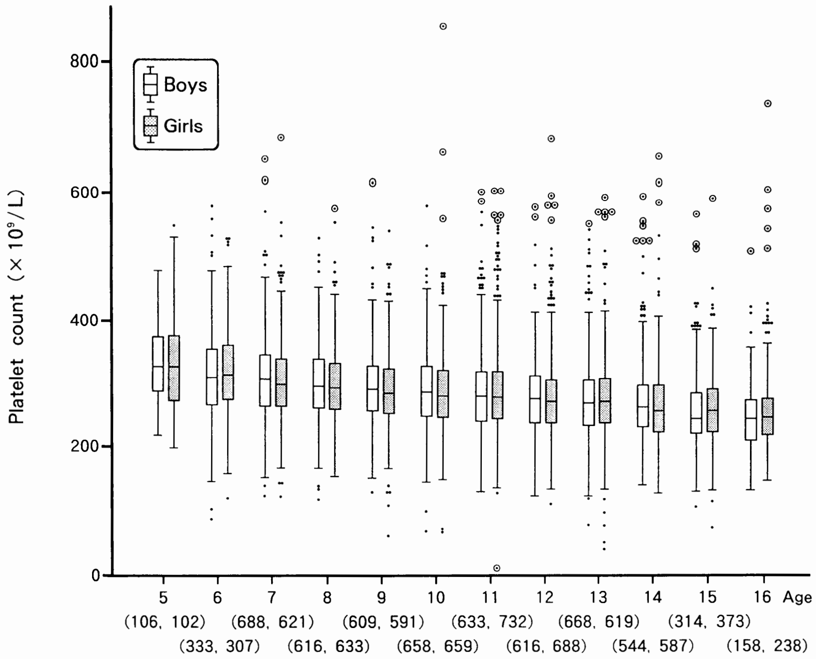

Figure 18. The box-and-whisker plots of platelet count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

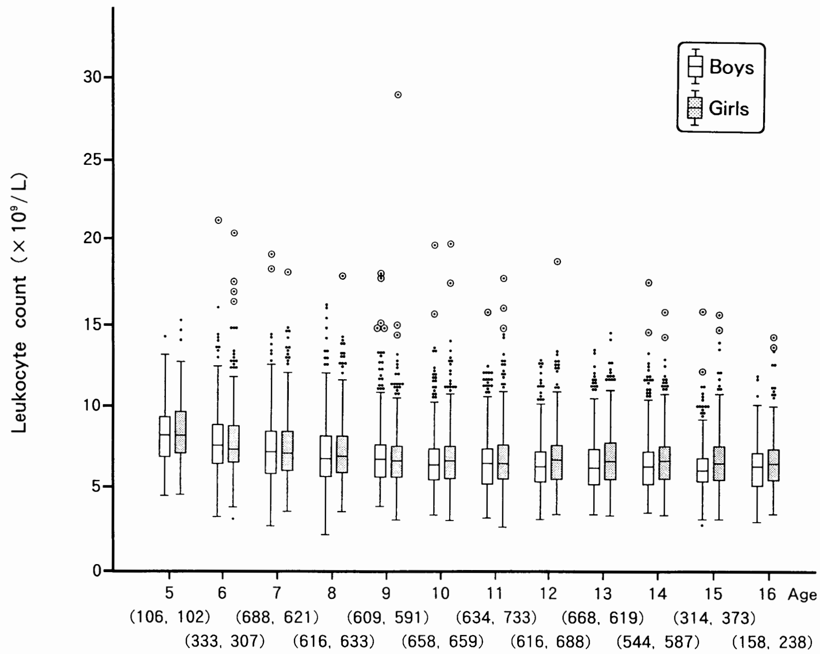

Figure 19. The box-and-whisker plots of leukocyte count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

Table 5A. Frequency of boys with hematological abnormalities by place of residence.[a]

Blood analysis		Place of residence[b]													Total
Item (unit)[c]	Abnormality criteria	SLA	KLI	CHA	KRI	BYK	MOG	MGR	KOS	KRA	CHR	KLC	BOB	GLU	
Hb (g/L)	<110						4 (0.2)	3 (0.3)							7 (0.1)
	>180					2 (0.3)	1 (0.04)		6 (0.5)						4 (0.1)
WBC (×10⁹/L)	<3.8			1 (0.2)		5 (0.7)	27 (1.0)	3 (0.3)	3 (1.6)						39 (0.7)
	>10.6	11 (6.2)	2 (4.4)	29 (4.5)	19 (14.4)	26 (3.7)	42 (1.6)	47 (4.3)	5 (2.7)	6 (3.9)	12 (8.7)	3 (5.0)		1 (3.8)	203 (3.4)
PLT (×10⁹/L)	<100						2 (0.1)			1 (0.7)					3 (0.1)
	>440	4 (2.2)		14 (2.2)	6 (4.5)	12 (1.7)	21 (0.8)	13 (1.2)	32 (17.0)		3 (2.2)		1 (14.3)		106 (1.8)
MCV (fl)	<80	8 (4.5)	1 (2.2)	47 (7.3)	7 (5.3)	30 (4.3)	180 (7.0)	39 (3.6)	6 (3.2)	12 (7.8)	6 (4.3)	1 (1.7)	2 (28.6)	3 (11.5)	342 (5.7)
	>100			1 (0.2)											1 (0.02)
Ly (×10⁹/L)	<1.2		2 (4.4)	93 (14.4)	1 (0.8)	65 (9.2)	261 (10.1)	80 (7.3)	28 (14.9)	7 (4.6)	4 (2.9)	1 (1.7)		1 (3.8)	545 (9.2)
	>3.5	21 (11.8)	7 (15.6)	65 (10.1)	45 (34.1)	95 (13.5)	176 (6.8)	108 (9.9)	22 (11.7)	9 (5.9)	8 (5.8)	6 (10.0)	2 (28.6)	7 (26.9)	571 (9.6)
Ne (×10⁹/L)	<1.4			3 (0.5)	1 (0.8)		8 (0.3)	2 (0.2)			1 (0.7)				15 (0.3)
	>6.6	8 (4.5)	1 (2.2)	44 (6.8)	13 (9.8)	32 (4.5)	54 (2.1)	54 (4.9)	7 (3.7)	9 (5.9)	11 (8.0)	4 (6.7)		1 (3.8)	238 (4.0)
Eo (×10⁹/L)	>0.5	53 (29.8)	18 (40.0)	148 (23.0)	53 (40.2)	57 (8.1)	277 (10.8)	179 (16.4)	35 (18.6)	25 (16.3)	37 (26.8)	14 (23.3)		2 (7.7)	898 (15.1)
Mo (×10⁹/L)	<0.12	77 (43.3)	18 (40.0)	56 (8.7)	52 (39.4)	105 (14.9)	299 (11.6)	100 (9.1)	26 (13.8)	16 (10.5)	7 (5.1)	2 (3.3)	3 (42.9)	5 (19.2)	766 (12.9)
	>1.00		1 (2.2)	25 (3.9)		66 (9.4)	100 (3.9)	51 (4.7)	7 (3.7)	6 (3.9)	5 (3.6)	3 (5.0)			264 (4.4)
Number of children measured		178	45	644	132	705	2575	1094	188	153	138	60	7	26	5951

[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; MGR, Mogilevskii; KOS, Kostyukovichskii; KRA, Krasnopolskii; CHR, Cherikovskii; KLC, Klichevskii; BOB, Bobruiskii; GLU, Glusskii.

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

Table 5B. Frequency of girls with hematological abnormalities by place of residence.[a]

Blood analysis		Place of residence[b]													Total
Item (unit)[c]	Abnormality criteria	SLA	KLI	CHA	KRI	BYK	MOG	MGR	KOS	KRA	CHR	KLC	BOB	GLU	
Hb (g/L)	<110			1 (0.1)			8 (0.3)	4 (0.4)		1 (0.6)					14 (0.2)
	>160			3 (0.4)		4 (0.6)	6 (0.2)	6 (0.6)	1 (0.5)		1 (0.6)				21 (0.3)
WBC ($\times 10^9$/L)	<3.6			2 (0.3)		2 (0.3)	16 (0.6)	1 (0.1)							21 (0.3)
	>11.0	5 (2.7)	1 (2.5)	32 (4.6)	16 (11.0)	26 (3.7)	31 (1.1)	30 (2.8)	3 (1.4)	7 (4.3)	5 (3.1)	1 (2.0)			157 (2.5)
PLT ($\times 10^9$/L)	<100			2 (0.3)			3 (0.1)	1 (0.1)	1 (0.5)	1 (0.6)					8 (0.1)
	>440	4 (2.1)	1 (2.5)	11 (1.6)	3 (2.1)	18 (2.6)	23 (0.9)	6 (0.6)	52 (23.7)		3 (1.9)				121 (2.0)
MCV (fl)	<80	3 (1.6)		17 (2.5)	7 (4.8)	6 (0.9)	68 (2.5)	20 (1.9)	3 (1.4)	3 (1.9)	6 (3.8)		1 (6.7)		134 (2.2)
	>100			3 (0.4)			2 (0.1)	1 (0.1)							6 (0.1)
Ly ($\times 10^9$/L)	<1.2		1 (2.5)	104 (15.0)	1 (0.7)	57 (8.1)	267 (9.9)	67 (6.3)	22 (10.0)	3 (1.9)	5 (3.1)	1 (2.0)			529 (8.6)
	>3.5	34 (18.1)	3 (7.5)	77 (11.1)	50 (34.5)	115 (16.4)	178 (6.6)	90 (8.5)	21 (9.6)	26 (16.0)	16 (10.0)	6 (12.0)	6 (40.0)	3 (13.0)	625 (10.1)
Ne ($\times 10^9$/L)	<1.4			1 (0.1)			10 (0.4)	2 (0.2)	1 (0.5)						14 (0.2)
	>6.6	10 (5.3)	1 (2.5)	68 (9.8)	10 (6.9)	31 (4.4)	77 (2.9)	60 (5.7)	10 (4.6)	12 (7.4)	9 (5.6)	4 (8.0)	1 (6.7)		293 (4.8)
Eo ($\times 10^9$/L)	>0.5	35 (18.6)	10 (25.0)	163 (23.5)	45 (31.0)	68 (9.7)	243 (9.0)	156 (14.7)	35 (16.0)	26 (16.0)	32 (20.0)	12 (24.0)	3 (20.0)	1 (4.3)	830 (13.5)
Mo ($\times 10^9$/L)	<0.12	80 (42.6)	20 (50.0)	70 (10.1)	53 (36.6)	98 (14.0)	331 (12.3)	111 (10.5)	26 (11.9)	28 (17.3)	7 (4.4)	1 (2.0)	5 (33.3)	4 (17.4)	835 (13.6)
	>1.00			41 (5.9)	3 (2.1)	50 (7.1)	91 (3.4)	48 (4.5)	7 (3.2)	4 (2.5)	6 (3.8)	4 (8.0)	1 (6.7)		256 (4.2)
Number of children measured		188	40	693	145	702	2698	1059	219	162	160	50	15	23	6160

[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; MGR, Mogilevskii; KOS, Kostyukovichskii; KRA, Krasnopolskii; CHR, Cherikovskii; KLC, Klichevskii; BOB, Bobruiskii; GLU, Glusskii.
[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

Table 6A. Frequency of boys with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	7(0.1)					7(0.1)
	>180	4(0.1)					4(0.1)
WBC (×10⁹/L)	<3.8	38(0.7)	1(0.2)				39(0.7)
	>10.6	163(3.1)	31(6.4)	7(6.5)	2(10.0)		203(3.4)
PLT (×10⁹/L)	<100	3(0.1)					3(0.1)
	>440	89(1.7)	13(2.7)	3(2.8)	1(5.0)		106(1.8)
MCV (fl)	<80	321(6.0)	16(3.3)	5(4.7)			342(5.7)
	>100		1(0.2)				1(0.02)
Ly (×10⁹/L)	<1.2	495(9.3)	46(9.5)	3(2.8)	1(5.0)		545(9.2)
	>3.5	492(9.2)	68(14.1)	9(8.4)	2(10.0)		571(9.6)
Ne (×10⁹/L)	<1.4	14(0.3)		1(0.9)			15(0.3)
	>6.6	192(3.6)	36(7.5)	7(6.5)	2(10.0)	1(50.0)	238(4.0)
Eo (×10⁹/L)	>0.5	779(14.6)	104(21.5)	14(13.1)	1(5.0)		898(15.1)
Mo (×10⁹/L)	<0.12	664(12.4)	81(16.8)	18(16.8)	3(15.0)		766(12.9)
	>1.00	241(4.5)	21(4.3)	2(1.9)			264(4.4)
Number of children measured		5339	483	107	20	2	5951

[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.

Table 6B. Frequency of girls with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	13(0.2)		1(1.4)			14(0.2)
	>160	21(0.4)					21(0.3)
WBC (×10⁹/L)	<3.6	20(0.4)	1(0.2)				21(0.3)
	>11.0	140(2.5)	13(3.2)	4(5.8)			157(2.5)
PLT (×10⁹/L)	<100	8(0.1)					8(0.1)
	>440	106(1.9)	12(2.9)	2(2.9)	1(7.1)		121(2.0)
MCV (fl)	<80	126(2.2)	7(1.7)	1(1.4)			134(2.2)
	>100	6(0.1)					6(0.1)
Ly (×10⁹/L)	<1.2	501(8.8)	23(5.6)	4(5.8)	1(7.1)		529(8.6)
	>3.5	555(9.8)	60(14.7)	9(13.0)	1(7.1)		625(10.1)
Ne (×10⁹/L)	<1.4	12(0.2)	1(0.2)		1(7.1)		14(0.2)
	>6.6	260(4.6)	26(6.4)	6(8.7)	1(7.1)		293(4.8)
Eo (×10⁹/L)	>0.5	725(12.8)	86(21.0)	16(23.2)	3(21.4)		830(13.5)
Mo (×10⁹/L)	<0.12	763(13.5)	56(13.7)	13(18.8)	3(21.4)		835(13.6)
	>1.00	238(4.2)	15(3.7)	3(4.3)			256(4.2)
Number of children measured		5667	409	69	14	1	6160

[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.

ease and acute attacks of chronic inflammatory diseases. A high frequency of eosinophilia was found in girls residing in Krichevskii (31.0%), Klimovichskii (25.0%), and Klichevskii (24.0%) Rayons and the lowest in Mogilev City (9.0%). The causes of eosinophilia were the same in girls and boys.

Tables 6A and 6B show the frequency of deviations from normal in the hemogram for boys and girls in relation to the ^{137}Cs activity value (Bq/kg), respectively.

The group of boys in which the ^{137}Cs 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 was difficult to conduct a comparative analysis. In 22 boys whose level of ^{137}Cs specific activity was 200 Bq/kg or over, the following deviations from normal were found: leukocytosis-2; eosinophilia-1; thrombocytosis-1; lymphopenia-1. Neither anemia nor thrombocytopenia were found.

The group of girls in which ^{137}Cs specific activity ranged from 0 to 50 Bq/kg was the largest, and most of the deviations were registered in this group. In the 15 girls whose level of ^{137}Cs specific activity was 200 Bq/kg or higher, the following was observed: thrombocytosis-1, eosinophilia-3, lymphopenia-1, neutropenia-1. Neither anemia nor thrombocytopenia were found.

The prevalence of eosinophilia and its influential factors were studied. No significant seasonal difference was observed in the prevalence of eosinophilia: 15.8% (550/3476) was found in autumn and 14.4% (361/2503) was found in spring, resulting in the estimated odds ratio ($\pm$standard error) of 1.12 ± 0.08. No significant association was observed between eosinophilia and a history of asthma: the prevalence of eosinophilia was 15.9% (50/314) and 14.3% (1656/11 548) in children with and without a history of asthma, respectively, resulting in the estimated odds ratio ($\pm$standard error) of 1.13 ± 0.18. However, the prevalence of eosinophilia was lower in children with a history of skin diseases (232/1894 or 12.2%) than in those without the history (1475/9963 or 14.8%): estimated odds ratio ($\pm$standard error) was 0.80 ± 0.06. Children from families with domestic animals showed a higher prevalence of eosinophilia (1149/6861 or 16.7%) than those from families without domestic animals (579/5174 or 11.2%): estimated odds ratio ($\pm$standard error) was 1.60 ± 0.09.

Correlation between eosinophil count and platelet, monocyte and lymphocyte counts is shown in Figures 20–22 by their scatter plots. A significant correlation was observed between these counts but the correlation coefficients were all small. 95% confidence intervals of the respective correlation coefficients were as follows: $0.10<\rho<0.13$ for eosinophil and platelet counts; $-0.09<\rho<-0.05$ for eosinophil and monocyte counts; and $0.19<\rho<0.23$ for eosinophil and lymphocyte counts.

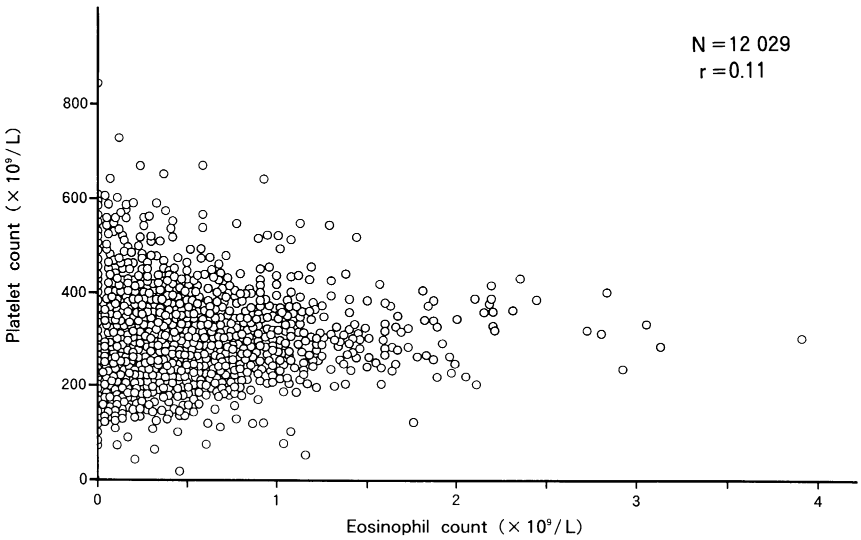

Figure 20. Scatter plots of eosinophil and platelet counts.

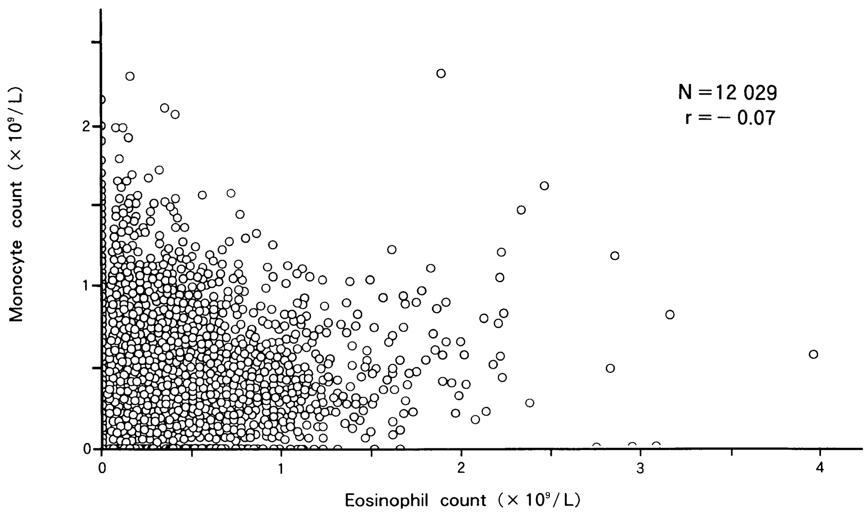

Figure 21. Scatter plots of eosinophil and monocyte counts.

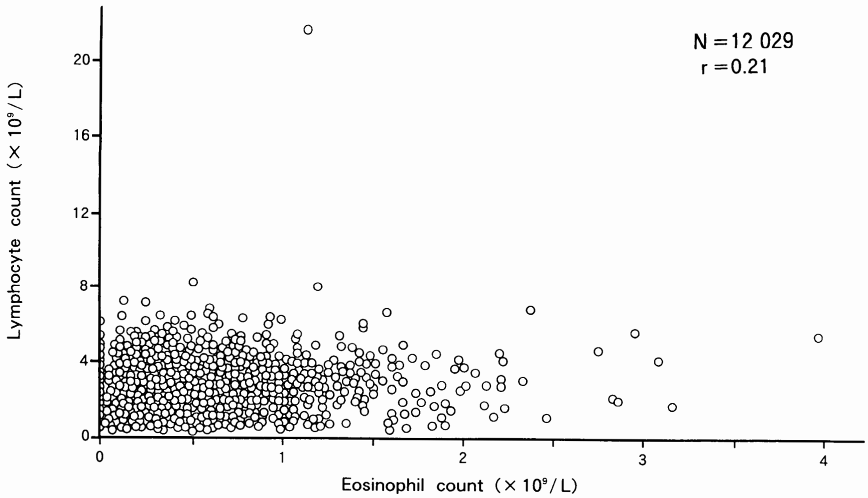

Figure 22. . Scatter plots of eosinophil and lymphocyte counts.

4. Conclusions

The results of the investigations show that abnormalities in the thyroid and peripheral blood continue to appear in recent years, in most cases without obvious signs of disease. Sharp increases in disorders of the thyroid and blood system were not observed, and the disorders found in these systems may not be attributable wholly to the effects of radiation. It is necessary to continue these investigations and to carefully observe children with abnormalities, since some diseases are often preceded by changes in the hormonal and immune status as observed in laboratory findings.

Results of the Examination of the Health Status of Children in Gomel Oblast 1991–1993 Chernobyl Sasakawa Project

Gomel Specialized Medical Dispensary

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1. Introduction

The Chernobyl disaster—the catastrophe of the 20th century—caused an unfavorable medical situation in the Gomel Oblast (Province) of Belarus. About 15% of the territory of the oblast was exposed to ^{131}I radiation contamination ranging from 5 to 50 Ci/km^2. The contamination density in the remaining territory amounted to 50–150 Ci/km^2, and in Vetkovskii, Checherskii, Hoyinikskii and Braginskii Rayons (Districts) it reached 500 Ci/km^2. On May 10, 1986, there were areas in Braginskii Rayon where radioactive iodine contamination density was higher than 1500 Ci/km^2.

More than 80% of an area with a population of approximately 1.35 million people was exposed to a ^{137}Cs contamination density of 1 Ci/km^2 or over.

More than 120 000 residents of areas recognized as zones unfavorable for living have been resettled elsewhere.

The aftermath of the Chernobyl accident has adversely affected both demographic rates (reduction in population and a mortality rate higher than the birth rate) and the level of morbidity of the population (an increase in diseases of the thyroid and other endocrine organs, abnormalities of the circulatory and the digestive systems, nervous and mental disorders, etc.)

Under these conditions, a long-term program for medical examinations and the study of the state of health of the children of the Gomel Oblast on the basis of the Chernobyl Sasakawa Project is of inestimable importance. This program was initiated by the Sasakawa Memorial Health Foundation and began operation in 1991. The program is financed mainly by the foundation and enjoys the participation of prominent Japanese scientists.

An investigation has been carried out for 3 years on the health status of children residing in the Gomel Oblast. The program is implemented in accordance with the Chernobyl Sasakawa Project and provides a conceptual basis for the development of preventive measures directed towards the treatment and health improvement of the children.

A total of 12 791 children were examined by the staff of the dispensary during the period from May 1991 to December 31, 1993. Among them, 8949 were born between April 26, 1976 and 26 April, 1986. The total number of children examined does not include those who were re-examined or those who did not undergo a complete examination (when one or more of the required parameters was missing). There were 3842 such children.

To examine the children, a mobile diagnostic laboratory donated by the Sasakawa Foundation was dispatched to the various places of residence. The laboratory is equipped with facilities suitable for dosimetry, ultrasonographic and laboratory analyses. The examination of children was carried out by a skilled staff.

Individual groups of children were also examined directly at the specialized dispensary using a set of stationary medical equipment donated by the Sasakawa Foundation.

2. Materials and Methods

2.1 Study subjects

Children residing in areas with a ^{137}Cs contamination density over 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, Vetkovskii, Gomelskii, Dobrushskii, Elskii, Zlobinskii, Kalinkovichskii, Kormyanskii, Lelchitskii, Loevskii, Mozirskii, Petrikovskii, Rechitskii, Rogachevskii, Svetlogorskii, Hoynikskii and Checherskii Rayons and also in the cities of Gomel and Mozir. Zitkovichskii, Narovlyanskii and Oktyabrskii Rayons were excluded because less than 10 subjects were examined there.

The information was analyzed for the oblast as a whole and for each individual rayon. The results were analyzed for the whole population regardless of sex and also for boys and girls grouped separately according to age.

Figure 1 shows the ^{137}Cs contamination levels (Ci/km^2) including the extreme values for all rayons of the Gomel Oblast. Measurement of ^{137}Cs concentration in the bodies of the children and thyroid and hematological studies were performed by special techniques.

2.2 Measurement of whole body ^{137}Cs concentration

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

Energetic calibration of the gamma-spectrometer with a standard source of ^{137}Cs and ^{60}Co 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

Figure 1. ^{137}Cs 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.

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 next step was the measurement of radiation background using phantoms made from Lucite plates of 5, 10, 15 and 20 cm in thickness.

After these preparatory procedures, the whole body ^{137}Cs 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 complete examination of the thyroid gland consisted of an ultrasound examination, determination of the circulating levels of thyroid stimulating hormone (TSH) and free T_4 (FT_4), titers of anti-microsome antibody (AMC) and anti-thyroglobulin antibody (ATG). The data for the first screening were evaluated by endocrinologists. Ultrasound examinations were performed with an Aloka SSD–520 and Aloka–630. A quantitative and qualitative analysis of the state of the thyroid and surrounding tissues, blood vessels and lymph nodes was carried out. Using an arch-automatic ultrasonographic instrument, thyroid volume, position, structure, echogenity and the presence of pathologic structures (such as nodules, cysts and congenital abnormalities) were examined. In the cases of children with abnormal echography, fine needle aspiration biopsy was performed to confirm diagnoses.

The functional state of the thyroid (FT_4 and TSH) was studied by the immunometric technique using an Amerlite unit manufactured by the Amersham Company.

The titers of AMC and ATG were determined visually by the reaction of passive hemagglutination using diagnostic kits provided by the Fujirevio Company.

These techniques are the main criteria for establishing clinical diagnoses of thyroid diseases.

2.4 Hematological studies

Hematological tests were carried out for the following 8 parameters: (1) white blood cell count (WBC); (2) red blood cell count (RBC); (3) hemoglobin concentration (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). Blood testing was conducted with a Sysmex K–1000 hemoanalyzer.

Special EK–0205 vacuum tubes were used for blood sampling.

The differential leukocyte count in stained smears was analyzed with an Olympus–BH–2.

3. Results

3.1 Study subjects

The results of the examination of 8949 children (4271 boys and 4678 girls) were analyzed.

Table 1 shows the number of children examined by age and sex along with the 25th, 50th and 75th percentiles for each rayon and the oblast as a whole.

3.2 Measurement of whole body ^{137}Cs concentration

Figure 2 shows the distribution of ^{137}Cs specific activity per kg body weight (Bq/kg) by sex and age. The data obtained were virtually the same as those of 1992. There was no essential difference in the specific ^{137}Cs concentration level in either boys or girls under 10 years old. In a group of children from 11–15 years old the accumulation of ^{137}Cs was higher in boys than in girls of the same age. The opposite was observed among teenagers of 16–17 years old.

In order to achieve more representative information, we have analyzed the data obtained in Gomel City and 7 rayons with sufficient statistical data (not less than 100 boys and 100 girls). These data allowed us to confirm the difference in the ^{137}Cs accumulation levels between the sexes. In all cases the medians of ^{137}Cs specific activity were higher in boys by an average of 6.6% (3–11%).

Figure 3 shows the data of the distribution of ^{137}Cs specific concentration in

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

Place of residence	Boys	Girls	Total
Braginskii	314 (8, 10, 12)[b]	296 (8, 10, 12)	610 (8, 10, 12)
Buda-Koshelevskii	153 (7, 10, 12)	192 (8, 11, 13)	345 (8, 10, 13)
Vetkovskii	17 (9, 10, 13)	14 (9, 11, 11)	31 (9, 11, 13)
Gomelskii	1368 (8, 10, 12)	1471 (8, 10, 12)	2839 (8, 10, 12)
Dobrushskii	563 (7, 9, 11)	638 (7, 9, 11)	1201 (7, 9, 11)
Elskii	139 (7, 9, 12)	194 (7, 10, 12)	333 (7, 9, 12)
Zlobinskii	27 (8, 10, 12)	34 (9, 10, 12)	61 (8, 10, 12)
Kalinkovichskii	20 (8, 11, 12)	24 (11, 12, 13)	44 (10, 11, 13)
Kormyanskii	53 (7, 8, 9)	54 (7, 8, 10)	107 (7, 8, 9)
Lelchitskii	25 (6, 7, 10)	52 (7, 10, 12)	77 (6, 9, 11)
Loevskii	288 (7, 9, 12)	257 (7, 10, 12)	545 (7, 9, 12)
Mozirskii	11 (8, 10, 11)	22 (8, 10, 11)	33 (8, 10, 11)
Petrikovskii	66 (7, 9, 12)	105 (6, 9, 12)	171 (6, 9, 12)
Rechitskii	38 (9, 11, 14)	41 (9, 11, 13)	79 (9, 11, 13)
Rogachevskii	9 (9, 11, 11)	12 (10, 10, 11)	21 (10, 10, 11)
Svetlogorskii	19 (8, 11, 12)	26 (11, 13, 17)	45 (11, 12, 14)
Hoynikskii	167 (8, 9, 13)	151 (9, 10, 13)	318 (8, 10, 13)
Checherskii	34 (10, 12, 14)	45 (9, 10, 13)	79 (9, 11, 13)
Gomel City	936 (8, 9, 12)	1026 (8, 10, 12)	1962 (8, 9, 12)
Mozir City	24 (8, 9, 11)	24 (9, 10, 11)	48 (8, 10, 11)
Total	4271 (8, 10, 12)	4678 (8, 10, 12)	8949 (8, 10, 12)

[a] Subjects in the following rayons are not shown because the number was less than 10: Zitkovichskii, Narovlyanskii and Oktyabrskii.

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

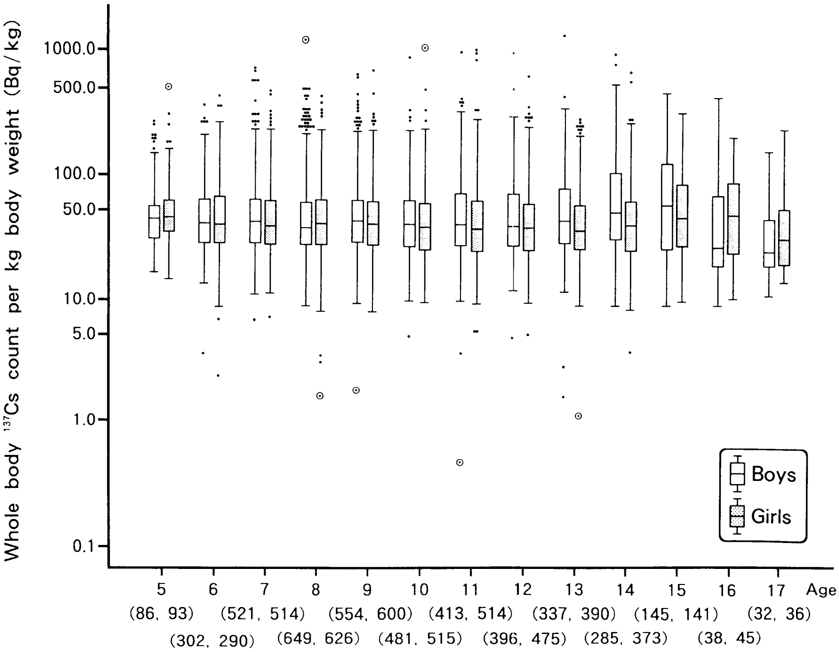

Figure 2. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by sex and age. Each pair presents the number of examined boys and girls. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, called "outside" and "far out," respectively.

the body by place of residence. The medians of the absorbed ^{137}Cs activity were in the range of 30–140 Bq/kg. The highest levels were registered in Braginskii, Kormyanskii, Lelchitskii, Elskii and Vetkovskii Rayons (140, 116, 83, 83, 81 Bq/kg, respectively). The level was not higher than 50 Bq/kg in the remaining 13 rayons. It is logical that higher levels were noted in the rayons affected most severely by the Chernobyl accident (Braginskii, Vetkovskii, Kormyanskii) and also in the territories which are included in the radioecological anomaly zone of the Belarus-Ukraine Polessye (Elchitskii and Elskii Rayons), where coefficients of proportionality in soil-vegetation ratio are 3–10 times higher than those found outside the Polessye zone boundaries.

The 25th, 50th and 75th percentiles of the distribution of the ^{137}Cs specific activity did not exceed 40, 60 and 140 Bq/kg, respectively for any age groups in either boys and girls. Specific concentrations exceeding 500 Bq/kg were registered in only 11 boys (0.26%) and 6 girls (0.13%). However, in our opinion, these figures do not reflect the actual radiation situation in the Gomel Oblast as a whole or in individual areas in particular. The following facts should be taken into account when evaluating the results: firstly, the data to be analyzed were obtained in settlements with relatively low ^{137}Cs contamination density (1–15 Ci/km^2); secondly, the evaluation of these data by administrative rayons

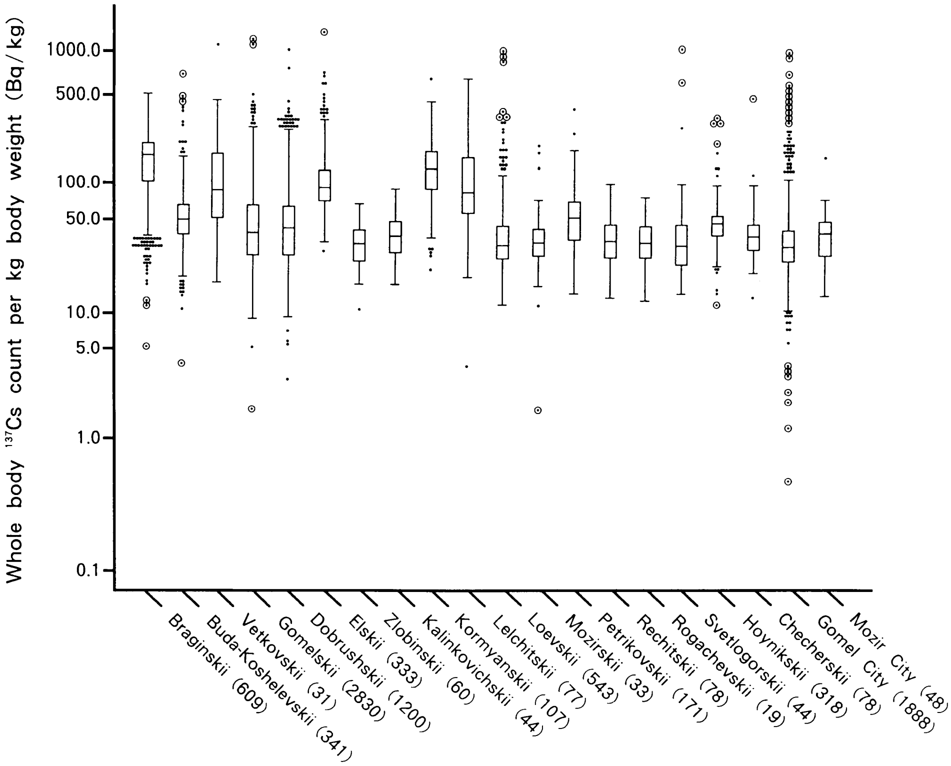

Figure 3. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by place of residence. The parenthetic entries refer to the number of examined children. See Figure 2 for details.

is unsatisfactory because it does not reflect the real radiation situation in each particular settlement. This fact was confirmed by the high gradient of contamination density in exposed rayons, the dispersion of individual ^{137}Cs specific activity values and by the presence of a relatively large number of outliers ("outside" points) in the "box-and-whisker" plots. It is reasonable to assume, therefore, that a number of settlements even with low ^{137}Cs contamination densities may have critical groups of children with high internal radiation levels exceeding the medians obtained in the course of the Chernobyl Sasakawa Project examinations.

3.3 Thyroid examinations

Figure 4 shows the sex and age distribution of the thyroid volume: (1) the thyroid volume increased with age in both boys and girls; (2) the thyroid volume especially increased from the start of puberty (girls-11 years old, boys-12 years old); (3) the thyroid volume reached a peak in girls at the age of 15 and in boys from the age of 16.

Figure 5 shows the prevalence of goiter (%) by place of residence. The prevalence of goiter was obviously higher in girls than in boys. The largest

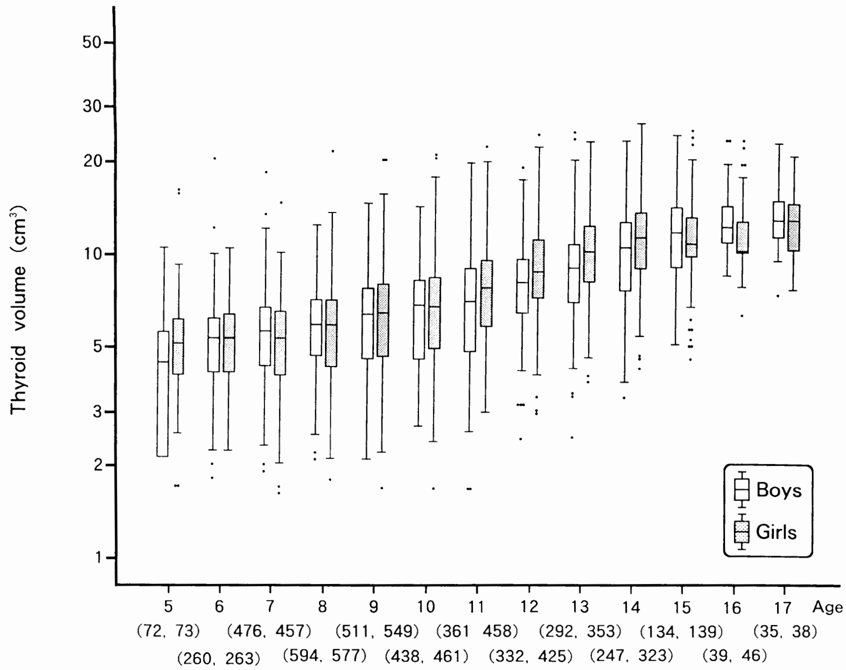

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

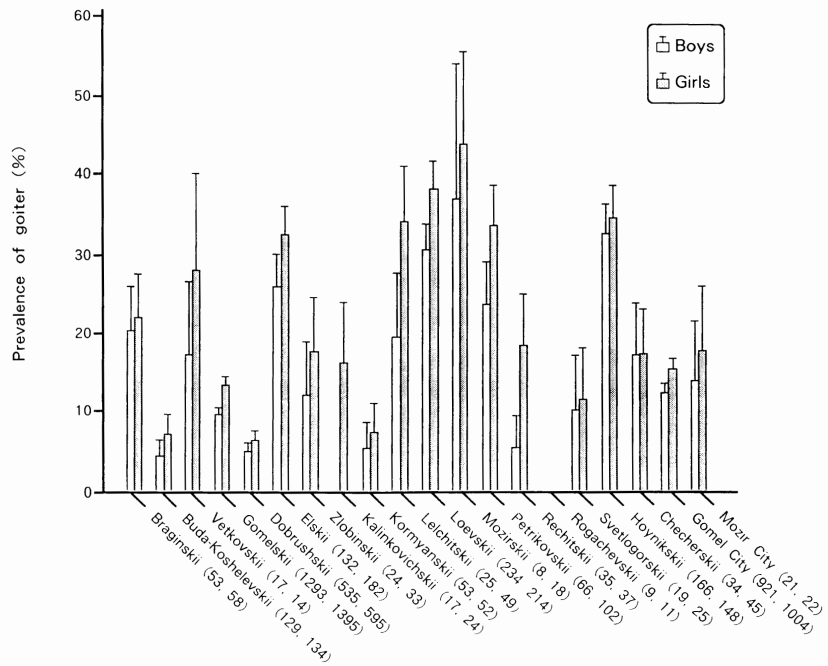

Figure 5. Prevalence of goiter by sex and place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

number of goiter cases was noted in Hoynikskii, Petrikovskii, Elskii and Loevskii Rayons. The information was considered unreliable in Vetkovskii, Zlobinskii, Kalinkovichskii, Lelchitskii, Mozirskii, Rechitskii, Rogachevskii, Svetlogorskii and Checherskii Rayons because of the small number of children examined.

Figure 6 shows the prevalence of goiter in relation to the ^{137}Cs concentration in the bodies of boys and girls. No significant relationship could be established between the internal radiation dose and the prevalence of goiter.

No correlation was observed between absorbed ^{137}Cs concentration and FT_4 level (Figure 7): 95% confidence interval of the correlation coefficient was $-0.03<\rho<0.16$. While a statistically significant correlation was observed between ^{137}Cs level and the residual of the thyroid volume adjusted for age, height and weight, and TSH level, the respective correlation coefficients were small (Figures 8 and 9): 95% confidence interval of the correlation coefficient was $-0.07<\rho<-0.03$ for ^{137}Cs level and the residual thyroid volume; and $0.02<\rho<0.06$ for ^{137}Cs and TSH levels.

Table 2 shows the classification of children according to sex and place of residence with a high level of TSH and low level of FT_4 (hypothyroidism) and a low level of TSH and high level of FT_4 (hyperthyroidism).

Children with cancer who received replacement therapy for thyroid

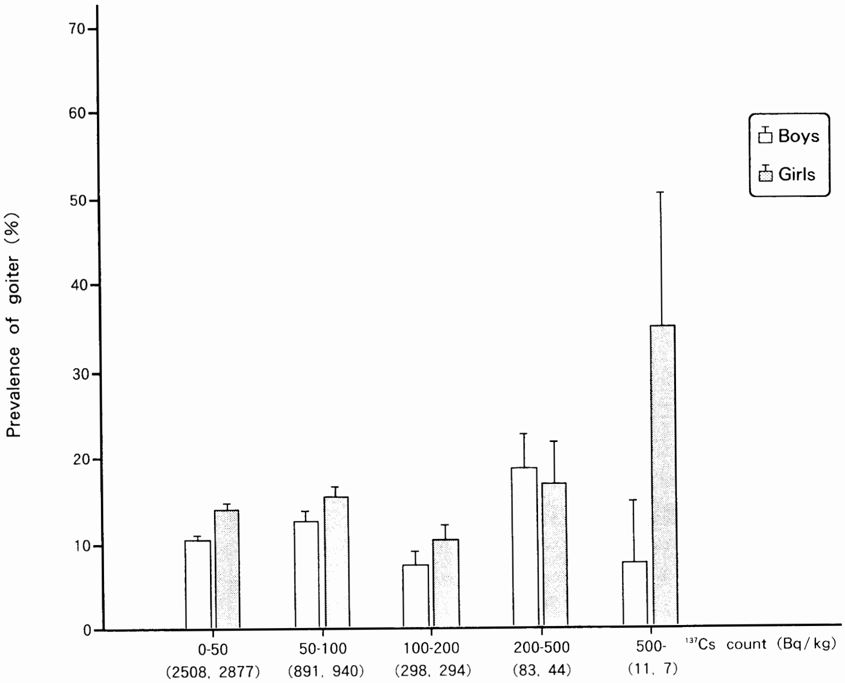

Figure 6. Prevalence of goiter by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

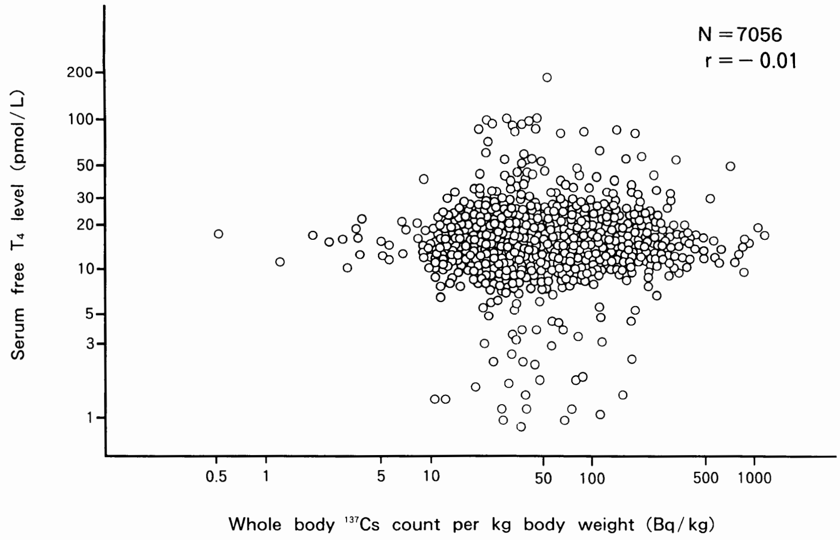

Figure 7. Scatter plots of whole body ^{137}Cs count per kg body weight and serum free T_4 level.

hormones were excluded for verification of the data.

Table 3 shows the total number of children first examined by sex and place of residence including positive titers of ATG and AMC antibodies. From Table 3 it may be concluded that: (1) positive AMC titers were 3 times as frequent as those of ATG; (2) the highest percentage of children with positive AMC and ATG titers was noted in Elskii Rayon; (3) the prevalence of a positive titer of AMC and ATG was twice as high in girls as in boys; and (4) children with positive AMC and ATG titers were not found in Rechitskii,

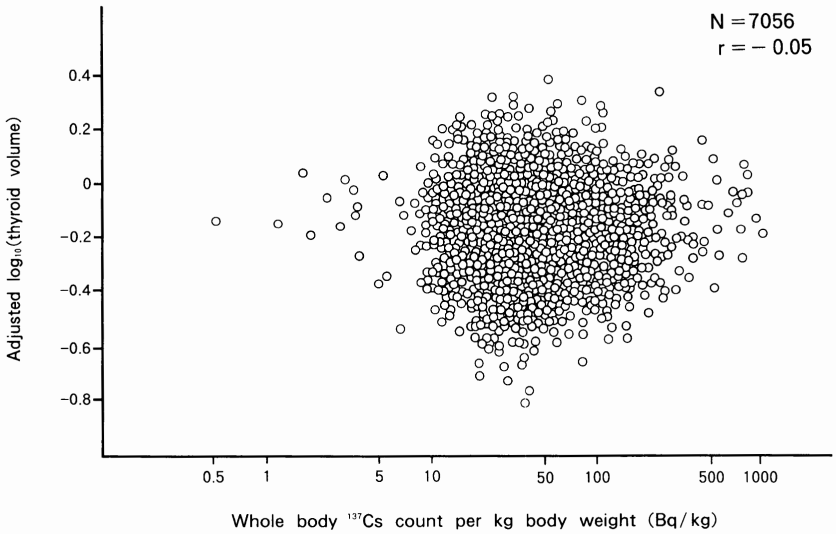

Figure 8. Scatter plots of whole body ^{137}Cs count per kg body weight and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

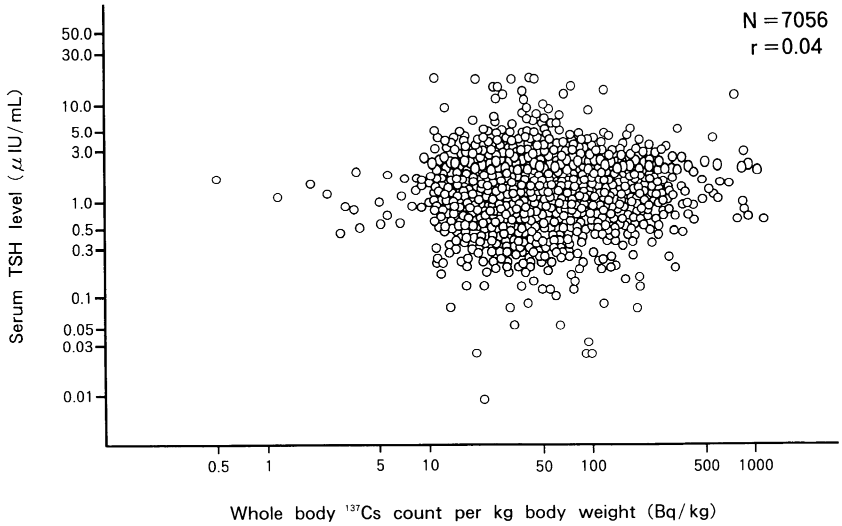

Figure 9. Scatter plots of whole body ^{137}Cs count per kg body weight and serum TSH level.

Table 2. Number of subjects with hypothyroidism and hyperthyroidism by sex and place of residence.

Place of residence	Number of subjects with measurement			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Braginskii	610	314	296	0	0	0	0	0	0
Buda-Koshelevskii	345	153	192	1	0	1	0	0	0
Vetkovskii	31	17	14	0	0	0	0	0	0
Gomelskii	2839	1368	1471	11	3	8	2	0	2
Dobrushskii	1201	563	638	5	1	4	0	0	0
Elskii	333	139	194	1	0	1	0	0	0
Zlobinskii	61	27	34	0	0	0	0	0	0
Kalinkovichskii	44	20	24	1	0	1	0	0	0
Kormyanskii	107	53	54	1	1	0	0	0	0
Lelchitskii	77	25	52	0	0	0	1	0	1
Loevskii	545	288	257	3	2	1	0	0	0
Mozirskii	33	11	22	0	0	0	0	0	0
Petrikovskii	171	66	105	1	0	1	0	0	0
Rechitskii	79	38	41	0	0	0	0	0	0
Rogachevskii	21	9	12	0	0	0	0	0	0
Svetlogorskii	21	19	26	0	0	0	0	0	0
Hoynikskii	318	167	151	1	1	0	0	0	0
Checherskii	79	34	45	0	0	0	0	0	0
Gomel City	1962	936	1026	6	4	2	1	0	1
Mozir City	48	24	24	0	0	0	0	0	0
Total	8949	4271	4678	31	12	19	4	0	4

[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 3. Prevalence of positive ATG (anti-thyroglobulin antibody) and AMC (anti-microsome antibody) titers by sex and place of residence.[a]

Place of residence	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Braginskii	610	314	296	2 (0.3)	2 (0.6)		3 (0.5)	1 (0.3)	2 (0.7)
Buda-Koshelevskii	345	153	192	2 (0.6)	1 (0.7)	1 (0.5)	7 (2.0)	4 (2.6)	3 (1.6)
Vetkovskii	31	17	14				2 (6.5)		2 (14.3)
Gomelskii	2839	1368	1471	15 (0.5)	5 (0.4)	10 (0.7)	57 (2.0)	20 (1.5)	37 (2.5)
Dobrushskii	1201	563	638	13 (1.1)	5 (0.9)	8 (1.3)	32 (2.7)	13 (2.3)	19 (3.0)
Elskii	333	139	194	9 (2.7)	2 (1.4)	7 (3.6)	27 (8.1)	10 (7.2)	17 (8.8)
Zlobinskii	61	27	34				1 (1.6)	1 (3.7)	
Kalinkovichskii	44	20	24				1 (2.3)		1 (4.2)
Kormyanskii	107	53	54				1 (0.9)		1 (1.9)
Lelchitskii	77	25	52				1 (1.3)		1 (1.9)
Loevskii	545	288	257	3 (0.6)		3 (1.2)	9 (1.7)	2 (0.7)	7 (2.7)
Mozirskii	33	11	22				2 (6.1)	1 (9.1)	1 (4.5)
Petrikovskii	171	66	105	1 (0.6)		1 (1.0)	2 (1.2)		2 (1.9)
Rechitskii	79	38	41						
Rogachevskii	21	9	12						
Svetlogorskii	45	19	26						
Hoynikskii	318	167	151	5 (1.6)	3 (1.8)	2 (1.3)	9 (2.8)	5 (3.0)	4 (2.6)
Checherskii	79	34	45				1 (1.3)	1 (2.9)	
Gomel City	1962	963	1026	21 (1.1)	6 (0.6)	15 (1.5)	71 (3.6)	23 (2.5)	48 (4.7)
Mozir City	48	24	24	2 (4.2)		2 (8.3)	2 (4.2)		2 (8.3)
Total	8949	4271	4678	73 (0.8)	24 (0.6)	49 (1.0)	228 (2.5)	81 (1.9)	147 (3.1)

[a] Number of subjects with percentages in parentheses.

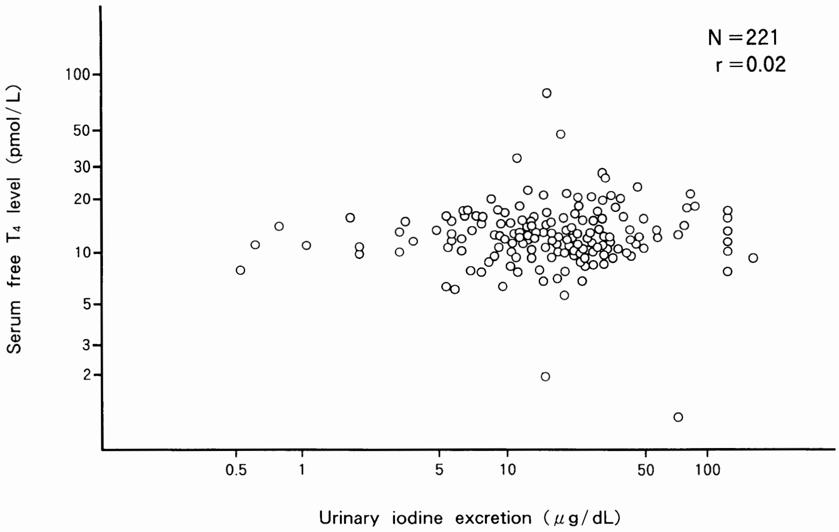

Figure 10. Scatter plots of urinary iodine excretion and serum free T_4 level.

Svetlogoroskii or Rogachevskii Rayons, but it is difficult to draw reliable conclusions because the number of children in these rayons was quite small.

The total number of children with positive ATG and AMC titers amounted to 73 (0.8%) and 228 (2.5%), respectively.

Urinary iodine content was measured in 235 children and below normal levels were found in 29 children (12%). As shown in Figures 10 and 11, no correlation was observed between urinary iodine content and FT_4 level or residual thyroid volume: 95% confidence interval of the correlation coefficient was $-0.11<\rho<0.15$ for urinary iodine content and FT_4 level; and $-0.14<\rho<0.12$

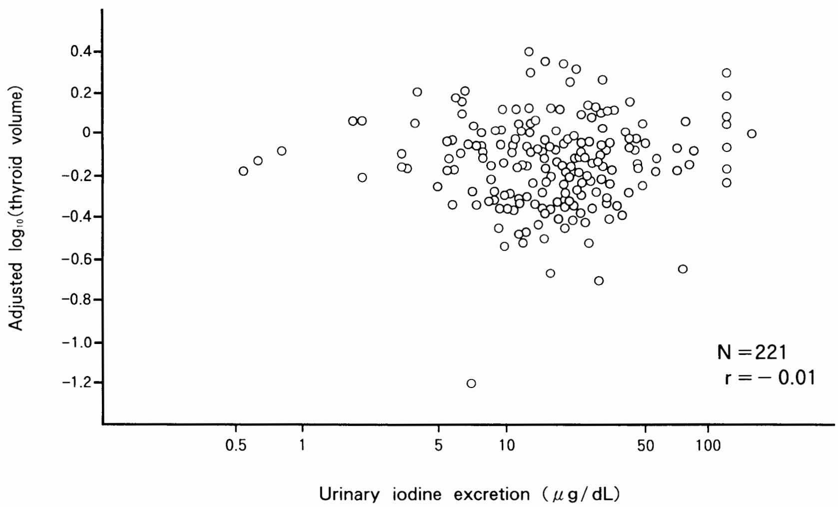

Figure 11. Scatter plots of urinary iodine excretion and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

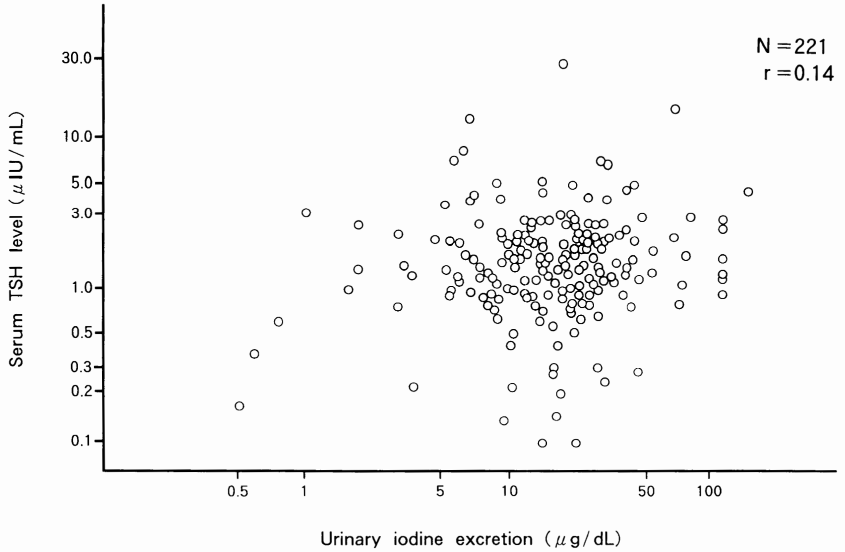

Figure 12. Scatter plots of urinary iodine excretion and serum TSH level.

for urinary iodine content and residual thyroid volume. A statistically significant correlation was observed between urinary iodine content and TSH level, but the correlation coefficient was not large (Figure 12): 95% confidence interval of the correlation coefficient was $0.01 < \rho < 0.27$.

Figures 13 and 14 show the prevalence of positive ATG and AMC titers in boys and girls relative to the absorbed ^{137}Cs concentration. No relationship was observed between the prevalence of positive titers of antibodies and

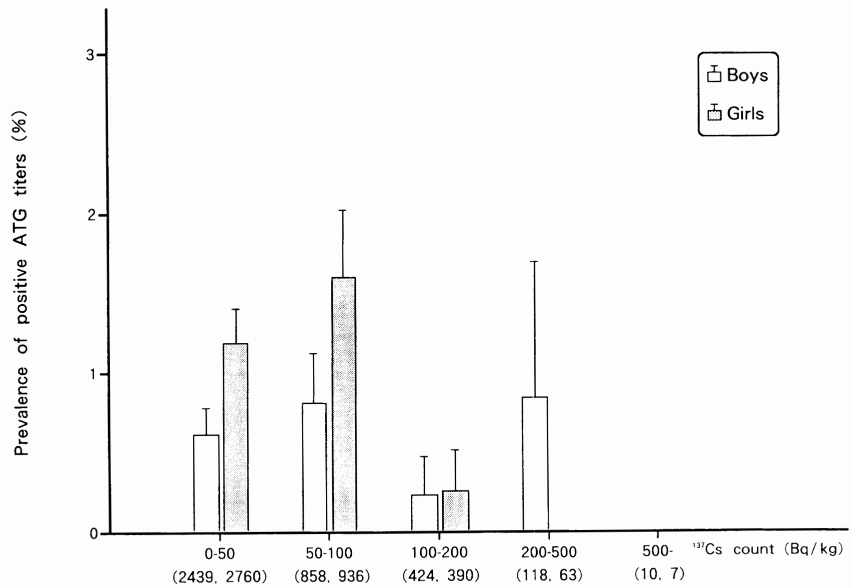

Figure 13. Prevalence of positive ATG titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

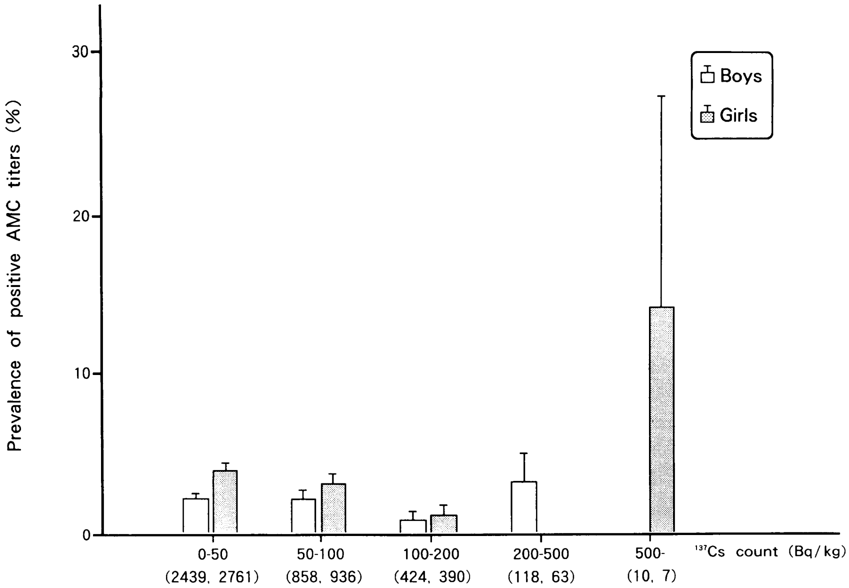

Figure 14. Prevalence of positive AMC titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

Table 4. Subjects with thyroid abnormalities by sex and place of residence.

Place of residence	Number of subjects examined		Diagnosis							
			Nodular lesion		Cystic lesion		Abnormal echogenity		Anomaly	
	B[a]	G[a]	B	G	B	G	B	G	B	G
Braginskii	314	296	0	0	0	0	2	5	0	1
Buda-Koshelevskii	153	192	4	3	0	0	0	4	1	1
Vetkovskii	17	14	0	0	0	1	0	2	0	0
Gomelskii	1368	1471	33	49	1	5	30	51	3	5
Dobrushskii	563	638	4	4	0	0	3	6	0	0
Elskii	139	194	0	0	0	0	0	3	0	0
Zlobinskii	27	34	1	0	0	0	0	2	0	0
Kalinkovichskii	20	24	0	0	0	0	0	1	0	0
Kormyanskii	53	54	0	1	0	0	0	1	0	1
Lelchitskii	25	52	2	0	0	0	1	2	0	0
Loevskii	288	257	2	2	0	0	3	1	0	1
Mozirskii	11	22	1	2	0	0	2	5	0	0
Petrikovskii	66	105	1	0	0	0	0	5	0	0
Rechitskii	38	41	0	4	0	1	0	0	0	0
Rogatchevskii	9	12	0	1	0	0	0	1	0	0
Svetlogorskii	19	26	0	1	0	0	0	0	0	0
Hoynikskii	167	151	1	0	1	0	0	0	2	0
Checherskii	34	45	0	0	0	0	0	0	0	0
Gomel City	936	1026	16	33	5	5	26	65	6	16
Mozir City	24	24	2	2	1	0	0	6	0	2
Total	4271	4678	67	102	8	12	67	161	12	27

[a]B, boys; G, girls.

specific ^{137}Cs concentration.

Table 4 shows thyroid abnormalities by sex and place of residence. The largest number of children with nodular lesions and decreased echogenity was found in Gomelskii Rayon and Gomel City (because of children resettled from contaminated areas).

In the period from 1986 to December 1993, 131 carcinomas of the thyroid (9.4 cases per 100 000 children) were diagnosed in the Gomel Oblast. This is the highest level in all the provinces of Belarus.

In the period from May 1991 to December 1993, 9 thyroid carcinomas (3 boys and 6 girls; 4 cases in Braginskii, 2 in Gomel City, 1 in Hoynikskii, 1 in Dobrushskii and 1 in Lelchitskii) were diagnosed in connection with the Sasakawa Project. Histologically, these carcinomas were papillary (6), papillary-follicular (2) and follicular (1). Surgery was performed in the Thyroid Oncology Department, Minsk.

In the period from May 1991 to December 1993, 49 autoimmune thyroiditis diagnoses were established on the basis of ultrasonography, definition of AMC antibodies, fine needle aspiration biopsy and cytological diagnosis.

3.4 Hematological studies

A total of 8949 hematological tests were carried out, but only 5076 analyses included leukocyte differential count since this test was not introduced until the middle of 1992.

Tables 5A, 5B, 6A and 6B and Figures 15–19 below show hematological studies grouped by sex, age, place of residence and data on Hb, WBC, PLT, lymphocyte, neutrophil, eosinophil, monocyte and MCV. The results obtained were mainly within normal limits. Minor deviations were noted (an increase or a decrease).

Figure 15 shows the relationship between Hb level in the blood and age and sex. The mean value was within the normal range in all age groups. Hb level increased with age, particularly in boys. It leveled off in girls from 12 to 15 years of age and then a small decrease was observed at the age of 16–17.

A certain increase in MCV values was observed, particularly in girls, as shown in Figure 16. Iron and ferritin deficiency was observed in 58 children with MCV and Hb changes (decreased levels) who are under the permanent observation of a hematologist. It is necessary, therefore, to continue the investigation of iron and ferritin levels in order to obtain accurate hematological data.

Figure 17 shows the distribution of WBC by age and sex. The mean WBC was within the normal range at each age. An increase was observed in children with chronic inflammatory diseases.

Figure 18 shows the distribution of PLT by sex and age. The PLT in the blood of children (boys and girls) was within normal limits. The trend was toward a decrease in PLT in both boys and girls, particularly in boys of 16–17

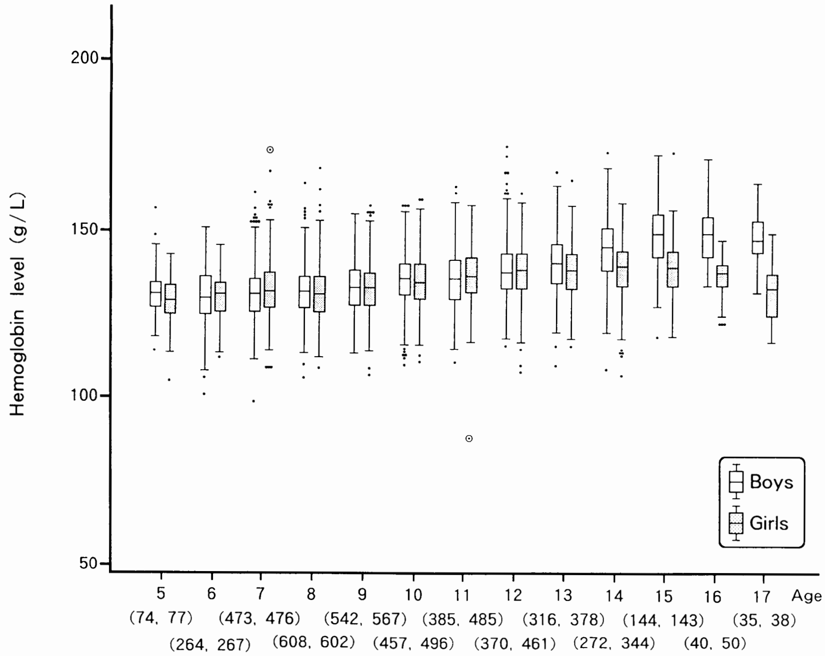

Figure 15. The box-and-whisker plots of hemoglobin level by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

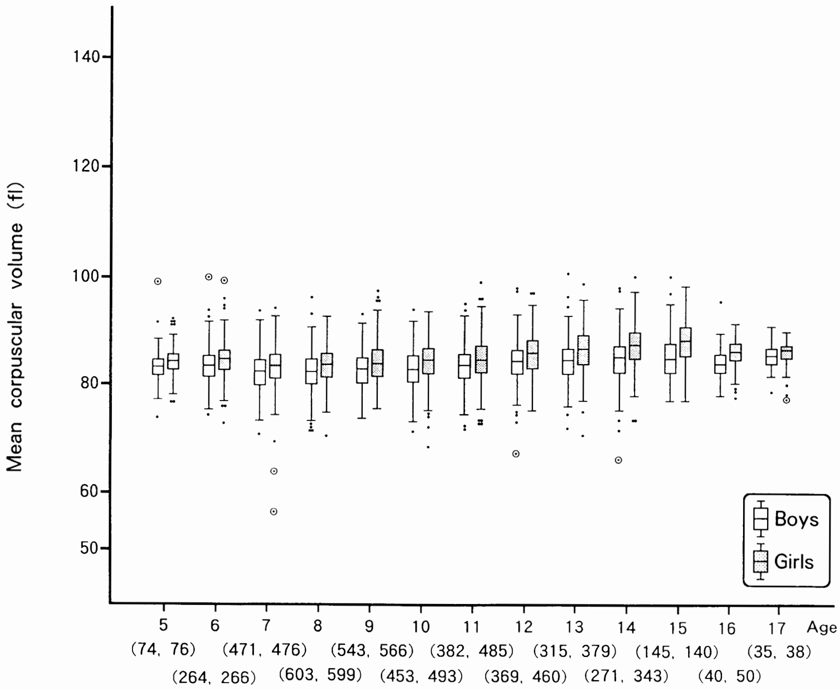

Figure 16. The box-and-whisker plots of mean corpuscular volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

Table 5A. Frequency of boys with hematological

Blood analysis		Place of								
Item (unit)[c]	Abnormality criteria	BRA	B-K	VET	GOR	DOB	ELS	ZLO	KLN	KOR
Hb (g/L)	<110	1 (0.3)			2 (0.1)					
	>180	1 (0.3)			1 (0.1)					
WBC ($\times 10^9$/L)	<3.8			1 (5.9)	5 (0.4)	7 (1.2)				
	>10.6	19 (6.1)	8 (5.2)	1 (5.9)	61 (4.5)	30 (5.3)	9 (6.5)	3 (11.1)	2 (10.0)	2 (3.8)
PLT ($\times 10^9$/L)	<100	1 (0.3)						1 (3.7)		
	>440	6 (1.9)	6 (3.9)		22 (1.6)	12 (2.1)	4 (2.9)		1 (5.0)	2 (3.8)
MCV (fl)	<80	30 (9.6)	16 (10.5)	10 (58.8)	263 (19.2)	49 (8.7)	6 (4.3)	2 (7.4)	3 (15.0)	3 (5.7)
	>100		1 (0.7)		1 (0.1)					
Number of children measured[e]		314	153	17	1368	563	139	27	20	53
Ly ($\times 10^9$/L)	<1.2				6 (0.7)	1 (0.4)	2 (1.8)	1 (7.1)		
	>3.5	1 (6.7)	3 (11.1)	3 (17.6)	198 (21.8)	62 (22.1)	14 (12.6)		5 (33.3)	7 (16.3)
Ne ($\times 10^9$/L)	<1.4		1 (3.7)	1 (5.9)	38 (4.2)	23 (8.2)	3 (2.7)			1 (2.3)
	>6.6		1 (3.7)	1 (5.9)	38 (4.2)	5 (1.8)	5 (4.5)	1 (7.1)	2 (13.3)	2 (4.7)
Eo ($\times 10^9$/L)	>0.5	2 (13.3)	5 (18.5)	2 (11.8)	160 (17.6)	74 (26.3)	21 (18.9)	1 (7.1)	2 (13.3)	7 (16.3)
Mo ($\times 10^9$/L)	<0.12				82 (9.0)	30 (10.7)	2 (1.8)	1 (7.1)		1 (2.3)
	>1.00	1 (6.7)	2 (7.4)	1 (5.9)	6 (0.7)	12 (4.3)	3 (2.7)		1 (6.7)	3 (7.0)
Number of children measured[f]		15	27	17	909	281	111	14	15	43

[a] Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of sub-

[b] BRA, Braginskii; B-K, Buda-Koshelevskii; VET, Vetkovskii; GOR, Gomelskii; DOB, Dobrushskii; Loevskii; MOZ, Mozirskii; PET, Petrikovskii; REC, Rechitskii; ROG, Rogachevskii; SVT,

[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume;

[d] One boy in Oktyabrskii is included.

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

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

abnormalities by place of residence.[a]

residence[b]											Total
LEL	LOE	MOZ	PET	REC	ROG	SVT	HOY	CHE	GOC	MOC	
	3								3		9
	(1.0)								(0.3)		(0.2)
											2
											(0.05)
1	3		1				1		9		28
(4.0)	(1.0)		(1.5)				(0.6)		(1.0)		(0.7)
	15		7	3		1	4	1	40	4	210
	(5.2)		(10.6)	(7.9)		(5.3)	(2.4)	(2.9)	(4.3)	(16.7)	(4.9)
	1								1	1	5
	(0.3)								(0.1)	(4.2)	(0.1)
	4				1				17		75
	(1.4)				(11.1)				(1.8)		(1.8)
3	28	2	7	8	4	4	12	5	257	8	721[d]
(12.0)	(9.7)	(18.2)	(10.6)	(21.1)	(44.4)	(21.1)	(7.2)	(14.7)	(28.1)	(33.3)	(16.9)
											2
											(0.05)
25	288	11	66	38	9	19	167	34	936	24	4271
1							4	1	10		26
(25.0)							(2.7)	(25.0)	(1.5)		(1.1)
	5		1	2	2	5	14		112	2	436
	(8.2)		(14.3)	(6.9)	(22.2)	(29.4)	(9.3)		(16.3)	(12.5)	(18.0)
							1		17		85
							(0.7)		(2.5)		(3.5)
	3			1			5	1	29	2	96
	(4.9)			(3.4)			(3.3)	(25.0)	(4.2)	(12.5)	(4.0)
1	9	2			1	1	27	1	62	2	380
(25.0)	(14.8)	(25.0)			(11.1)	(5.9)	(18.0)	(25.0)	(9.0)	(12.5)	(15.7)
	7	1		2		3	12		43	2	186
	(11.5)	(12.5)		(6.9)		(17.6)	(8.0)		(6.3)	(12.5)	(7.7)
							2	1	12		44
							(1.3)	(25.0)	(1.7)		(1.8)
4	61	8	7	29	9	17	150	4	688	16	2425

jects with abnormalities.
ELS, Elskii; ZLO, Zlobinskii; KLN, Kalinkovichskii; KOR, Kormyanskii; LEL, Lelchitskii; LOE, Svetlogorskii; HOY, Hoynikskii; CHE, Checherskii; GOC, Gomel City; MOC, Mozir City.
Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

Table 5B. Frequency of girls with hematological

Blood analysis		Place of								
Item (unit)[c]	Abnormality criteria	BRA	B-K	VET	GOR	DOB	ELS	ZLO	KLN	KOR
Hb (g/L)	<110				4 (0.3)	3 (0.5)				
	>160				5 (0.3)	2 (0.3)				
WBC ($\times 10^9$/L)	<3.6	1 (0.3)			4 (0.3)	1 (0.2)				
	>11.0	14 (4.7)	18 (9.4)		38 (2.6)	20 (3.1)	4 (2.1)	1 (2.9)	2 (8.3)	2 (3.7)
PLT ($\times 10^9$/L)	<100	1 (0.3)			1 (0.1)					
	>440	5 (1.7)	4 (2.1)	1 (7.1)	18 (1.2)	6 (0.9)	2 (1.0)	1 (2.9)		2 (3.7)
MCV (fl)	<80	17 (5.7)	12 (6.3)	5 (38.7)	158 (10.7)	25 (3.9)	4 (2.1)	5 (14.7)	3 (12.5)	6 (11.1)
	>100				1 (0.1)	2 (0.3)				
Number of children measured[f]		296	192	14	1471	638	194	34	24	54
Ly ($\times 10^9$/L)	<1.2			1 (9.1)	6 (0.6)	1 (0.3)	4 (3.0)			
	>3.5	4 (16.0)	2 (5.1)	1 (9.1)	215 (22.1)	61 (19.2)	9 (6.7)	6 (24.0)	4 (20.0)	8 (17.4)
Ne ($\times 10^9$/L)	<1.4				48 (4.9)	11 (3.5)	9 (6.7)		3 (15.0)	2 (4.3)
	>6.6		1 (2.6)		37 (3.8)	11 (3.5)	5 (3.7)		1 (5.0)	
Eo ($\times 10^9$/L)	>0.5	2 (8.0)	7 (17.9)	2 (18.2)	147 (15.1)	69 (21.7)	32 (23.9)	7 (28.0)	2 (10.0)	6 (13.0)
Mo ($\times 10^9$/L)	<0.12	2 (8.0)		1 (9.1)	111 (11.4)	33 (10.4)	4 (3.0)	1 (4.0)	3 (15.0)	7 (15.2)
	>1.00				5 (0.5)	7 (2.2)	3 (2.2)			
Number of children measured[g]		25	39	11	975	318	134	25	20	46

[a] Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of sub-

[b] BRA, Braginskii; B-K, Buda-Koshelevskii; VET, Vetkovskii; GOR, Gomelskii; DOB, Dobrushskii; Loevskii; MOZ, Mozirskii; PET, Petrikovskii; REC, Rechitskii; ROG, Rogachevskii; SVT,

[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume;

[d] One girl in Oktyabrskii is included.

[e] One girl in Narovlyanskii is included.

[f] Number of children measured for Hb, WBC, PLT, MCV.

[g] Number of children measured for Ly, Ne, Eo, Mo.

abnormalities by place of residence.[a]

residence[b]											Total
LEL	LOE	MOZ	PET	REC	ROG	SVT	HOY	CHE	GOC	MOC	
			2 (1.9)			2 (7.7)			2 (0.2)		13 (0.3)
									1 (0.1)		8 (0.2)
					1 (8.3)				3 (0.3)		10 (0.2)
1 (1.9)	6 (2.3)		6 (5.7)	1 (2.4)		2 (7.7)	4 (2.6)	1 (2.2)	37 (3.6)	1 (4.2)	158 (3.4)
	1 (0.4)		1 (1.0)								4 (0.1)
	2 (0.8)	1 (4.5)	1 (1.0)	2 (4.9)		1 (3.8)	4 (2.6)	2 (4.4)	12 (1.2)		64 (1.4)
8 (15.4)	17 (6.6)	4 (18.2)	10 (10.0)	7 (17.1)	4 (33.3)	3 (11.5)	4 (2.6)		162 (15.8)	2 (8.3)	457[d] (9.7)
	1 (0.4)						1 (0.7)			1 (4.2)	6 (0.1)
52	257	22	105	41	12	26	151	45	1026	24	4678
	2 (2.9)						1 (0.8)		13 (1.8)		28 (1.1)
4 (22.2)	14 (20.3)	1 (7.1)	3 (33.3)	5 (17.2)	4 (36.4)	3 (12.0)	4 (3.3)		142 (19.2)	3 (15.0)	493 (18.5)
					1 (9.1)		2 (1.7)		19 (2.6)	1 (5.0)	97[e] (3.6)
1 (5.6)	4 (5.8)		1 (11.1)	1 (3.4)		3 (12.0)	4 (3.3)		29 (3.9)	2 (10.0)	101[d] (3.8)
4 (22.2)	12 (17.4)	2 (14.3)		2 (6.9)	1 (9.1)	2 (8.0)	13 (10.7)		74 (10.0)	1 (5.0)	385 (14.5)
	9 (13.0)			2 (6.9)		2 (8.0)	7 (5.8)		54 (7.3)	1 (5.0)	238[d] (8.9)
	2 (2.9)					1 (4.0)	2 (1.7)		11 (1.5)		31 (1.2)
18	69	14	9	29	11	25	121	2	740	20	2651

jects with abnormalities.

ELS, Elskii; ZLO, Zlobinskii; KLN, Kalinkovichskii; KOR, Kormyanskii; LEL, Lelchitskii; LOE, Svetlogorskii; HOY, Hoynikskii; CHE, Checherskii; GOC, Gomel City; MOC, Mozir City.

Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

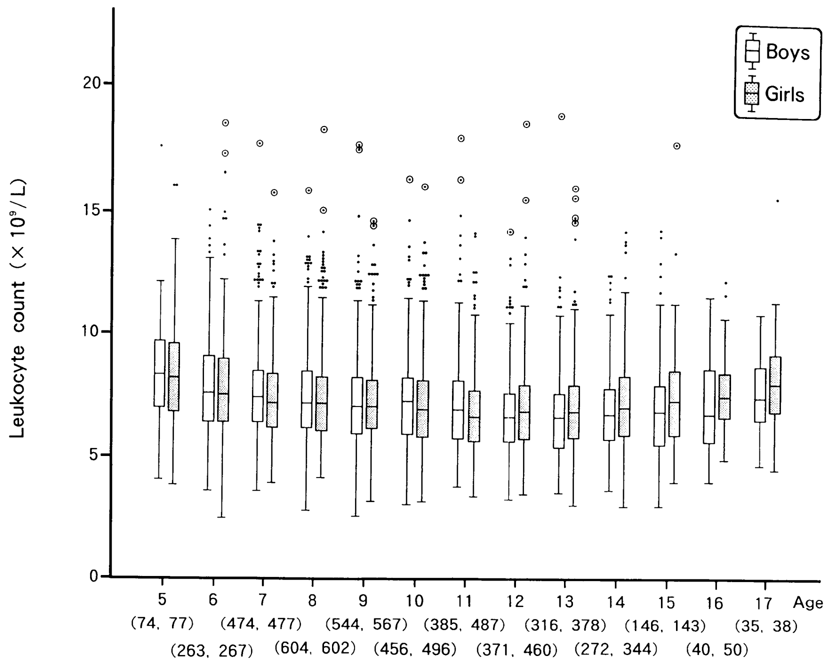

Figure 17. The box-and-whisker plots of leukocyte count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

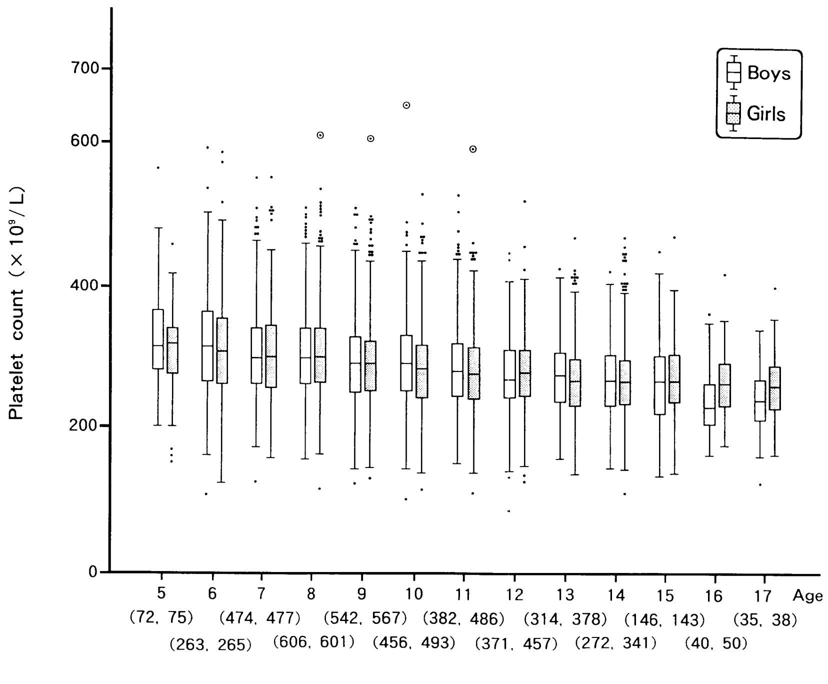

Figure 18. The box-and-whisker plots of platelet count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

Table 6A. Frequency of boys with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	7(0.3)		2(0.4)			9(0.2)
	>180	1(0.04)		1(0.2)			2(0.1)
WBC (×10⁹/L)	<3.8	22(0.9)	5(0.6)	1(0.2)			28(0.7)
	>10.6	127(5.2)	54(6.0)	21(4.4)	8(5.7)		210(4.9)
PLT (×10⁹/L)	<100	4(0.2)		1(0.2)			5(0.1)
	>440	48(2.0)	14(1.6)	11(2.3)	1(0.7)	1(10.0)	75(1.8)
MCV (fl)	<80	492(20.0)	142(15.7)	68(14.2)	16(11.3)	3(30.0)	721(16.9)
	>100	2(0.1)					2(0.1)
Number of children measured[c]		2738	903	479	141	10	4271
Ly (×10⁹/L)	<1.2	22(1.4)	1(0.2)	2(0.8)	1(1.8)		26(1.1)
	>3.5	250(16.0)	123(22.0)	48(19.1)	15(26.8)		436(18.0)
Ne (×10⁹/L)	<1.4	49(3.1)	24(4.3)	10(4.0)	2(3.6)		85(3.5)
	>6.6	66(4.2)	26(4.7)	2(0.8)	2(3.6)		96(4.0)
Eo (×10⁹/L)	>0.5	236(15.1)	93(16.7)	41(16.3)	10(17.9)		380(15.7)
Mo (×10⁹/L)	<0.12	111(7.1)	47(8.4)	25(10.0)	3(5.4)		186(7.7)
	>1.00	27(1.7)	12(2.2)	4(1.6)	1(1.8)		44(1.8)
Number of children measured[d]		1557	558	251	56	3	2425

[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] Number of children measured for Hb, WBC, PLT, and MCV.
[d] Number of children measured for Ly, Ne, Eo, and Mo.

years of age. A 10 year-old boy with congenital microspherocytic anemia was shown to have thrombocytosis (650×10^9/L) after splenectomy.

Tables 5A and 5B show the frequency of hematological abnormalities in boys and girls, respectively by place of residence. An increase in WBC was noted in 368 (4.1%) children, an increase in platelet count in 139 (1.6%), a decrease in monocyte count in 424 (8.4%), lymphocytosis in 929 (18.3%), eosinophilia in 765 (15.1%) and a decrease in MCV in 1178 (13.2%). As a whole, deviations from normal levels in the differential leukocyte count were observed in 2626 (51.7%) of the children, including 1373 girls and 1253 boys from the total number of children examined (5076). The highest number of deviations was noted among children from Gomelskii, Dobrushskii, Elskii and Hoynikskii Rayons and from Gomel City (because of the children relocated from zones with high contamination levels).

It is impossible to draw final conclusions about the association of ^{137}Cs level and the frequency of hematological abnormalities on the basis of the data in Tables 6A and 6B because the number of children with ^{137}Cs specific activity exceeding 100 Bq/kg was small.

No significant association was observed between eosinophilia and a history

Table 6B. Frequency of girls with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	6(0.2)	3(0.3)	2(0.4)	1(1.3)	1(16.7)	13(0.3)
	>160	7(0.2)		1(0.2)			8(0.2)
WBC ($\times 10^9$/L)	<3.6	7(0.2)	3(0.3)				10(0.2)
	>11.0	99(3.5)	37(3.7)	20(4.4)	2(2.6)		158(3.4)
PLT ($\times 10^9$/L)	<100	3(0.1)	1(0.1)				4(0.1)
	>440	37(1.3)	17(1.7)	10(2.2)			64(1.4)
MCV (fl)	<80	313(10.9)	88(8.8)	51(11.2)	4(5.1)	1(16.7)	457(9.8)
	>100	5(0.2)	1(0.1)				6(0.1)
Number of children measured[c]		3142	995	457	78	6	4678
Ly ($\times 10^9$/L)	<1.2	21(1.2)	5(0.9)	2(0.8)			28(1.1)
	>3.5	286(15.9)	137(23.5)	66(26.9)	4(14.8)		493(18.6)
Ne ($\times 10^9$/L)	<1.4	44(2.4)	31(5.3)	21(8.6)	1(3.7)		97(3.7)
	>6.6	80(4.4)	13(2.2)	7(2.9)	1(3.7)		101(3.8)
Eo ($\times 10^9$/L)	>0.5	231(12.8)	97(16.7)	51(20.8)	4(14.8)	2(33.3)	385(14.5)
Mo ($\times 10^9$/L)	<0.12	144(8.0)	56(9.6)	34(13.9)	4(14.8)		238(9.0)
	>1.00	22(1.2)	5(0.9)	4(1.6)			31(1.2)
Number of children measured[d]		1791	582	245	27	6	2651

[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] Number of children measured for Hb, WBC, PLT, and MCV.
[d] Number of children measured for Ly, Ne, Eo, and Mo.

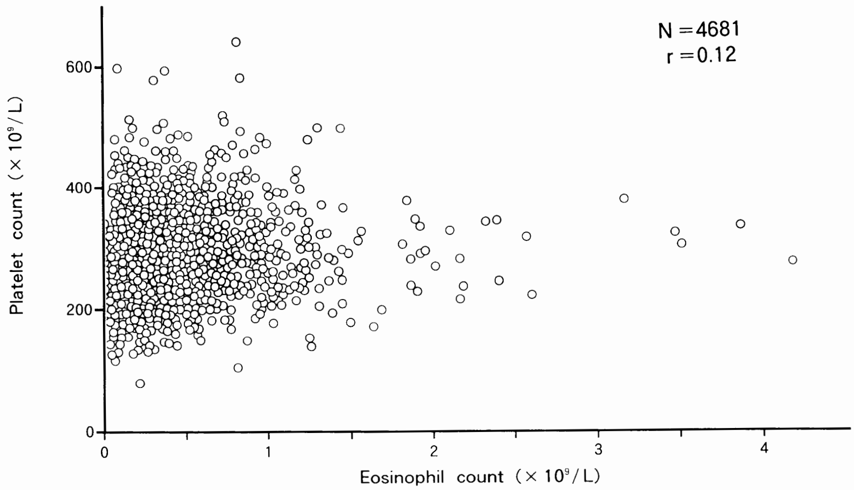

Figure 19. Scatter plots of eosinophil and platelet counts.

of skin diseases or bronchial asthma in children. The prevalence of eosinophilia in children with and without a history of skin diseases was 15.4% (76/494) and 14.6% (534/3650): the estimated odds ratio (±standard error) was 1.06±0.02. Similarly, the prevalence of eosinophilia in children with and without a history of asthma was 15.0% (19/127) and 14.7% (586/3977): the estimated odds ratio (±standard error) was 1.02±0.26. No significant seasonal difference was observed either: the prevalence of eosinophilia was 17.7% (269/1521) in spring and 15.7% (196/1252) in autumn, resulting in an estimated odds ratio (±standard error) of 1.16±0.12. However, a significant difference in the prevalence of eosinophilia was observed between children with and without domestic animals: the respective prevalence was 18.5% (543/2937) and 12.2% (222/1814), resulting in an estimated odds ratio (±standard error) of 1.60±0.14.

A statistically significant correlation was observed between PLT and eosinophil count but the correlation coefficient was not large: 95% confidence interval of the correlation coefficient was $0.09<\rho<0.14$ (Figure 19).

4. Conclusions

It should be noted that most of the children examined in connection with the Chernobyl Sasakawa Project over the past three years showed ^{137}Cs specific activity in the range from 30 to 80 Bq/kg. No significant difference in ^{137}Cs specific activity was found between boys and girls. The highest levels of ^{137}Cs specific activity in the body were found among children living in the most contaminated areas where contamination density was 15 Ci/km^2 or higher.

An increase in thyroid disease, particularly thyroid cancer in children, was noted in the Gomel Oblast. In the period between 1986–1993, thyroid cancer incidence in the Gomel Oblast was 9.4 per 100 000 children. The total of 131 cases represents 52.2% of all cases in the Republic of Belarus (251) and is the highest level among the oblasts.

Clinical experience shows that thyroid cancer in children displays a more acute manifestation and proceeds into the metastatic phase more often than in people of an older age.

On the basis of the analyses, we concluded that an additional group of children who experienced the impact of radioactive iodine fallout from the Chernobyl accident (children who were living in the restricted zones at the time of the disaster or who were born after the catastrophe and were moved to non-contaminated ("clean") zones) should be defined. These children should undergo close observation and systematic examinations not less than 2–3 times a year at their place of residence. The employment of an additional mobile team and the provision of an additional mobile laboratory will be necessary to facilitate early diagnoses of thyroid abnormalities in the children of the Gomel Oblast who were affected most severely by the Chernobyl disaster.

A considerable number of children in the Gomel Oblast revealed an increase or a decrease in hematological parameters, in particular the differential leukocyte count. It is not possible to draw any conclusions from these results because of the small number of children examined. It is necessary to increase the number of examinations, to expand the geography and to compare the results with those obtained from children suffering from various chronic diseases.

Results of the Examination of the Health Status of Children in the Southern-Western Rayons of Bryansk Oblast

Klincy City Children's Hospital

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1. Introduction

The Sasakawa Chernobyl Project investigations of children residing in the Southern-Western rayons (districts) of Bryansk Oblast (Province) in the Russian Federation are carried out by the staff of the diagnostic laboratory at the Klincy City Children's Hospital.

During the period between 1991 and 1993, the children of three rayons with various ^{137}Cs contamination densities, i.e. Klintsovskii Rayon (1–5 Ci/km^2), Klincy City (5–15 Ci/km^2) and Novozybkovskii Rayon (higher than 15 Ci/km^2), were examined (Figure 1).

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 residing in radionuclide contaminated areas at the time of the examination.

The examinations were carried out by the same techniques and details of disease history collected by the same methods as those employed by the other centers. A mobile diagnostic laboratory equipped with suitable investigation facilities and donated by the Sasakawa Foundation was dispatched to various settlements. Children were also brought to Klincy City to be examined using a set of stationary equipment. All biomaterials obtained (serum and blood smears) were stored after examinations. At the present time the center archive consists of about 12 000 samples.

2.2 Measurement of whole body ^{137}Cs concentration

^{137}Cs activity in the body of the children was measured with a WBC-101 gamma-spectrometer manufactured by the Aloka Company. The following parameters were taken at the time of examination: height, body weight and size of chest.

2.3 Thyroid examinations

The complex examination of the thyroid includes an ultrasound investiga-

Figure 1. ^{137}Cs contamination levels (Ci/km²) in the rayons of Bryansk Oblast.
[a] Minimum and maximum levels of contamination.

tion of the gland, determination of its functional state, the presence or absence of the titers of anti-microsome antibodies (AMC) and anti-thyroglobulin antibodies (ATG). The ultrasound examination was performed by scanning the thyroid gland and automatically measuring its volume by outlining each image using an Aloka SSD–520 instrument. The criterion for goiter is a thyroid volume exceeding the volume calculated by the following formula:

$$LIMIT = 1.7 \times 10^{0.013 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

where *age* is the age of a child in years at the time of the examination; *height* is the height of the child in cm; and *body weight* is the weight of the child in kg. See Appendix B in *A Report on the 1993 Chernobyl Sasakawa Project Workshop*, 1993 for details.

In order to study thyroid function, free thyroxine (FT_4) and thyroid stimulating hormone (TSH) concentrations were determined by the immunometric technique using an "Amerlite" hormone analyzer system.

Ascertainment of the titers of AMC and ATG was based on the reaction of agglutination by microtitration.

Thyroid volume, echogenity, the presence of thyroid abnormalities, nodules, cysts and calcificates 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 diagnoses.

2.4. Hematological studies

Peripheral blood tests were conducted with Sysmex K–1000 and NE–7000 hemoanalyzers. Quantitative determinations of the white blood cell count (WBC), red blood cell count (RBC), hemoglobin concentration (Hb), platelet count (PLT), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular hemoglobin (MCH) were conducted. An analysis of the morphologic leukocyte differentiation was carried out with an "Olympus" microscope. Peripheral blood smears were stained by the May-Grünwald-Giemsa method.

3. Results

3.1 Study subjects

Table 1 shows the quantitative distribution of the children by sex and place of residence. The triplets give the 25th, 50th and 75th sample percentiles of age distribution at the time of examination for each group.

A total of 12 271 children were examined from May 1991 to December 1993 (6141 boys and 6130 girls). 1958 children (Klintsovskii Rayon) live in areas with a contamination density ranging from 1 to 5 Ci/km^2; 8485 (Klincy City) live in areas with a contamination density of 5–15 Ci/km^2; and 1828 (Novozybkovskii Rayon) live in areas with a contamination density exceeding 15 Ci/km^2.

3.2 Measurement of whole body ^{137}Cs concentration

Figure 2 shows the relationship between ^{137}Cs specific activity and the age and sex of the children examined. The mean value of ^{137}Cs specific activity was independent of sex in all age groups and was about 50 Bq/kg.

Figure 3 shows the results of measurements of ^{137}Cs specific activity in the body in relation to the place of residence. The median of ^{137}Cs specific activity in the children from Novozybkovskii Rayon (where the contamination density exceeds 15 Ci/km^2) was approximately twice as high as that in children residing in areas with lower contamination densities. The similar medians of ^{137}Cs specific activity in rayons with various low contamination densities may be attributable to the fact that Klintsovskii Rayon is an agricultural zone.

Table 1. Classification of study subjects by sex and place of residence.

Place of residence	Boys	Girls	Total
Klintsovskii	989 (8, 11, 13)[a]	996 (8, 11, 13)	1958 (8, 11, 13)
Klincy City	4234 (9, 11, 13)	4251 (9, 11, 13)	8485 (9, 11, 13)
Novozybkovskii	918 (9, 11, 13)	910 (9, 11, 13)	1828 (9, 11, 13)
Total	6141 (9, 11, 13)	6130 (9, 11, 13)	12 271 (9, 11, 13)

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

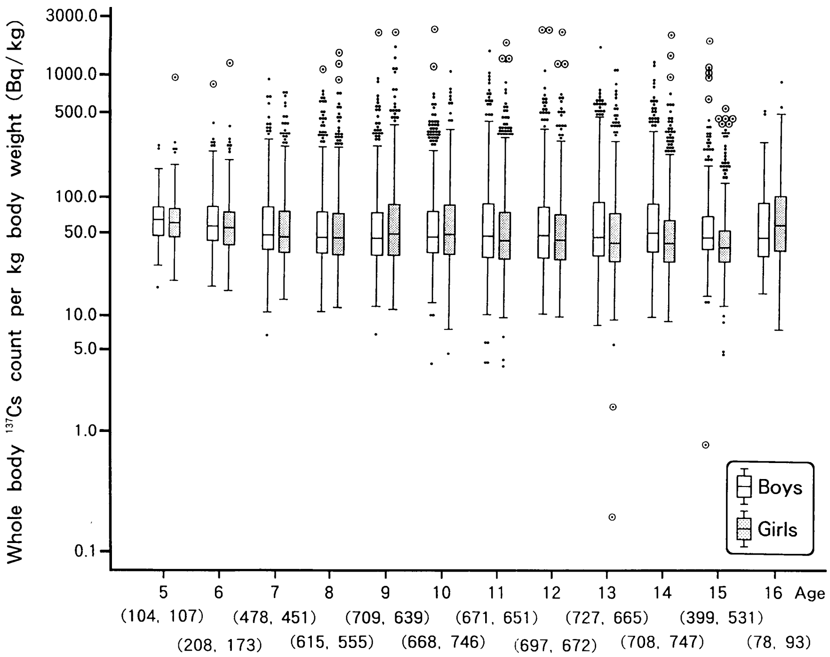

Figure 2. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by sex and age. Each pair presents the number of examined boys and girls. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, called "outside" and "far out," respectively.

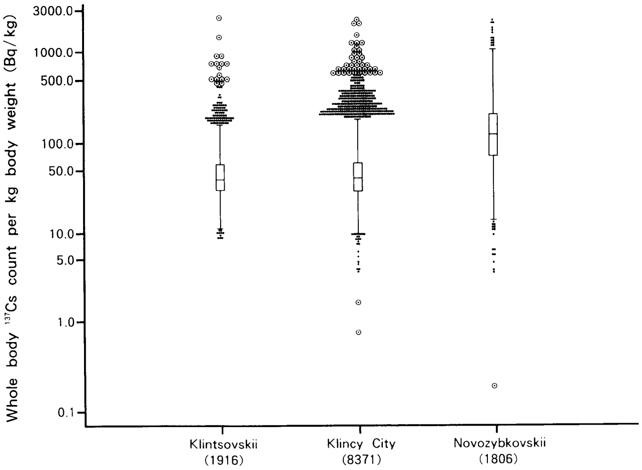

Figure 3. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by place of residence. The parenthetic entries refer to the number of examined children. See Figure 2 for details.

Residents of these zones consume food from private plots (meat, milk, vegetables) as well as mushrooms, forest berries, fish and game. A considerable number of children residing in Klincy City showed high levels of ^{137}Cs specific activity. The investigation of such cases has shown that the children of this group consume food from settlements, where the contamination density exceeds 15 Ci/km^2.

3.3 Thyroid examinations

Figure 4 shows the thyroid volume change in relation to sex and age. The thyroid volume increased with the age of the child.

Figure 5 shows the prevalence of goiter by sex and place of residence. The prevalence of goiter was higher in children living in Novozybkovskii Rayon. It was similar among boys living in Klincy City and in Klintsovskii Rayon but higher among girls living in Klincy City. The prevalence of goiter was higher in girls than in boys in all rayons.

Figure 6 shows the prevalence of goiter in boys and girls relative to ^{137}Cs specific activity. There was a trend towards a higher prevalence of goiter in boys as ^{137}Cs specific activity increases.

Table 2 shows the classification of thyroid abnormalities by sex and place of residence. The most common abnormalities found during examinations were nodules, cysts, changes in echogenity and anomalies. The largest proportion of abnormalities was found in children living in Klincy City. One boy living

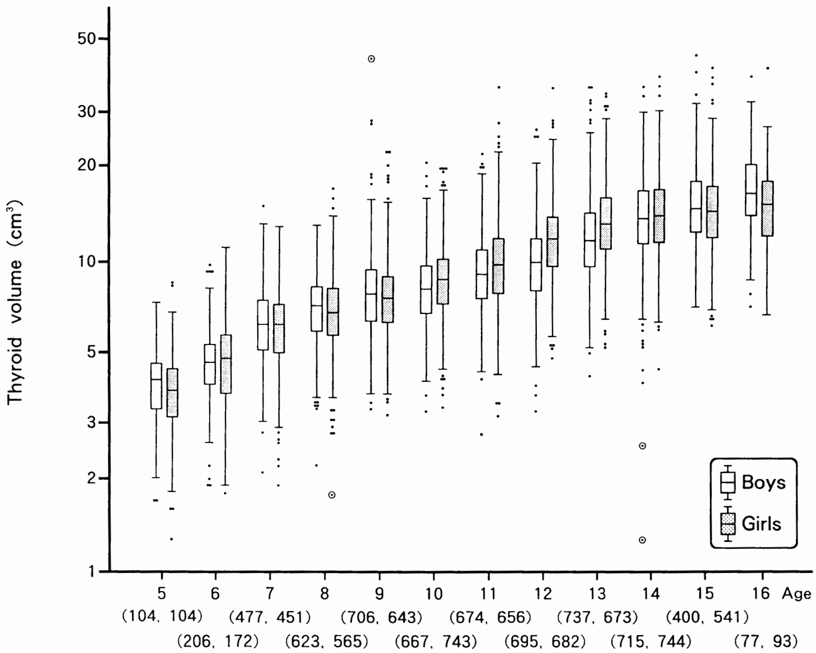

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

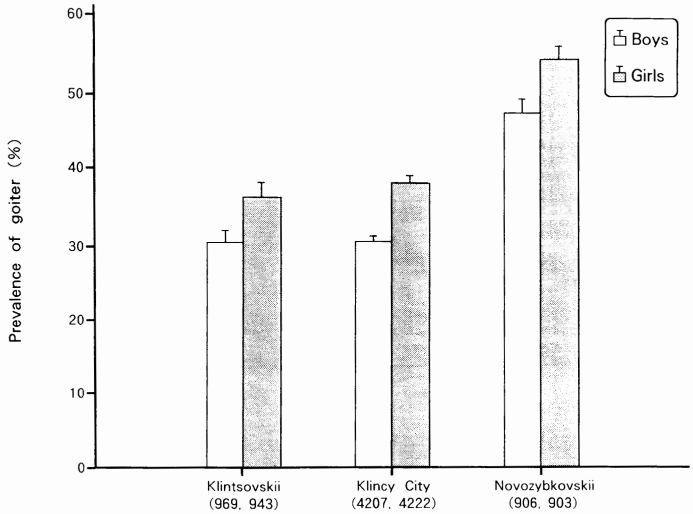

Figure 5. Prevalence of goiter by sex and place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 52 for the definition of goiter.

in Klincy City, aged 9, was found to have thyroid cancer with metastases to cervical lymph nodes. Papillary cancer was confirmed histologically. Surgery was performed.

Table 3 shows the prevalence of positive ATG and AMC titers according to sex and place of residence. The total number of investigations amounted to 11 964. Seventeen children living in Klintsovskii Rayon were found to have

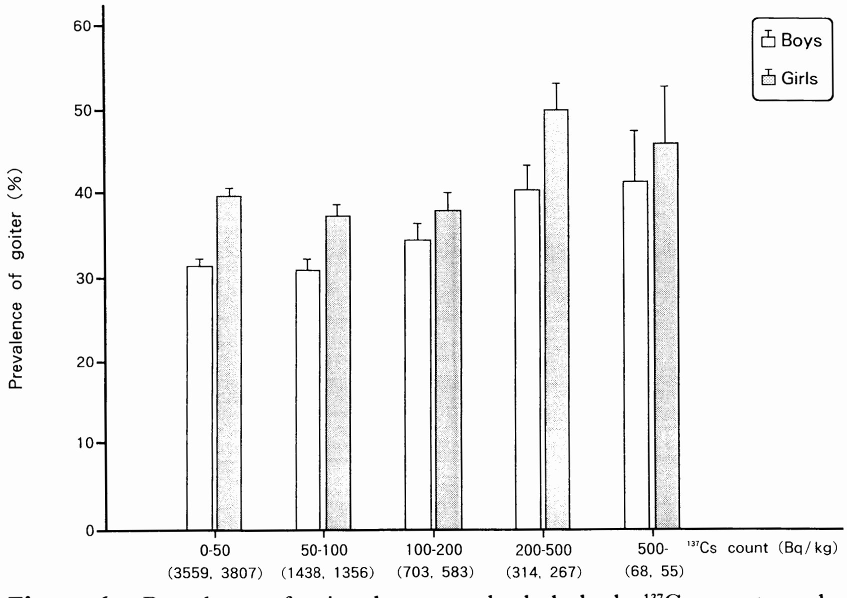

Figure 6. Prevalence of goiter by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 52 for the definition of goiter.

Table 2. Subjects with thyroid abnormalities by sex and place of residence.

Place of residence	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	986	943	6	5	0	0	13	27	0	0
Klincy City	4207	4221	20	23	2	9	124	156	10	8
Novozybkovskii	905	903	6	10	5	6	7	17	0	1
Total	6080	6067	32	38	7	15	144	200	10	9

[a] B, boys; G, girls.

Table 3. Prevalence of positive ATG (anti-thyroglobulin antibody) and AMC (anti-microsome antibody) titers by sex and place of residence.[a]

Place of residence	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Klintsovskii	1942	978	964	17 (0.9)	8 (0.8)	9 (0.9)	34 (1.8)	8 (0.8)	26 (2.7)
Klincy City	8212	4100	4112	91 (1.1)	23 (0.6)	68 (1.7)	171 (2.1)	43 (1.0)	128 (3.1)
Novozybkovskii	1810	910	900	22 (1.2)	16 (0.7)	16 (1.8)	15 (0.8)	3 (0.3)	12 (1.3)
Total	11 964	5988	5976	130 (1.1)	37 (0.6)	93 (1.6)	220 (1.8)	54 (0.9)	166 (2.8)

[a] Number of subjects with percentages in parentheses.

positive ATG titers and 34 to have positive AMC titers, while 91 subjects from Klincy City were found to have positive ATG titers and 171 to have positive AMC titers, and 22 subjects living in Novozybkovskii Rayon were found to have positive ATG titers and 15 to have positive AMC titers. As shown in the table, the prevalence of antibodies was higher in girls than in boys irrespective of the place of residence. The prevalence of positive AMC titers was higher than that of positive ATG titers.

Figure 7 shows the relationship between the prevalence of positive ATG titers in boys and girls and ^{137}Cs specific activity. No relationship between these two values could be established.

The relationship between the prevalence of positive AMC titers and ^{137}Cs specific activity in boys and girls is presented in Figure 8. It is difficult to establish any relationship since the data for the interval of ^{137}Cs specific activity exceeding 100 Bq/kg are unreliable.

Table 4 shows the quantitative distribution of children based on the results of the investigations of thyroid function relative to sex and place of residence. No thyroid function disorders were found in children living in Klintsovskii

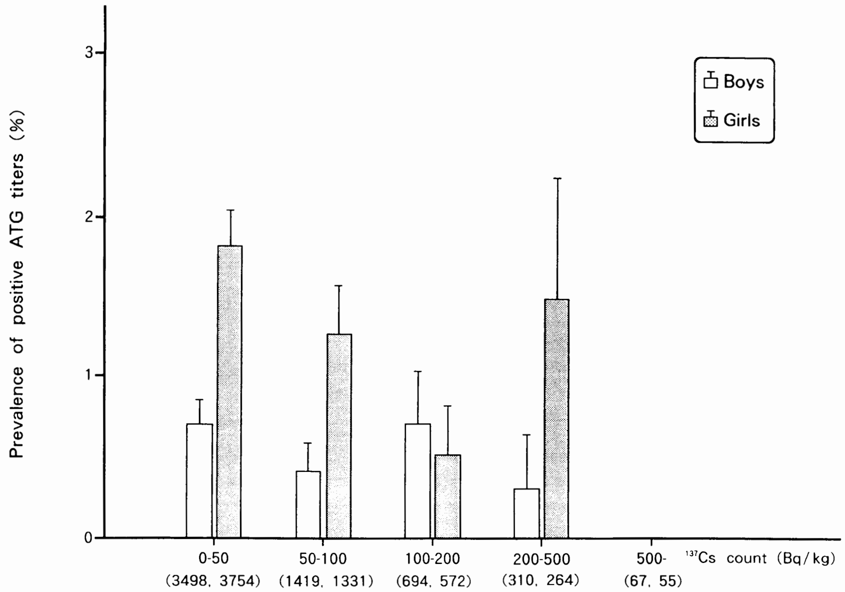

Figure 7. Prevalence of positive ATG titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

Rayon. Ten children living in Klincy City (5 boys and 5 girls) and 2 girls living in Novozybkovskii Rayon were found to have a thyroid hypofunction. Thyroid hyperfunction was detected in 4 subjects living in Klincy City (1 boy and 3 girls) and in 2 girls in Novozybkovskii Rayon.

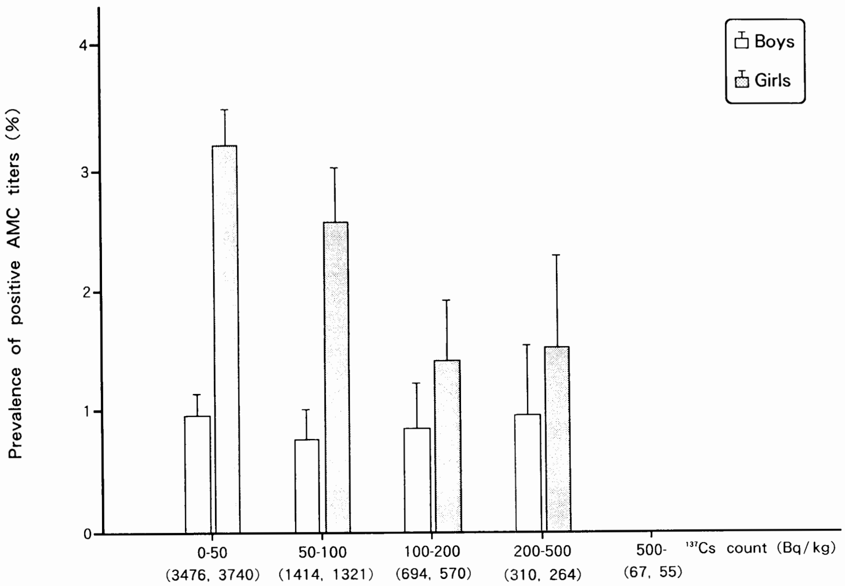

Figure 8. Prevalence of positive AMC titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

Table 4. Number of subjects with hypothyroidism and hyperthyroidism by sex and place of residence.

Place of residence	Number of subjects with measurement			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Klintsovskii	1928	971	957	0	0	0	0	0	0
Klincy City	8110	4047	4053	10	5	5	4	1	3
Novozybkovskii	1795	905	890	2	0	2	2	0	2
Total	11 823	5923	5900	12	5	7	6	1	5

[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.

The relationship between urinary iodine content and the residual of thyroid volume after adjustment for age, height and weight, and concentration of serum FT_4 and TSH was studied (Figures 9–11). No significant correlation was observed between urinary iodine content and the residual thyroid volume or FT_4 concentration. Although a statistically significant correlation was observed between urinary iodine content and TSH concentration, the correlation coefficient was small: 95% confidence interval of the correlation coefficient was $-0.20 < \rho < -0.02$.

A similar analysis was conducted for ^{137}Cs specific activity (Figures 12–14). A statistically significant correlation was observed between ^{137}Cs specific activity and residual thyroid volume and TSH concentration but the respective correlation coefficients were small: 95% confidence interval of the correlation coefficient was $0.02 < \rho < 0.05$ for ^{137}Cs specific activity and residual thyroid volume and $-0.09 < \rho < -0.05$ for ^{137}Cs specific activity and TSH.

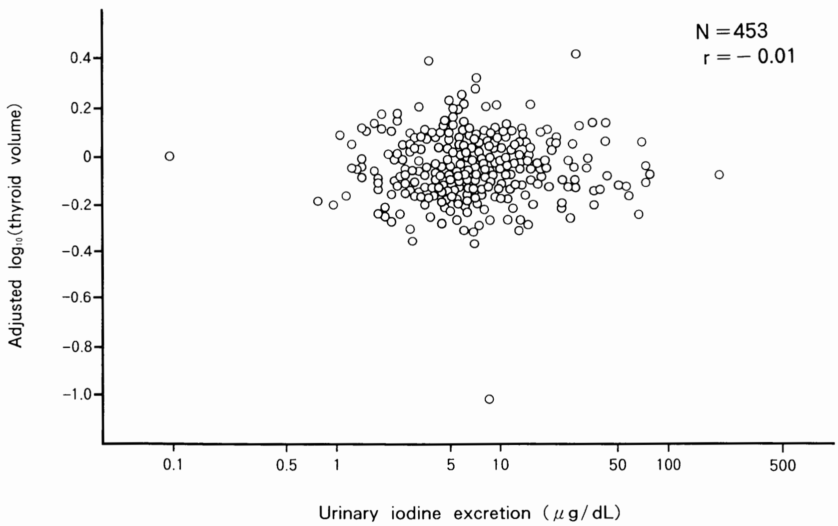

Figure 9. Scatter plots of urinary iodine excretion and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

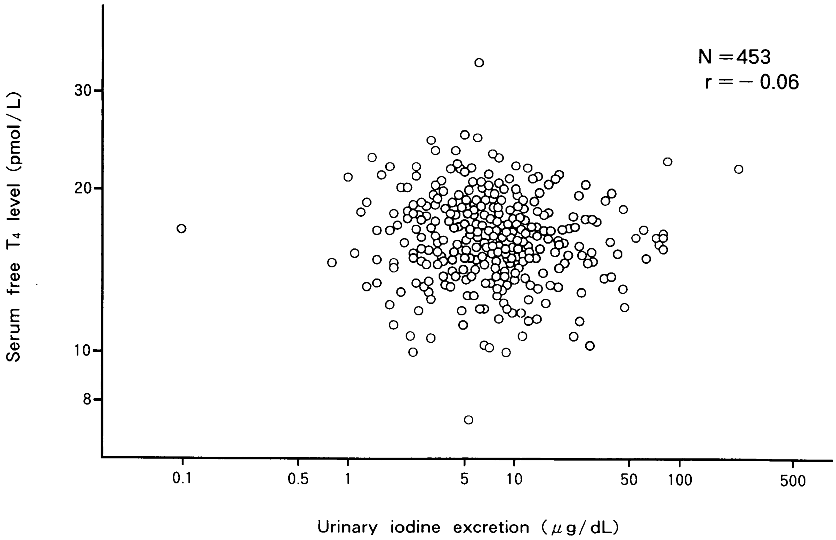

Figure 10. Scatter plots of urinary iodine excretion and serum free T_4 level.

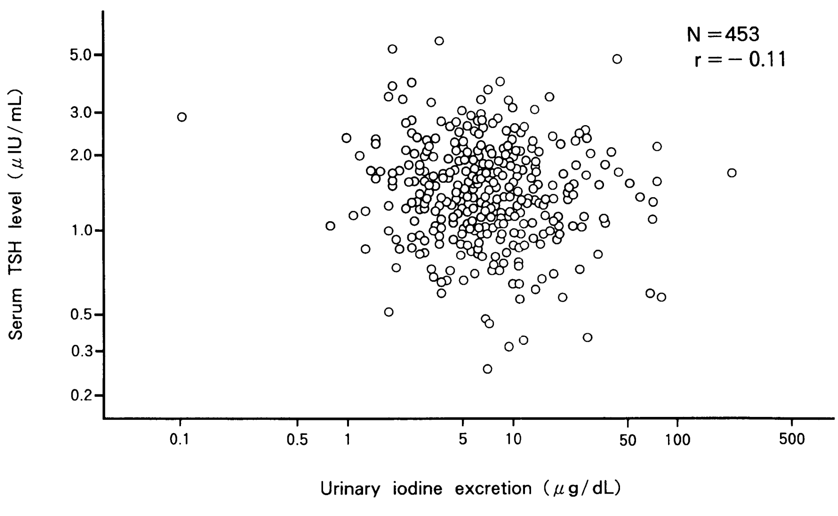

Figure 11. Scatter plots of urinary iodine excretion and serum TSH level.

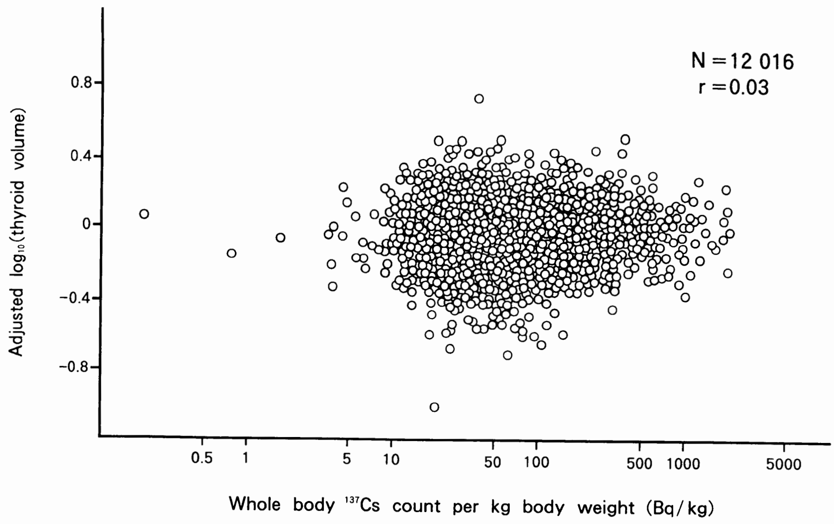

Figure 12. Scatter plots of whole body ^{137}Cs count per kg body weight and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

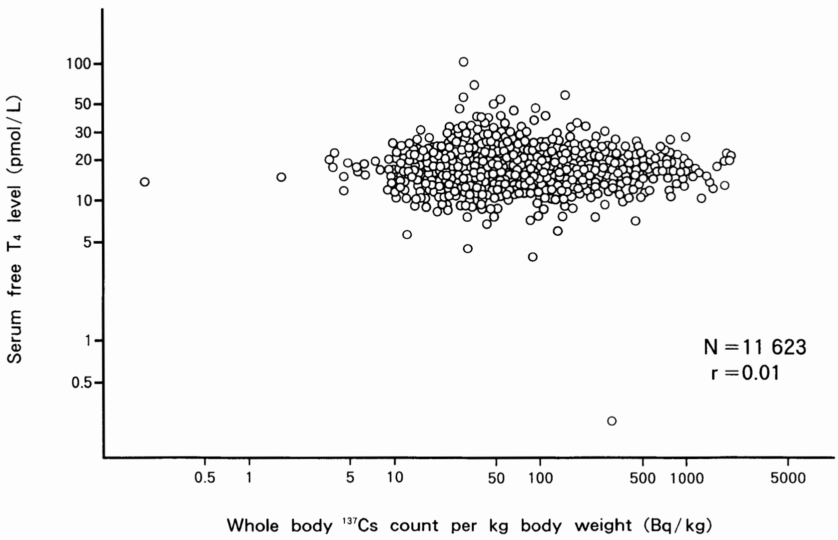

Figure 13. Scatter plots of whole body ^{137}Cs count per kg body weight and serum free T_4 level.

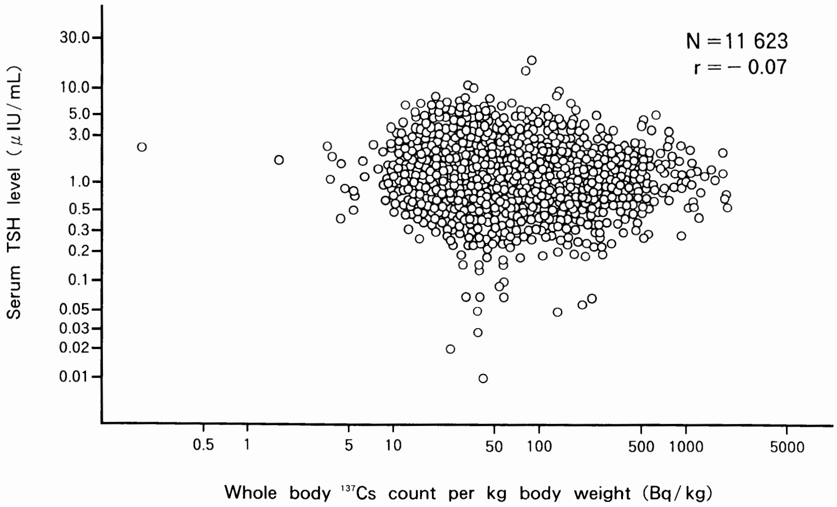

Figure 14. Scatter plots of whole body ^{137}Cs count per kg body weight and serum TSH level.

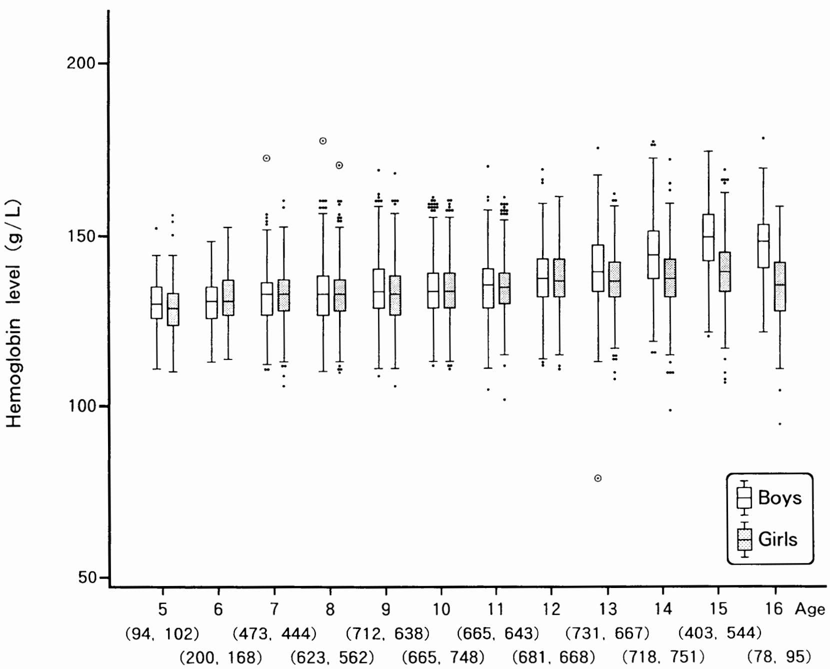

Figure 15. The box-and-whisker plots of hemoglobin level by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

3.4 Hematological studies

Figure 15 shows the relationship between Hb level in peripheral blood samples and sex and age. The mean value of Hb was within the normal range. Hb level increased with age. Children under 10 years of age (boys and girls) showed similar Hb mean values. Hb level increased in boys above 11 years old while remaining stable in girls. Girls of 16 years old, however, showed a slight decrease in Hb level.

Figure 16 shows the relationship between MCV and sex and age. The mean value of MCV was within normal limits and increased with age. The mean values were slightly lower among boys than among girls in all age groups.

Figure 17 shows the relationship between PLT and sex and age. The trend was toward a decrease with age, but girls about 16 years old showed an increase in PLT.

Figure 18 shows the relationship between WBC in peripheral blood samples and age and sex. WBC did not correlate with sex or age and was within normal limits.

Table 5A shows the hematological deviations from normal limits in boys in relation to the place of residence. A high frequency of elevated eosinophil count (average 22.1%) was noted irrespective of place of residence. Lymphocytosis was detected in 8.3% of children but was also unrelated to the place of

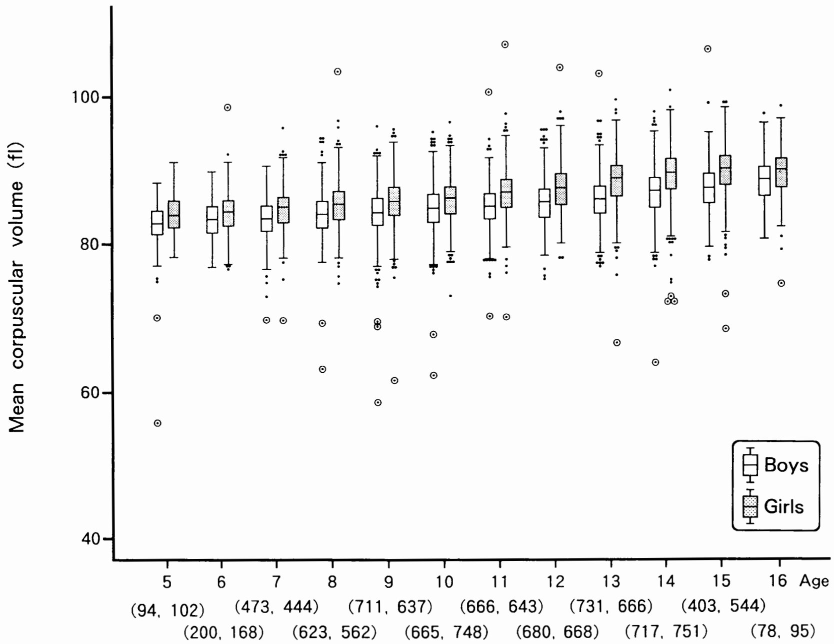

Figure 16. The box-and-whisker plots of mean corpuscular volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

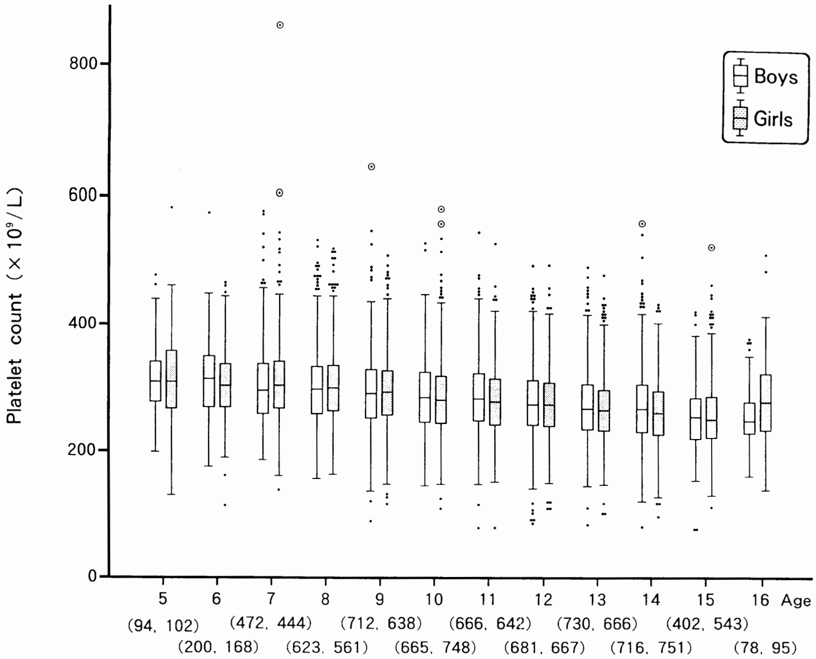

Figure 17. The box-and-whisker plots of platelet count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

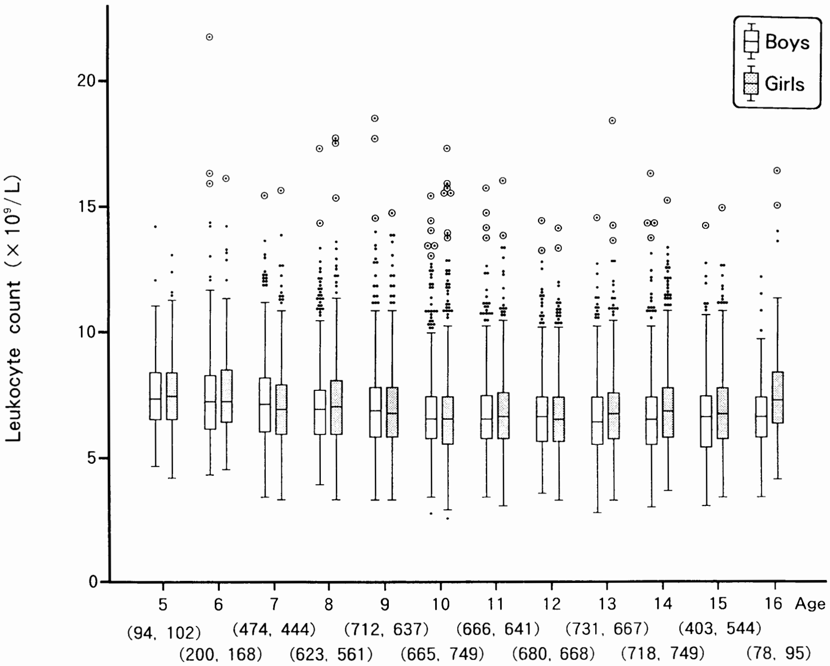

Figure 18. The box-and-whisker plots of leukocyte count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

Table 5A. Frequency of boys with hematological abnormalities by place of residence.[a]

Blood analysis		Place of residence			Total
Item (unit)[b]	Abnormality criteria	Klintsovskii	Klincy City	Novozybkovskii	
Hb (g/L)	<110		1(0.02)	2(0.2)	3(0.05)
	>180				
WBC ($\times 10^9$/L)	<3.8	4(0.4)	31(0.7)	9(1.0)	44(0.7)
	>10.6	37(3.8)	96(2.3)	37(4.1)	170(2.8)
PLT ($\times 10^9$/L)	<100	1(0.1)	3(0.1)	5(0.6)	9(0.1)
	>440	7(0.7)	45(1.1)	9(1.0)	61(1.0)
MCV (fl)	<80	62(6.4)	219(5.3)	50(5.5)	331(5.5)
	>100		1(0.02)	1(0.1)	2(0.03)
Ly ($\times 10^9$/L)	<1.2	68(7.0)	293(7.0)	16(1.8)	377(6.2)
	>3.5	80(8.2)	342(8.2)	81(8.9)	503(8.3)
Ne ($\times 10^9$/L)	<1.4	6(0.6)	44(1.1)	9(1.0)	59(1.0)
	>6.6	43(4.4)	138(3.3)	36(4.0)	217(3.6)
Eo ($\times 10^9$/L)	>0.5	257(26.3)	889(21.4)	190(20.9)	1336(22.1)
Mo ($\times 10^9$/L)	<0.12	30(3.1)	274(6.6)	14(1.5)	318(5.3)
	>1.00	32(3.3)	170(4.1)	35(3.9)	237(3.9)
Number of children measured		976	4160	908	6044

[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.

Table 5B. Frequency of girls with hematological abnormalities by place of residence.[a]

Blood analysis		Place of residence			Total
Item (unit)[b]	Abnormality criteria	Klintsovskii	Klincy City	Novozybkovskii	
Hb (g/L)	<110	2(0.2)	6(0.1)	2(0.2)	10(0.2)
	>160	4(0.4)	11(0.3)		15(0.2)
WBC ($\times 10^9$/L)	<3.6	6(0.6)	10(0.2)	3(0.3)	19(0.3)
	>11.0	31(3.2)	80(1.9)	25(2.8)	136(2.3)
PLT ($\times 10^9$/L)	<100		2(0.05)		2(0.03)
	>440	17(1.8)	30(0.7)	12(1.3)	59(1.0)
MCV (fl)	<80	22(2.3)	86(2.1)	19(2.1)	127(2.1)
	>100		3(0.1)		3(0.05)
Ly ($\times 10^9$/L)	<1.2	82(8.5)	288(6.9)	12(1.3)	382(6.3)
	>3.5	86(8.9)	358(8.6)	77(8.6)	521(8.6)
Ne ($\times 10^9$/L)	<1.4	7(0.7)	53(1.3)	13(1.4)	73(1.2)
	>6.6	53(5.5)	180(4.3)	42(4.7)	275(4.6)
Eo ($\times 10^9$/L)	>0.5	210(21.9)	839(20.1)	178(19.8)	1227(20.4)
Mo ($\times 10^9$/L)	<0.12	43(4.5)	272(6.5)	21(2.3)	336(5.6)
	>1.00	33(3.4)	148(3.6)	29(3.2)	210(3.5)
Number of children measured		961	4166	899	6026

[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.

Table 6A. Frequency of boys with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	1(0.03)	2(0.1)				3(0.05)
	>180						
WBC ($\times 10^9$/L)	<3.8	25(0.7)	13(0.9)	3(0.4)	3(1.0)		44(0.7)
	>10.6	96(2.7)	45(3.1)	12(1.7)	17(5.5)		170(2.8)
PLT ($\times 10^9$/L)	<100	1(0.03)	1(0.1)	12(1.7)	1(0.3)	1(1.5)	9(0.1)
	>440	40(1.1)	11(0.8)	7(1.0)	3(1.0)		61(1.0)
MCV (fl)	<80	189(5.3)	92(6.4)	38(5.4)	11(3.6)	1(1.5)	331(5.5)
	>100	1(0.03)	1(0.1)				2(0.03)
Ly ($\times 10^9$/L)	<1.2	239(6.8)	90(6.3)	34(4.9)	13(4.2)	1(1.5)	377(6.2)
	>3.5	272(7.7)	136(9.5)	61(8.7)	26(8.4)	8(11.8)	503(8.3)
Ne ($\times 10^9$/L)	<1.4	43(1.2)	9(0.6)	5(0.7)	2(0.6)		59(1.0)
	>6.6	122(3.4)	65(4.5)	16(2.3)	14(4.5)		217(3.6)
Eo ($\times 10^9$/L)	>0.5	778(22.0)	315(22.0)	160(22.9)	61(19.7)	22(32.4)	1336(22.1)
Mo ($\times 10^9$/L)	<0.12	190(5.4)	87(6.1)	26(3.7)	14(4.5)	1(1.5)	318(5.3)
	>1.00	146(4.1)	57(4.0)	21(3.0)	11(3.6)	2(2.9)	237(3.9)
Number of children measured		3539	1429	699	309	68	6044

[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.

Table 6B. Frequency of girls with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	6(0.2)		1(0.2)	2(0.8)	1(1.9)	10(0.2)
	>160	11(0.3)	4(0.3)				15(0.2)
WBC ($\times 10^9$/L)	<3.6	13(0.3)	3(0.2)	2(0.3)	1(0.4)		19(0.3)
	>11.0	86(2.3)	30(2.2)	12(2.1)	8(3.0)		136(2.3)
PLT ($\times 10^9$/L)	<100	2(0.1)					2(0.03)
	>440	39(1.0)	12(0.9)	4(0.7)	3(1.1)	1(1.9)	59(1.0)
MCV (fl)	<80	74(2.0)	34(2.5)	15(2.6)	4(1.5)		127(2.1)
	>100	1(0.03)	1(0.1)	1(0.2)			3(0.05)
Ly ($\times 10^9$/L)	<1.2	280(7.4)	72(5.4)	20(3.5)	8(3.0)	2(3.7)	382(6.3)
	>3.5	307(8.1)	126(9.4)	62(10.7)	20(7.5)	6(11.1)	521(8.6)
Ne ($\times 10^9$/L)	<1.4	43(1.1)	18(1.3)	5(0.9)	5(1.9)	2(3.7)	73(1.2)
	>6.6	171(4.5)	59(4.4)	28(4.9)	15(5.6)	2(3.7)	275(4.6)
Eo ($\times 10^9$/L)	>0.5	761(20.1)	282(21.0)	127(22.0)	47(17.7)	10(18.5)	1227(20.4)
Mo ($\times 10^9$/L)	<0.12	204(5.4)	94(7.0)	22(3.8)	15(5.6)	1(1.9)	336(5.6)
	>1.00	137(3.6)	41(3.1)	20(3.5)	11(4.1)	1(1.9)	210(3.5)
Number of children measured		3786	1343	577	266	54	6026

[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.

residence. The frequency of deviations in other parameters was insignificant and independent of the place of residence.

Table 5B shows the hematological deviations from the normal limits among girls in relation to the place of residence. The frequency of lymphocytosis and eosinophilia was approximately the same as that among boys and was independent of the place of residence. The frequency of deviations in other blood parameters was not significant.

Tables 6A and 6B show the deviations from the normal limits in boys and girls relative to ^{137}Cs specific activity, respectively. The highest frequency of deviations from the normal limits was for eosinophilia in boys (22.1%) and in girls (20.3%), but no difference was observed in the frequency among ^{137}Cs specific activity groups.

A statistically significant correlation was observed between eosinophil count and platelet, monocyte and lymphocyte counts but the respective correlation coefficients were small (Figures 19–21). The 95% confidence intervals of respective correlation coefficients were as follows: $0.09<\rho<0.12$ for eosinophil and platelet counts; $0.05<\rho<0.08$ for eosinophil and monocyte counts; and $0.04<\rho<0.08$ for eosinophil and lymphocyte counts.

One child (Klincy City) was found to have acute leukemia (myeloblastic type, AML) three months after screening. At the time of examination at the Sasakawa Laboratory, the child showed absolute lymphocytosis and eosinophilia, but at the time of re-examination by a pediatrician, no pathologic changes were found in the internal organs. This case will be presented next year as a case report.

Two children living in Klincy City were shown to have Pelger anomaly, but the state of their health is satisfactory.

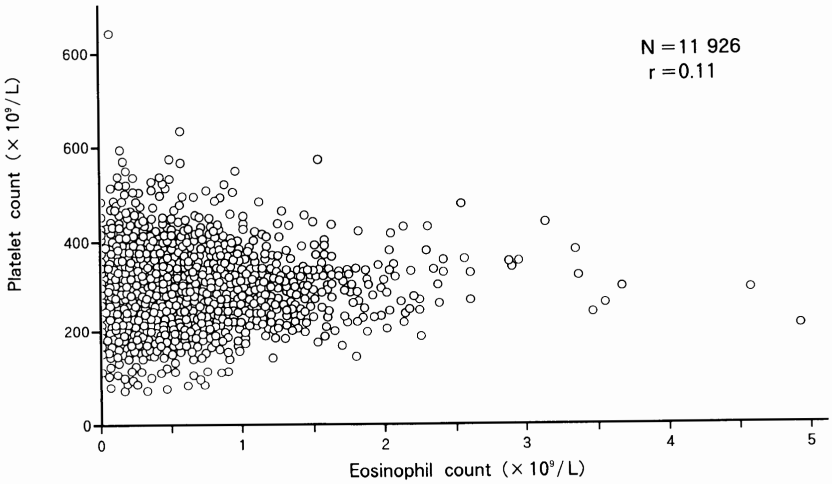

Figure 19. Scatter plots of eosinophil and platelet counts.

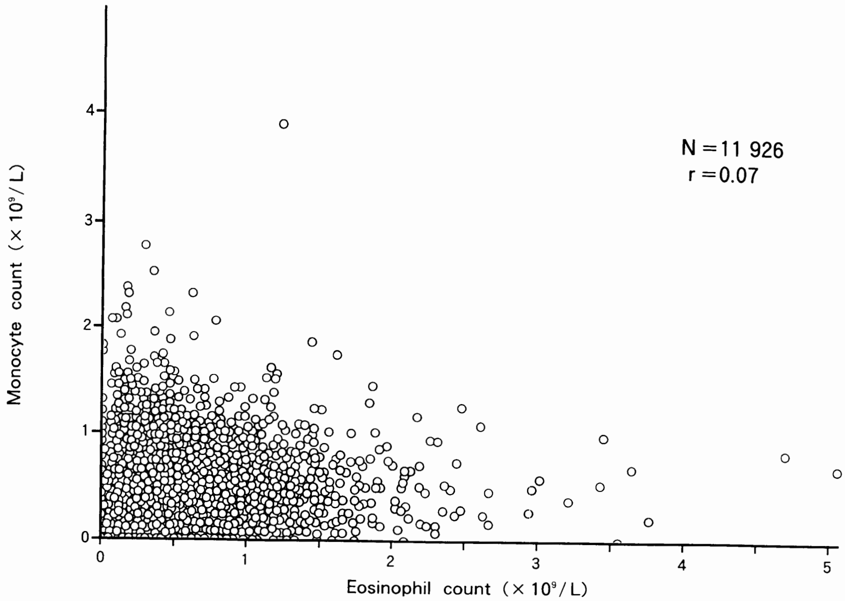

Figure 20. Scatter plots of eosinophil and monocyte counts.

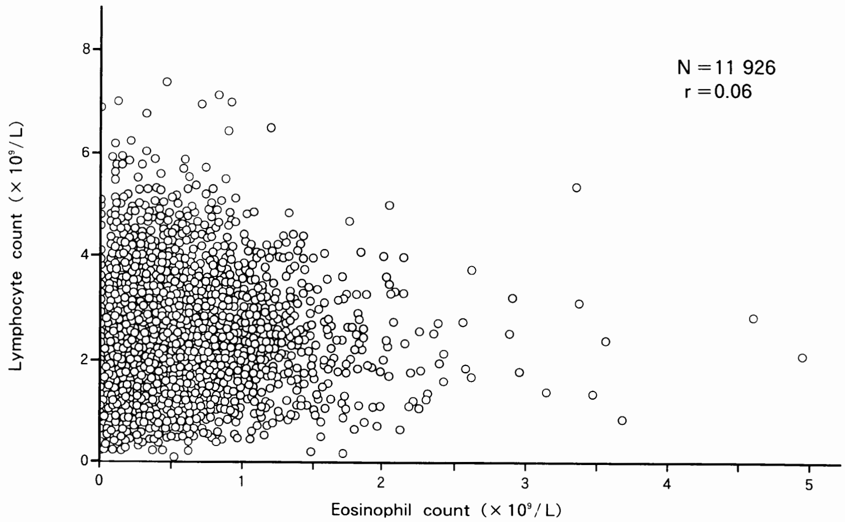

Figure 21. Scatter plots of eosinophil and lymphocyte counts.

4. Conclusions

The median of ^{137}Cs specific activity was 50 Bq/kg and no relationship between age and sex was observed. The median of ^{137}Cs specific activity in children living in a rayon with a contamination density exceeding 15 Ci/km^2 was higher than in other rayons.

A relationship was noted between the prevalence of goiter and place of residence. The prevalence of goiter was higher among children residing in areas with contamination densities exceeding 15 Ci/km^2. An increase in ^{137}Cs specific activity gave rise to an increase in goiter among boys.

A statistically significant correlation was observed between ^{137}Cs specific activity and the residual of thyroid volume after adjustment for age, height and weight, but the estimated correlation coefficient was very small and can be considered negligible.

One case of thyroid cancer was found in 1993 and one AML case was found in 1992.

A high frequency of elevated eosinophil count was registered during peripheral blood testing. Hematological abnormalities like anemia, leukocytosis, leukopenia, lymphocytosis, thrombocytopenia and thrombocytosis were observed in this project. But the prevalence of these abnormalities was not high and no correlation was observed between the prevalence and sex, age or ^{137}Cs specific activity in the body.

Results of the Examination of Children in Kiev Oblast

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

Avramenko A. I., Elagin V. V., Nikiforova N. V., Semoushina S. V., Grinko V. I., Nedozhdy A. V., Kochubey S.S.

1. Introduction

In 1991, on the initiative of the Sasakawa Memorial Health Foundation, a program of study was launched to investigate the health status of children affected by radiation as a result of the Chernobyl accident.

In Kiev Oblast (Province) the program is implemented by the "Sasakawa-Chernobyl" Diagnostic Center at the Regional Hospital No. 2.

The program of examinations includes: (1) collection of disease history and filling in of questionnaires; (2) anthropometric data; (3) measurement using a whole body counter; (4) ultrasonography of the thyroid; (5) general blood analyses; (6) blood serum testing for the presence of anti-thyroglobulin and anti-microsome antibodies; (7) determination of thyroid hormone levels; (8) determination of iodine and creatinine content in the urine; and (9) examination by a pediatrician.

2. Materials and Methods

2.1 Study subjects

The subjects under study are children born between 26 April 1976 and 26 April 1986 and residing in 15 rayons (districts) of Kiev Oblast and Kiev City. The geographical location of these rayons and their respective soil contamination levels are shown on the map (Figure 1).

2.2 Measurement of whole body ^{137}Cs concentration

The whole body ^{137}Cs concentration was measured using equipment manufactured by the Aloka Company and implementing a technique proposed by Japanese specialists. This method consists of the calibration of a gamma-spectrometer at peaks with standard ^{137}Cs and ^{60}Co sources, the measurement of the external background without phantoms, the measurement of the background using Lucite phantoms of various thicknesses (5, 10, 15, 20 cm), and the measurement of ^{137}Cs activity in the body of the patient. Duration of the measurement is 5 minutes. The information thus obtained is processed and recorded in a computer.

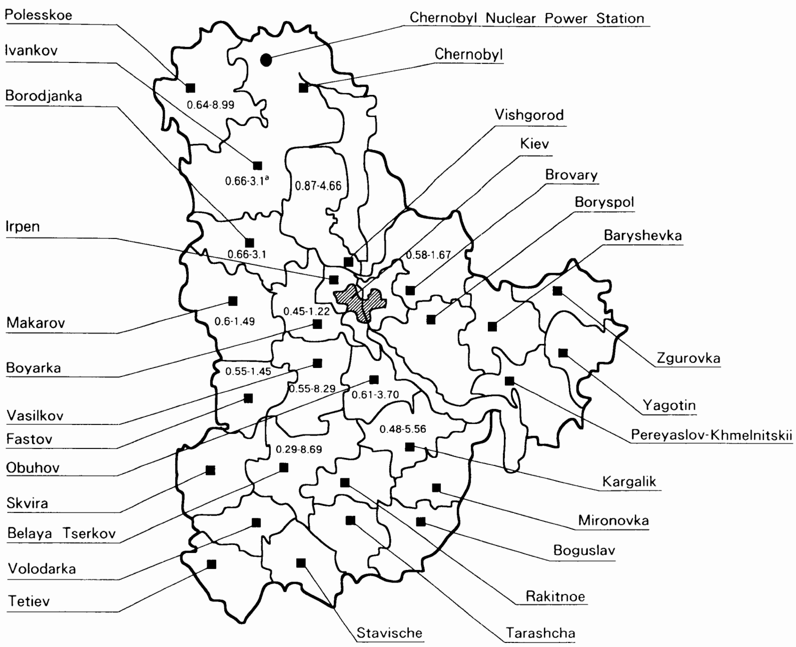

Figure 1. $^{137,134}Cs$ contamination levels (Ci/km^2) in the rayons of Kiev Oblast as measured in 1994. The black circle indicates the location of the Chernobyl Nuclear Power Station while the black squares (except one for Chernobyl) indicate the capitals of the respective rayons. For example, Vishgorod is the capital of Vishgorod*skii* Rayon.
[a] Minimum and maximum levels of contamination.

2.3 Thyroid examinations

Examination of the thyroid was performed in all children with an arch-scanning technique using an ALOKA-520 apparatus followed by the outlining of each image of the thyroid and automatic calculation of its volume using a computer. Determination of the presence of anti-thyroglobulin antibodies (ATG), anti-microsome antibodies (AMC) and hormone levels in the blood serum was carried out using an Amerlite Analyzer. Standard serum kits were used.

The following criteria were used to establish the diagnosis: the structure and volume of the thyroid, circulating levels of FT_4 and TSH, positive titers of ATG and AMC in serum, the hemogram and clinical symptoms. If deviations from normal were found in any of these criteria, the children in question were re-examined with an "Aloka-630" and further evaluated.

2.4 Hematological studies

Hematological studies involved the analysis of peripheral venous blood with Sysmex K-1000 and NE-7000 analyzers and the microscopic examination of blood smears. The staining of smears was performed by the Romanovsky-Grünwald technique using a "Sakura" device. Three smears (two stained and one fixed) were prepared for each child examined. Conclusions on hematological studies were drawn on the basis of laboratory data and the results of the examination of children.

3. Results

3.1 Study subjects

Table 1 shows the distribution of the children by sex, age and place of residence. A total of 10 699 children residing in 15 rayons of Kiev Oblast and Kiev City were examined during the study period. 823 (7.69%) of the chil-

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

Place of residence	Boys	Girls	Total
Vishgorodskii	522 (8, 11, 14)[b]	552 (9, 11, 14)	1074 (9, 11, 14)
Polesskii	409 (8, 10, 12)	414 (8, 10, 12)	823 (8, 10, 12)
Borodyanskii	171 (7, 9, 11)	200 (7, 9, 10)	371 (7, 9, 11)
Makarovskii	427 (8, 10, 12)	511 (8, 10, 13)	938 (8, 10, 13)
Ivankovskii	408 (7, 9, 11)	385 (7, 9, 10)	793 (7, 9, 10)
Kiev City	177 (9, 11, 13)	244 (9, 11, 14)	421 (9, 11, 14)
Irpenskii	382 (8, 10, 13)	430 (8, 10, 13)	812 (8, 10, 13)
Vasilkovskii	263 (9, 11, 14)	298 (10, 12, 14)	561 (10, 12, 14)
Baryshevskii	98 (9, 11, 13)	70 (10, 12, 13)	168 (9, 11, 13)
Svyatoshinskii	496 (10, 14, 15)	515 (10, 13, 15)	1011 (10, 14, 15)
Kagarlytskii	348 (10, 11, 14)	443 (10, 12, 14)	791 (10, 12, 14)
Fastovskii	218 (10, 12, 14)	395 (11, 13, 14)	613 (11, 13, 14)
Belotserkovskii	189 (10, 11, 13)	197 (9, 11, 13)	386 (9, 11, 13)
Brovarskii	482 (10, 12, 14)	504 (10, 12, 14)	986 (10, 12, 14)
Borispolskii	153 (9, 11, 14)	135 (10, 12, 14)	288 (9, 12, 14)
Obukhovskii	332 (9, 11, 13)	321 (9, 11, 14)	653 (9, 11, 14)
Total	5078 (9, 11, 14)	5621 (9, 12, 14)	10 699 (9, 12, 14)

[a] Subjects in the following rayons are not shown because the number wes less than 10: Boguslavskii, Taraschanskii, Zgurovskii, Mironovskii and Skvirskii.

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

dren live in territories with a ^{137}Cs contamination density from 0.5 to 40 Ci/km^2 (Polesskii Rayon), while 966 children were resettled from contaminated areas and 102 children were born from parents who participated in the clean-up after the Chernobyl disaster. Children aged 9–14 comprise the main group of the subjects examined. From the total number of children examined, 47.5% were boys and 52.5% girls.

3.2 Measurement of whole body ^{137}Cs concentration

Dosimetric measurement was carried out in the stationary department of the center and by a mobile laboratory at the place of residence of the children. Of the 10 699 children, 4767 (45%) were examined in the stationary department and 5932 (55%) at their place of residence. The staff implemented the techniques proposed by Japanese specialists and used equipment manufactured by the Aloka Company and donated by the Sasakawa Memorial Health Foundation.

Figure 2 shows the distribution of ^{137}Cs count per kg body weight (Bq/kg) by age and sex. The mean value of the ^{137}Cs specific activity in girls and boys was at the level of 30 Bq/kg. The dispersion of values of ^{137}Cs specific activity was characteristic in both sexes. The maximum value of ^{137}Cs specific activity

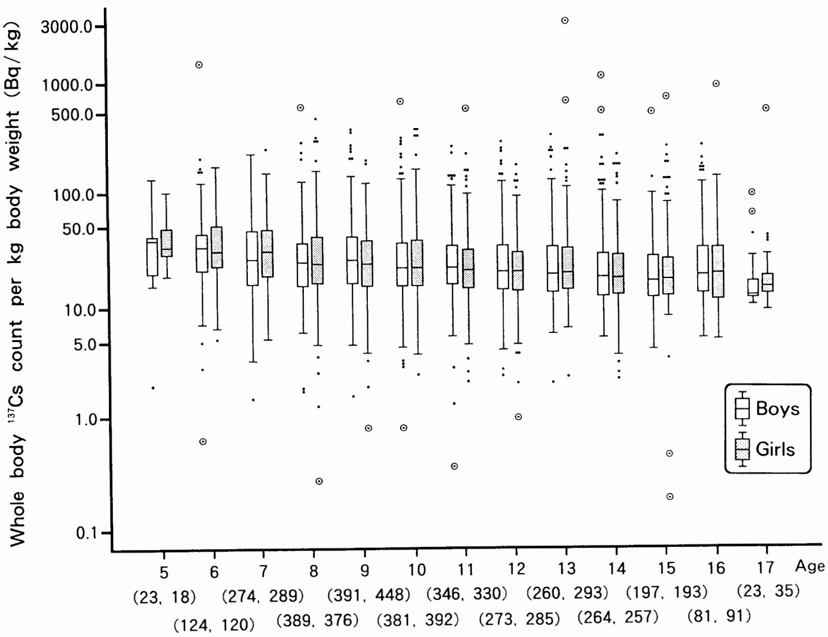

Figure 2. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by sex and age. Each pair presents the number of examined boys and girls. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, called "outside" and "far out," respectively.

was about 3200 Bq/kg. Differences between values of ^{137}Cs specific activity by age groups were not observed. Since the age groups including children aged 5 and 17 were the smallest, the dispersion of values in these groups was inadequate statistically.

Figure 3 shows the distributions of ^{137}Cs specific activity per kg body weight by place of residence. Children living in the northern rayons of Kiev Oblast located close to the Chernobyl zone, i.e. Polesskii, Vishgorodskii and Ivankovskii Rayons, have the largest ^{137}Cs concentration, ranging from 5 to 500 Bq/kg, whereas in the southern rayons the results ranged from 5 to 100 Bq/kg. Individual outliers of extreme values were mainly associated with visits of individual children from contaminated territories and with the consumption of mushrooms and game.

At the same time, no clear relationship was observed between the ^{137}Cs concentration level in the body and the prevalence of goiters in children, as shown in Figures 3 and 5. This situation requires additional analysis.

3.3 Thyroid examinations

Thyroid volume

Figure 4 shows the relationship between the thyroid volume and sex and age. The thyroid volume increased with age, and girls in the 11–15 year-old groups showed a larger thyroid volume than boys.

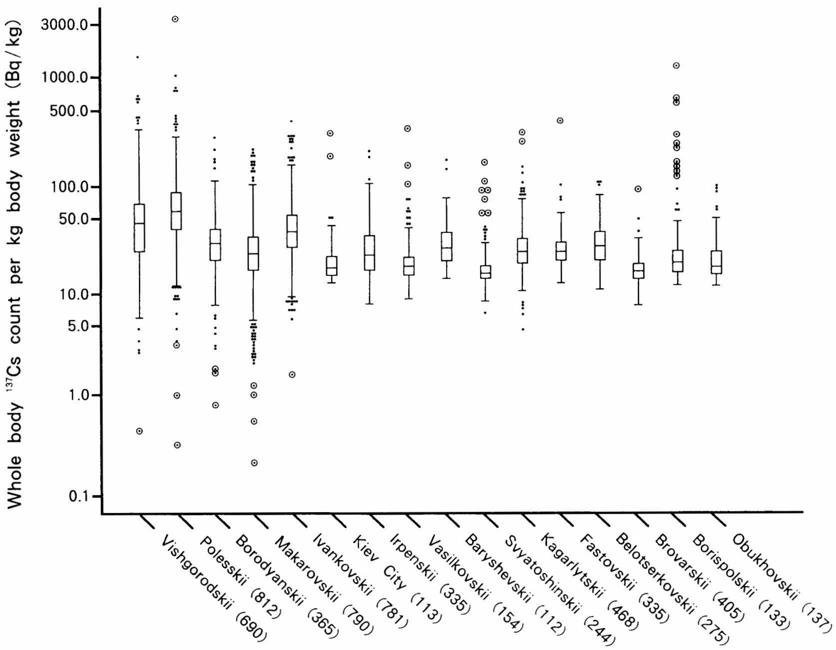

Figure 3. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by place of residence. The parenthetic entries refer to the number of examined children. See Figure 2 for details.

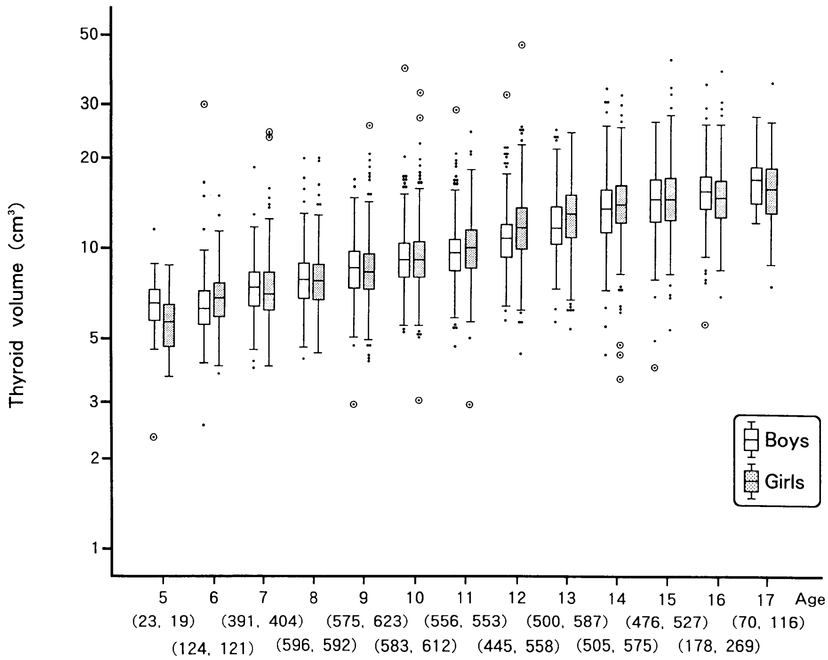

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

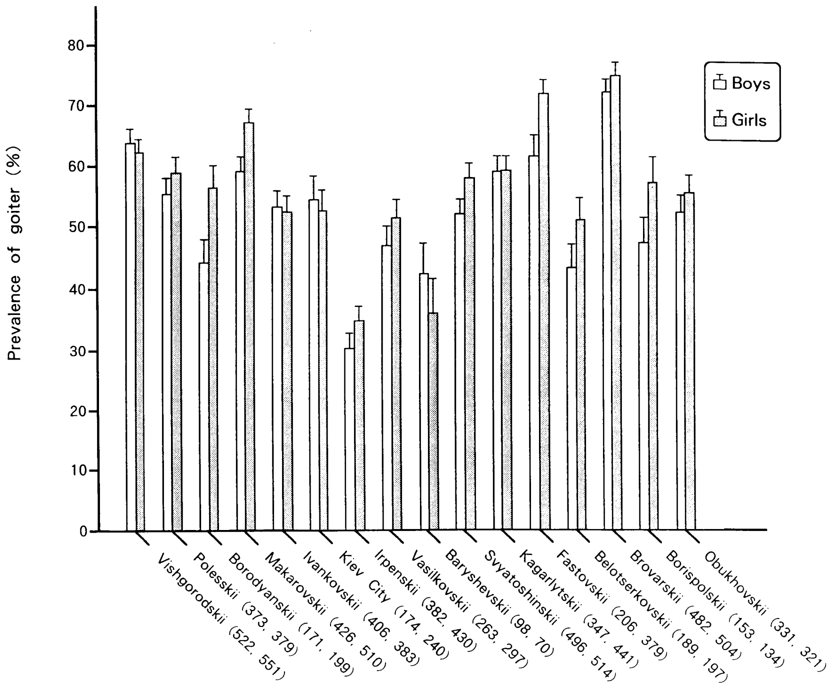

Figure 5. Prevalence of goiter by sex and place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

Figure 5 shows that the prevalence of goiter was highest in Brovarskii Rayon (77.5%) and lowest in Irpenskii Rayon (36.9%). The prevalence of goiter was higher in girls than in boys.

Children living in Brovarskii Rayon had a ^{137}Cs specific activity in the body averaging 161 Bq/kg. Attempts were made to establish a relationship between the prevalence of goiter and ^{137}Cs specific activity in the body.

As shown in Figure 6, the prevalence of goiter increased with increasing ^{137}Cs specific activity in the body, but because the group of children with ^{137}Cs specific activity exceeding 100 Bq/kg was very small, the accuracy of the data obtained was not reliable.

In our opinion, this high percentage of goiter among children residing in the Kiev Oblast is partially due to an inadequate ration of iodine in the body, which was proven by our investigations into urinary iodine content. This work was carried out in 1993. 516 urine samples from children in 12 rayons were analyzed. Although the permissible limit is 10 μg/dL, the mean content of urinary iodine was 3–8 μg/dL. The highest percentage of goiter was registered in Brovarskii Rayon (76/77) where children had an average iodine content of 3.4 μg/dL. It should be noted that the children experienced an iodine impact on the thyroid at the time of the accident. At the present time this dose is being retrospectively restored.

Hormones

Table 2 shows the prevalence of positive ATG and AMC titers relative to place of residence and sex. The table shows that the prevalence of positive

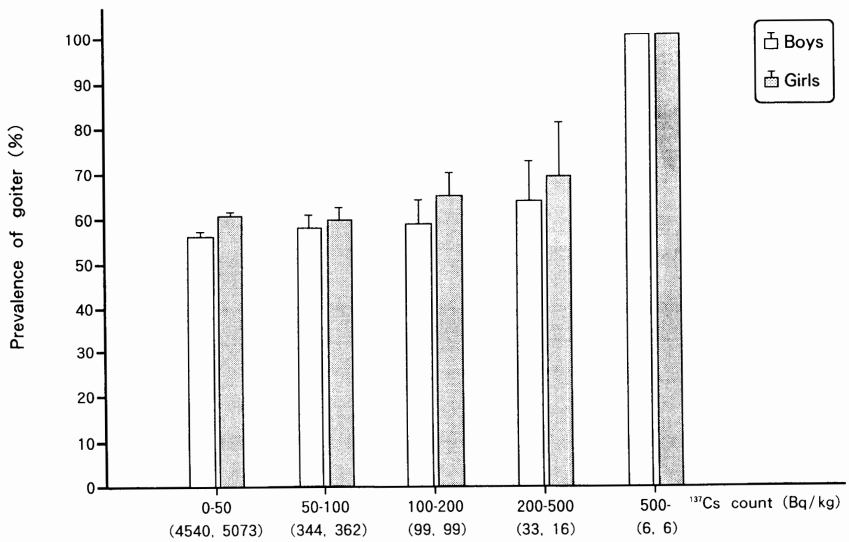

Figure 6. Prevalence of goiter by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 2 for the definition of goiter.

Table 2. Prevalence of positive ATG (anti-thyroglobulin antibody) and AMC (anti-microsome antibody) titers by sex and place of residence.[a]

Place of residence	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Vishgorodskii	1072	522	550	6 (0.6)	1 (0.2)	5 (0.9)	11 (1.0)	2 (0.4)	9 (1.6)
Polesskii	803	396	407	2 (0.2)	2 (0.5)	0	6 (0.7)	3 (0.8)	3 (0.7)
Borodyanskii	368	170	198	1 (0.3)	0	1 (0.5)	3 (0.8)	0	3 (1.5)
Makarovskii	934	427	507	8 (0.9)	4 (0.9)	4 (0.8)	6 (0.6)	1 (0.2)	5 (1.0)
Ivankovskii	790	406	384	3 (0.4)	1 (0.2)	2 (0.5)	2 (0.3)	1 (0.2)	1 (0.3)
Kiev City	420	176	244	13 (3.1)	3 (1.7)	10 (4.1)	21 (5.0)	4 (2.3)	17 (7.0)
Irpenskii	803	378	425	8 (1.0)	2 (0.5)	6 (1.4)	13 (1.6)	2 (0.5)	11 (2.6)
Vasilkovskii	559	263	296	0	0	0	0	0	0
Baryshevskii	168	98	70	4 (2.4)	0	4 (5.7)	6 (3.6)	2 (2.0)	4 (5.8)
Svyatoshinskii	1011	496	515	13 (1.3)	4 (0.8)	9 (1.7)	29 (2.9)	8 (1.6)	21 (4.1)
Kagarlytskii	790	347	443	6 (0.8)	0	6 (1.4)	15 (1.9)	3 (0.9)	12 (2.7)
Fastovskii	585	208	377	7 (1.2)	2 (1.0)	5 (1.3)	22 (3.8)	6 (2.9)	16 (4.2)
Belotserkovskii	364	175	189	3 (0.8)	1 (0.6)	2 (1.1)	4 (1.1)	1 (0.6)	3 (1.6)
Brovarskii	986	482	504	7 (0.7)	2 (0.4)	5 (1.0)	15 (1.5)	4 (0.8)	11 (2.2)
Borispolskii	288	153	135	3 (1.0)	0	3 (2.2)	6 (2.1)	1 (0.7)	5 (3.7)
Obukhovskii	653	332	321	5 (0.8)	1 (0.3)	4 (1.2)	10 (1.5)	2 (0.6)	8 (2.5)
Total	10 603	5032	5571	89 (0.8)	23 (0.5)	66 (1.2)	169 (1.6)	40 (0.8)	129 (2.3)

[a] Number of subjects with percentages in parentheses.

ATG and AMC titers was higher in girls and amounted to 3.5% of all the girls examined. This percentage was 1.25% in boys. ATG prevalence was approximately the same for all rayons and accounted for 0.1–0.2% (0.8% of all children). It was higher in girls than in boys. The prevalence of positive ATG titers in Baryshevskii Rayon was about 6%, but this result could not be considered reliable because a positive ATG titer was found in 4 of only 70 girls examined. The prevalence of positive AMC titers was slightly higher than

Table 3. Number of subjects with hypothyroidism and hyperthyroidism by sex and place of residence.

Place of residence	Number of subjects with measurement			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Vishgorodskii	1072	522	550	0	0	0	0	0	0
Polesskii	803	396	407	0	0	0	0	0	0
Borodyanskii	368	170	198	2	0	2	0	0	0
Makarovskii	934	427	507	0	0	0	0	0	0
Ivankovskii	790	406	384	0	0	0	0	0	0
Kiev City	420	176	244	0	0	0	2	0	2
Irpenskii	802	378	424	0	0	0	0	0	0
Vasilkovskii	558	263	295	0	0	0	0	0	0
Baryshevskii	168	98	70	0	0	0	0	0	0
Svyatoshinskii	1011	496	515	1	0	1	2	0	2
Kagarlytskii	789	347	442	0	0	0	3	1	2
Fastovskii	584	208	376	1	1	0	1	0	1
Belotserkovskii	364	175	189	0	0	0	1	0	1
Brovarskii	985	482	503	1	1	0	1	1	0
Borispolskii	288	153	135	0	0	0	0	0	0
Obukhovskii	653	332	321	0	0	0	0	0	0
Total	10 598	5032	5566	5	2	3	10	2	8

[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.

that of positive ATG titers and on average the frequency was 1.6%. It was higher in girls than in boys. The highest prevalence was observed in Kiev City (5%).

The number of children with hypothyroidism was 5 (2 boys and 3 girls) and the number of children with hyperthyroidism was 10 (2 boys and 8 girls) (Table 3).

Figure 7 shows the prevalence of positive ATG titers with regard to ^{137}Cs concentration level in the body for boys and girls. All children with positive ATG titers in the serum had a ^{137}Cs concentration level less than 50 Bq/kg. No relationship was found.

Figure 8 shows the prevalence of positive AMC titers relative to ^{137}Cs concentration level in boys and girls. All children with positive AMC titers had ^{137}Cs specific activity less than 50 Bq/kg. AMC was more frequent in boys.

Table 4 shows all thyroid abnormalities. Autoimmune thyroiditis was diagnosed in 242 children, amounting to 2.2% of the number of children examined. The diagnosis was established on the basis of a complex examination of the children (ultrasonography of the thyroid, determination of the hormone level and the presence of antibodies in the blood serum, clinical symptoms). Thyroid carcinoma was found in 3 girls (9, 9 and 6 years of age) and in 1 boy aged 9. Surgery was performed and the diagnoses were confirmed histologically.

The radiation burden on the thyroid in these children was between 50 and 200 cGy.

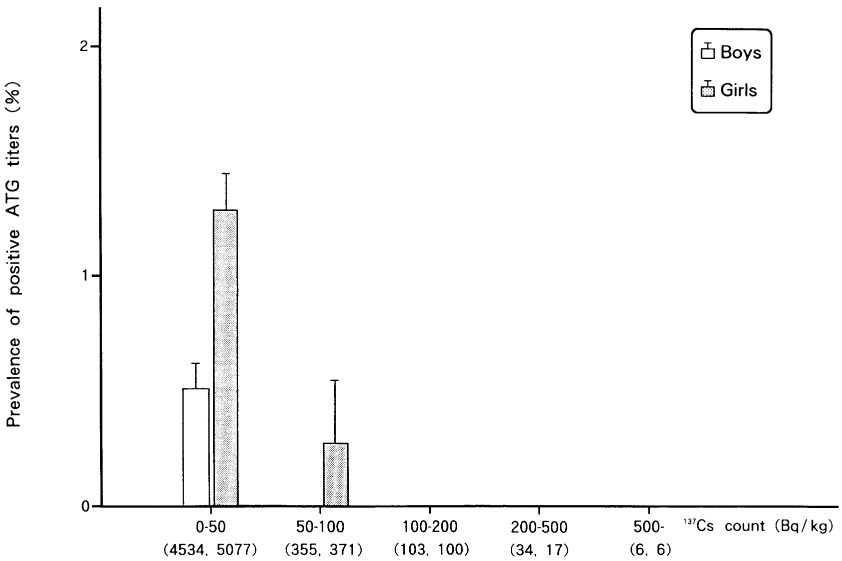

Figure 7. Prevalence of positive ATG titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

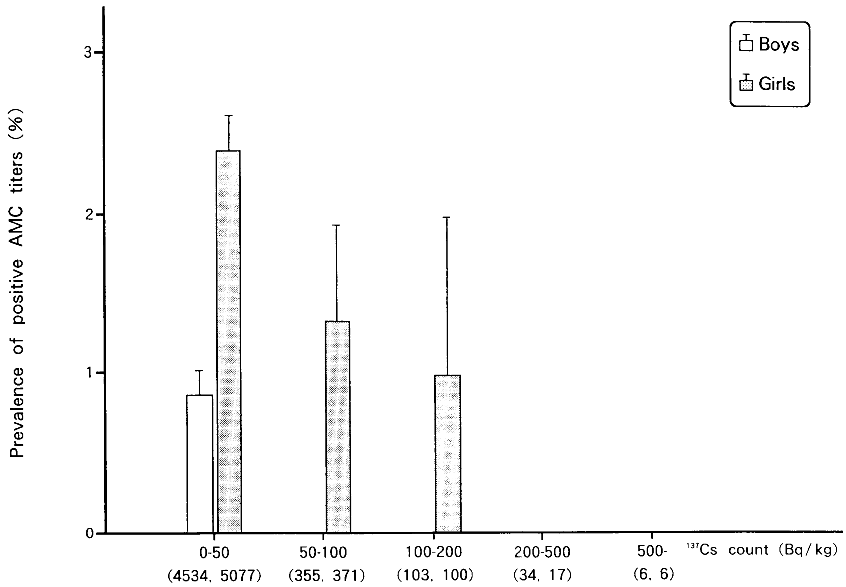

Figure 8. Prevalence of positive AMC titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

Table 4. Subjects with thyroid abnormalities by sex and place of residence.

Place of residence	Number of subjects examined		Diagnosis						
			Nodular lesion		Cystic lesion		Abnormal echogenity	Anomaly	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys and Girls	Boys	Girls
Vishgorodskii	522	551	0	1	0	0	26	0	0
Polesskii	373	379	0	0	0	0	5	0	0
Borodyanskii	171	199	0	0	0	0	3	0	0
Makarovskii	426	510	1	1	0	0	34	0	0
Ivankovskii	406	383	0	0	0	0	1	0	0
Kiev City	174	240	0	1	0	1	0	0	0
Irpenskii	382	430	0	0	0	0	8	0	0
Vasilkovskii	263	297	0	1	0	0	19	0	0
Baryshevskii	98	70	0	1	0	0	3	0	0
Svyatoshinskii	496	514	1	1	1	5	23	0	0
Kagarlytskii	347	441	0	0	1	0	8	0	0
Fastovskii	206	379	1	1	0	0	21	0	0
Belotserkovskii	189	197	0	0	1	0	13	0	0
Brovarskii	482	504	0	2	0	0	35	0	0
Borispolskii	153	134	0	0	0	0	12	0	0
Obukhovskii	331	321	0	3	2	1	31	0	0
Total	5022	5556	3	12	5	7	242	0	0

3.4 Hematological studies

The mean values of all parameters of hematological studies on the children were within normal range. No hematological malignancy has been found in the past two and a half years.

As shown in Figure 9, the trend toward an increase in Hb level with age in both boys and girls was still found last year. In the age group from 14 to 17, the increase in Hb level was more pronounced in boys than in girls of the same age, which is attributable to hormonal changes during puberty. A reduction in Hb level below normal was noted in both boys and girls in Svyatoshinskii Rayon. However, a reduction in Hb level below 100 g/L with a decrease in MCV was not found.

Figure 10 shows the increase in MCV level with age in both boys and girls. In the group of girls from 14 to 17 years of age, an increase in MCV was observed despite the definite reduction in Hb level. In this age group, 8 girls and 4 boys showed an MCV level above normal limits, although anemia ($Hb < 110$ g/dL) was found (cf. Tables 5A and 5B, pp. 86–89). A reduction in MCV accompanied by the development of anemia was found in 5 boys and 8 girls.

Figure 11 shows that the PLT was normal in most of the children examined. A PLT below normal limits was found in 2 boys and 4 girls. An additional study of the medical records of these children revealed one girl from Irpenskii

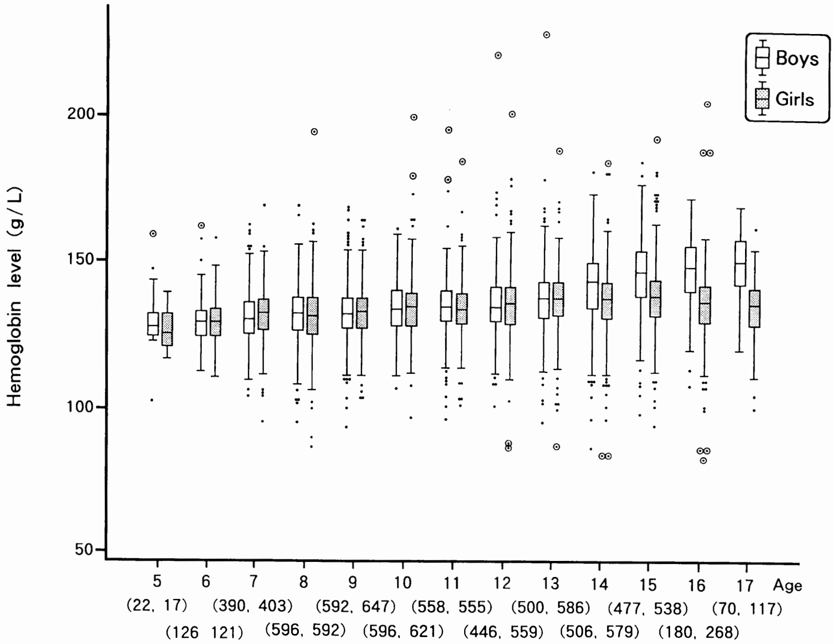

Figure 9. The box-and-whisker plots of hemoglobin level by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

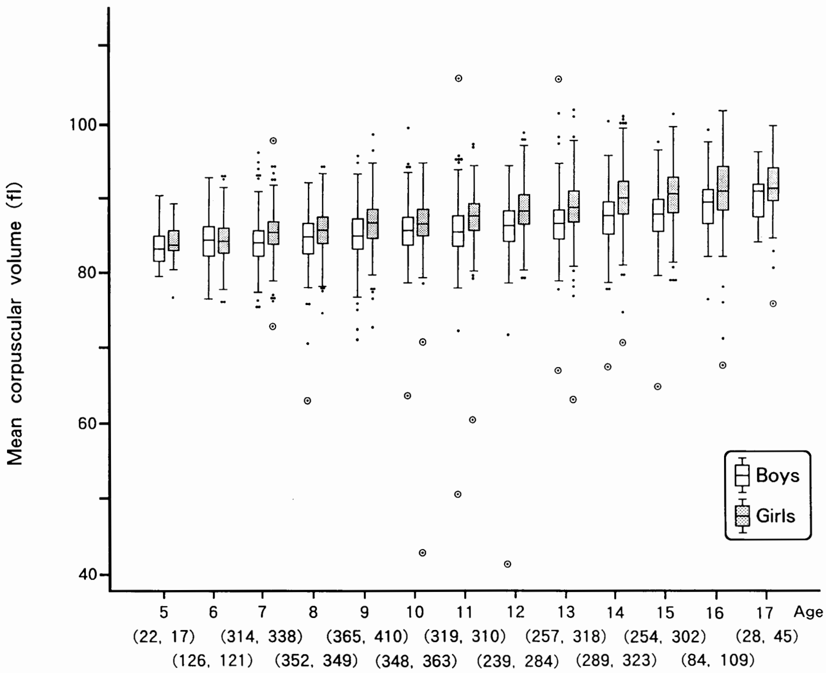

Figure 10. The box-and-whisker plots of mean corpuscular volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

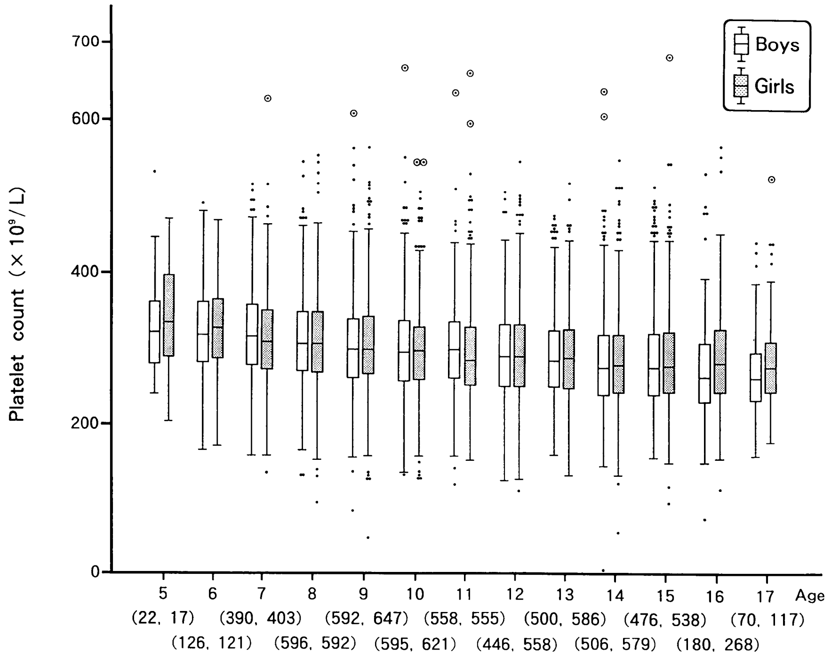

Figure 11. The box-and-whisker plots of platelet count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

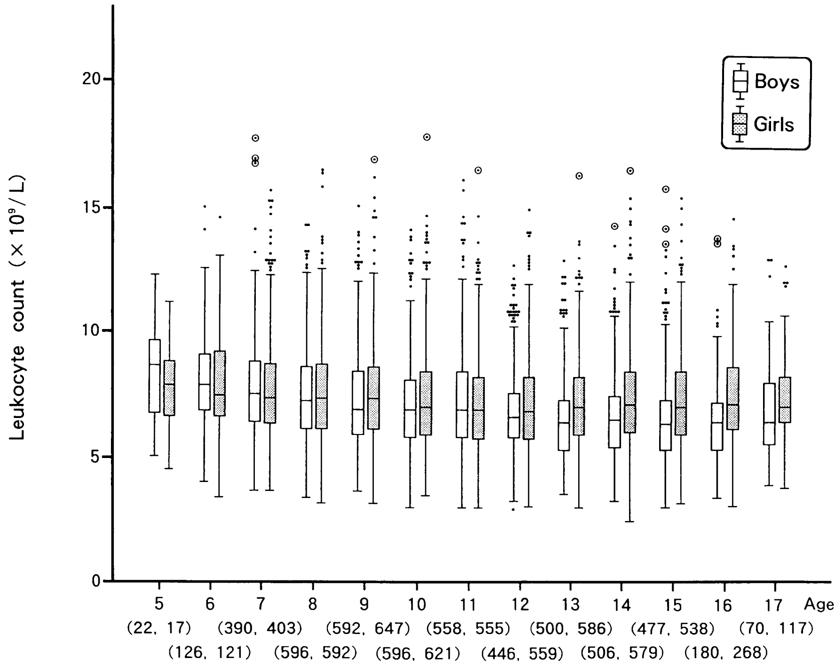

Figure 12. The box-and-whisker plots of leukocyte count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

Rayon who had been under observation for thrombophlebitic splenomegaly with hypersplenism for 4 years (at present the child has undergone a splenectomy) and one boy from Svyatoshinskii Rayon who is under observation for a thrombocytopenic purpura. Cases of increased PLT were noted in 120 boys and 120 girls (cf. Tables 5A and 5B, pp. 86–89). An analysis of these cases with regard to eosinophil count was made and the results are discussed below.

Figure 12 shows that the WBC in most of the children was within normal range relative to age and sex. An increase in WBC was found in 230 boys and 244 girls. No significant differences were found by place of residence or age. No seasonal differences were found (the warm and cold periods of the year). A reduction in WBC below normal was noted in 20 girls and 47 boys (cf. Tables 5A and 5B, pp. 86–89). A reduction in WBC below 3.1×10^9/L was registered in 5 girls and 4 boys. Two girls in Vishgorodskii and Irpenskii Rayons showed a considerable decrease in WBC (less than 1.6 and 2.5×10^9/L). They were diagnosed and treated by local doctors before the examination at the Sasakawa-Chernobyl Diagnostic Center.

The largest number of deviations was found in the eosinophil count. The data obtained using the Sysmex NE-7000 hemoanalyzer were virtually the same as those obtained from blood smear microscopy. An increase in eosinophil count was found in 801 boys and 885 girls.

The correlation between eosinophil count and platelet, monocyte and lymphocyte counts was studied (Figures 13–15). A significant correlation was observed in all cases but the correlation coefficients were not large, especially for eosinophil and platelet counts: 95% confidence intervals of the respective correlation coefficients were $0.06<\rho<0.10$ for eosinophil and platelet counts; $0.15<\rho<0.19$ for eosinophil and monocyte counts; and $0.22<\rho<0.26$ for eosinophil and lymphocyte counts.

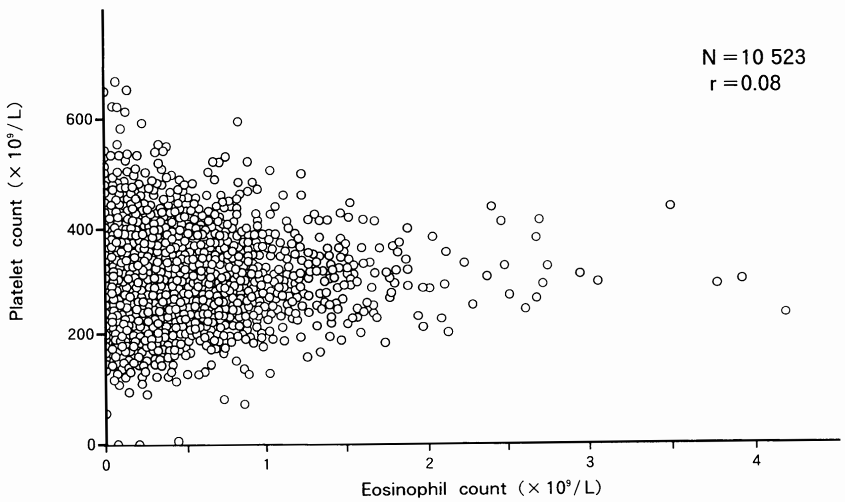

Figure 13. Scatter plots of eosinophil and platelet counts.

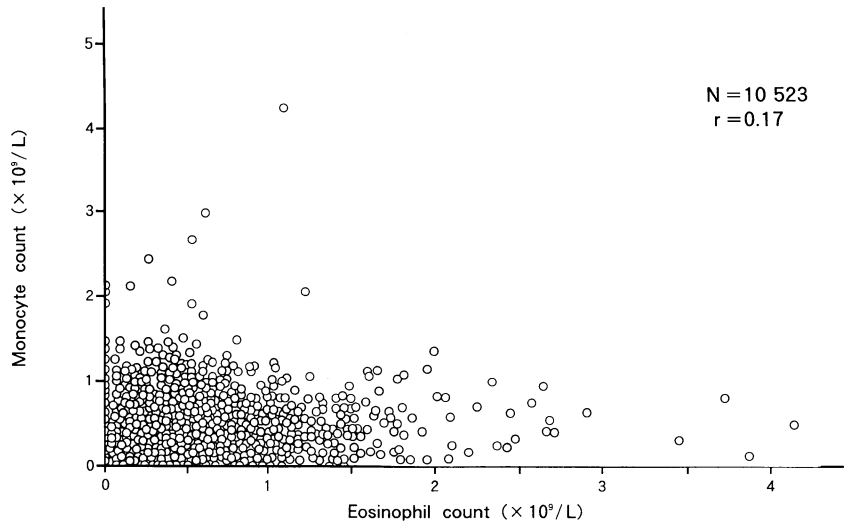

Figure 14. Scatter plots of eosinophil and monocyte counts.

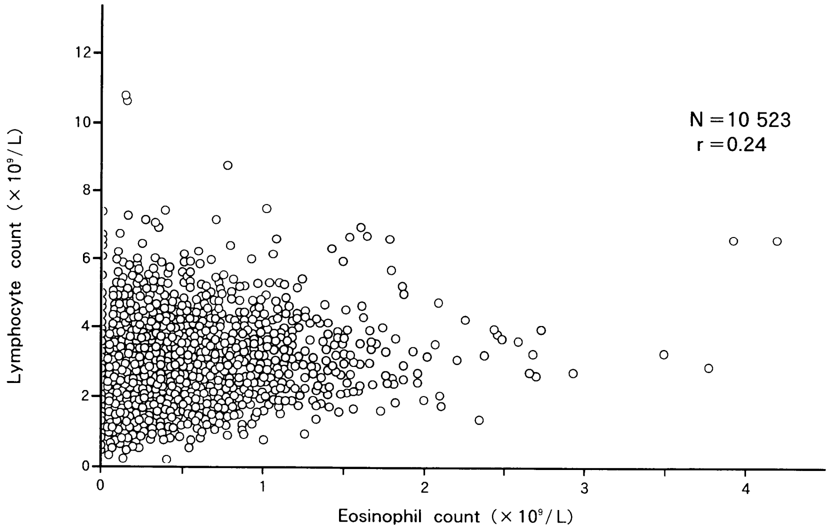

Figure 15. Scatter plots of eosinophil and lymphocyte counts.

The relationship between eosinophilia and skin diseases, asthma, the presence of domestic animals and seasonal factors was studied. No significant association was observed either between eosinophilia and skin diseases or asthma: the prevalence of eosinophilia was 18.3% (88/481) and 20.8% (656/3155) in children with and without a history of skin diseases, respectively, with an estimated odds ratio (±standard error) of 0.85±0.11, and the prevalence of eosinophilia was 21.7% (26/120) and 20.4% (717/3516) in children with and without a history of asthma, respectively, with an estimated odds ratio

Table 5A. Frequency of boys with hematological

Blood analysis		Place of						
Item (unit)[c]	Abnormality criteria	VIS	POL	BOR	MAK	IVN	KIE	IRP
Hb (g/L)	<110	3 (0.6)	2 (0.5)	1 (0.6)		2 (0.5)	1 (0.6)	1 (0.3)
	>180	1 (0.2)						
WBC ($\times 10^9$/L)	<3.8	9 (1.7)	1 (0.3)			1 (0.2)	4 (2.3)	1 (0.3)
	>10.6	19 (3.6)	37 (9.3)	10 (5.9)	21 (4.9)	27 (6.6)	5 (2.8)	15 (3.9)
PLT ($\times 10^9$/L)	<100				1 (0.2)			
	>440	16 (3.1)	10 (2.5)	7 (4.1)	11 (2.6)	8 (2.0)	5 (2.8)	4 (1.0)
MCV (fl)	<80	14 (2.7)	16 (4.0)	13 (7.6)	21 (4.9)	16 (3.9)	2 (1.1)	7 (1.8)
	>100							
Ly ($\times 10^9$/L)	<1.2	18 (3.4)	4 (1.0)	1 (0.6)	13 (3.0)	3 (0.7)	11 (6.3)	14 (3.7)
	>3.5	45 (8.6)	84 (21.2)	19 (11.2)	62 (14.5)	98 (24.1)	19 (10.8)	57 (15.0)
Ne ($\times 10^9$/L)	<1.4	15 (2.9)	2 (0.5)	1 (0.6)	1 (0.2)		5 (2.8)	6 (1.6)
	>6.6	26 (5.0)	25 (6.3)	4 (2.4)	25 (5.9)	20 (4.9)	5 (2.8)	18 (4.7)
Eo ($\times 10^9$/L)	>0.5	76 (14.6)	106 (26.8)	38 (22.4)	112 (26.2)	81 (19.9)	17 (9.7)	53 (13.9)
Mo ($\times 10^9$/L)	<0.12	39 (7.5)	50 (12.6)	34 (20.0)	28 (6.6)	96 (23.6)	12 (6.8)	22 (5.8)
	>1.00	24 (4.6)	12 (3.0)	4 (2.4)	12 (2.8)	4 (1.0)	2 (1.1)	4 (1.0)
Number of children measured		522	396	170	427	407	176	381

[a] Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of sub-
[b] VIS, Vishgorodskii; POL, Polesskii; BOR, Borodyanskii; MAK, Makarovskii; IVN, Ivankovskii; Kagarlytskii; FAS, Fastovskii; BEL, Belotserkovskii; BRO, Brovarskii; BRP, Borispolskii; OBU,
[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume;
[d] One boy in Skvirskii is included.
[e] One boy in Mironovskii is included.

($\pm$standard error) of 1.08 ± 0.24. On the other hand, a significant correlation between eosinophilia and the presence of domestic animals and a significant seasonal difference in the prevalence of eosinophilia were observed: the prevalence of eosinophilia was 22.4% (651/2901) and 13.6% (1035/7623) in children with and without domestic animals, respectively, with an estimated odds ratio ($\pm$standard error) of 1.84 ± 0.10, and the prevalence of eosinophilia was higher in children examined in autumn (540/3234 or 16.7%) than in those examined in spring (478/3284 or 14.6%), resulting in an estimated odds ratio ($\pm$standard

abnormalities by place of residence.[a]

residence[b]									Total
VAS	BSH	SVY	KAG	FAS	BEL	BRO	BRP	OBU	
1 (0.4)		12 (2.4)	1 (0.3)	2 (0.9)		5 (1.0)	2 (1.3)	4 (1.2)	37 (0.7)
1 (0.4)		1 (0.2)						2 (0.6)	5 (0.1)
		4 (0.8)	3 (0.9)	2 (0.9)	2 (1.1)	4 (0.8)	2 (1.3)	14 (4.2)	47 (0.9)
16 (6.1)	5 (5.2)	6 (1.2)	23 (6.6)	17 (7.8)	4 (2.1)	10 (2.1)	5 (3.3)	10 (3.0)	230 (4.6)
			1 (0.3)						2 (0.04)
9 (3.4)	1 (1.0)	6 (1.2)	6 (1.7)		3 (1.6)	11 (2.3)	5 (3.3)	18 (5.4)	120 (2.4)
2 (0.8)		2 (0.4)		1 (0.5)	7 (3.7)			3 (0.9)	104 (2.1)
				2 (0.9)	2 (1.1)				4 (0.1)
2 (0.8)		38 (7.7)	8 (2.3)	9 (4.1)	5 (2.7)	8 (1.7)	8 (5.2)	49 (14.8)	191 (3.8)
13 (4.9)	16 (16.5)	35 (7.1)	86 (24.7)	39 (17.9)	23 (12.2)	17 (3.5)	11 (7.2)	26 (7.8)	650 (12.8)
		12 (2.4)	2 (0.6)	1 (0.5)	5 (2.7)	4 (0.8)	1 (0.7)	7 (2.1)	62 (1.2)
22 (8.4)	7 (7.2)	16 (3.2)	28 (8.0)	16 (7.3)	5 (2.7)	10 (2.1)	6 (3.9)	17 (5.1)	251[d] (5.0)
52 (19.8)	18 (18.6)	33 (6.7)	66 (19.0)	30 (13.8)	12 (6.4)	66 (13.7)	19 (12.4)	21 (6.3)	801[e] (15.8)
1 (0.4)	11 (11.3)	49 (9.9)	40 (11.5)	20 (9.2)	12 (6.4)	5 (1.0)	7 (4.6)	36 (10.8)	462 (9.1)
2 (0.8)	2 (2.1)	4 (0.8)	2 (0.6)	2 (0.9)	1 (0.5)	3 (0.6)		5 (1.5)	83 (1.6)
263	97	496	348	218	188	482	153	332	5059

jects with abnormalities.
KIE, Kiev City; IRP, Irpenskii; VAS, Vasilkovskii; BSH, Baryshevskii; SVY, Svyatoshinskii; KAG, Obukhovskii.
Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

error) of 1.18±0.06. It is too early, however, to draw final conclusions because the groups of children differed by place of residence, age and season of examination, and the information on skin diseases and asthma could not be regarded as accurate (only data from questionnaires were used and these were not confirmed by medical records or physicians). We associate the high prevalence of immunized lymphocytes, neutrophils with toxic granules and monocytosis with both the impact of low radiation doses and the high level of gastrointestinal diseases and respiratory ailments complicated by allergological anamnesis.

Table 5B. Frequency of girls with hematological

Blood analysis		Place of						
Item (unit)[c]	Abnormality criteria	VIS	POL	BOR	MAK	IVN	KIE	IRP
Hb (g/L)	<110	1 (0.2)	1 (0.2)	1 (0.5)	3 (0.6)	2 (0.5)	3 (1.2)	
	>160	10 (1.8)	1 (0.2)	1 (0.5)	3 (0.6)	1 (0.3)	3 (1.2)	2 (0.5)
WBC ($\times 10^9$/L)	<3.6	1 (0.2)				1 (0.3)	2 (0.8)	1 (0.2)
	>11.0	28 (5.1)	32 (7.8)	7 (3.5)	16 (3.1)	24 (6.3)	4 (1.7)	9 (2.1)
PLT ($\times 10^9$/L)	<100				1 (0.2)			1 (0.2)
	>440	22 (4.0)	10 (2.5)	7 (3.5)	5 (1.0)	4 (1.0)	6 (2.5)	6 (1.4)
MCV (fl)	<80	7 (1.3)	6 (1.5)	5 (2.5)	7 (1.4)	7 (1.8)	3 (1.2)	2 (0.5)
	>100	1 (0.2)						
Ly ($\times 10^9$/L)	<1.2	29 (5.3)	4 (1.0)	1 (0.5)	9 (1.8)	6 (1.6)	15 (6.2)	7 (1.6)
	>3.5	61 (11.1)	89 (21.8)	30 (15.1)	78 (15.4)	94 (24.5)	28 (11.6)	72 (16.8)
Ne ($\times 10^9$/L)	<1.4	8 (1.5)			4 (0.8)	2 (0.5)	10 (4.1)	4 (0.9)
	>6.6	56 (10.2)	28 (6.9)	10 (5.0)	31 (6.1)	30 (7.8)	9 (3.7)	15 (3.5)
Eo ($\times 10^9$/L)	>0.5	75 (13.6)	83 (20.3)	58 (29.1)	125 (24.6)	96 (25.0)	21 (8.7)	69 (16.1)
Mo ($\times 10^9$/L)	<0.12	52 (9.5)	52 (12.7)	43 (21.6)	36 (7.1)	75 (19.5)	16 (6.6)	27 (6.3)
	>1.00	14 (2.5)	12 (2.9)	5 (2.5)	11 (2.2)	5 (1.3)		5 (1.2)
Number of children measured		550	408	199	508	384	242	428

[a] Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of sub-
[b] VIS, Vishgorodskii; POL, Polesskii; BOR, Borodyanskii; MAK, Makarovskii; IVN, Ivankovskii; Kagarlytskii; FAS, Fastovskii; BEL, Belotserkovskii; BRO, Brovarskii; BRP, Borispolskii; OBU,
[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume;
[d] Two girls in Taraschanskii and Zgurovskii are included
[e] One girl in Skvirskii is included.

Tables 5A and 5B show the frequency of subjects with hematological abnormalities by place of residence. No relationship was found.

Tables 6A and 6B show that the major portion of deviations from normal hematological limits was in the range of ^{137}Cs specific activity concentration from 0 to 50 Bq/kg. No statistically significant increase was observed in the frequency of deviations in relation to ^{137}Cs concentration.

abnormalities by place of residence.[a]

residence[b]									Total
VAS	BSH	SVY	KAG	FAS	BEL	BRO	BRP	OBU	
2 (0.7)		19 (3.7)	4 (0.9)	2 (0.5)		4 (0.8)	2 (1.5)	7 (2.2)	51 (0.9)
1 (0.3)	1 (1.4)	14 (2.7)	2 (0.5)	1 (0.3)		1 (0.2)	1 (0.7)	14 (4.4)	53 (1.0)
		3 (0.6)	1 (0.2)		1 (0.5)		1 (0.7)	9 (2.8)	20 (0.4)
34 (11.4)	5 (7.1)	12 (2.3)	29 (6.5)	18 (4.6)	7 (3.6)	8 (1.6)	5 (3.7)	7 (2.2)	245 (4.4)
		1 (0.2)				1 (0.2)			4 (0.1)
9 (3.0)	3 (4.3)	8 (1.6)	6 (1.4)		1 (0.5)	8 (1.6)	2 (1.5)	24 (7.5)	120 (2.2)
1 (0.3)		1 (0.2)	2 (0.5)	3 (0.8)	6 (3.0)			2 (0.6)	52 (0.9)
2 (0.7)		1 (0.2)		4 (1.0)					8 (0.1)
1 (0.3)	2 (2.9)	68 (13.2)	19 (4.3)	15 (3.8)	4 (2.0)	14 (2.8)	11 (8.1)	47 (14.6)	252 (4.5)
20 (6.7)	9 (12.9)	29 (5.6)	102 (23.0)	54 (13.7)	37 (18.8)	19 (3.8)	9 (6.7)	24 (7.5)	755 (13.5)
		9 (1.7)	1 (0.2)	1 (0.3)	2 (1.0)	2 (0.4)	1 (0.7)	6 (1.9)	50[d] (0.9)
57 (19.1)	8 (11.4)	39 (7.6)	47 (10.6)	46 (11.7)	8 (4.1)	19 (3.8)	5 (3.7)	30 (9.3)	439 (7.8)
32 (10.7)	15 (21.4)	39 (7.6)	76 (17.2)	51 (12.9)	22 (11.2)	82 (16.3)	13 (9.6)	26 (8.1)	885[e] (15.8)
1 (0.3)	4 (5.7)	54 (10.5)	53 (12.0)	46 (11.7)	6 (3.0)	11 (2.2)	15 (11.1)	28 (8.7)	520[e] (9.3)
		1 (0.2)	2 (0.5)	2 (0.5)	1 (0.5)	4 (0.8)	2 (1.5)	1 (0.3)	65 (1.2)
298	70	515	443	394	197	503	135	321	5602

jects with abnormalities.

KIE, Kiev City; IRP, Irpenskii; VAS, Vasilkovskii; BSH, Baryshevskii; SVY, Svyatoshinskii; KAG, Obukhovskii.

Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

Table 6A. Frequency of boys with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	35(0.8)	2(0.6)				37(0.7)
	>180	5(0.1)					5(0.1)
WBC ($\times 10^9$/L)	<3.8	46(0.1)		1(1.0)			47(0.9)
	>10.6	198(4.3)	18(5.1)	11(10.7)	3(8.8)		230(4.5)
PLT ($\times 10^9$/L)	<100	2(0.04)					2(0.04)
	>440	111(2.4)	7(2.0)		2(5.9)		120(2.4)
MCV (fl)	<80	81(1.8)	19(5.3)	3(2.9)	1(2.9)		104(2.1)
	>100	4(0.1)					4(0.1)
Ly ($\times 10^9$/L)	<1.2	184(4.0)	6(1.7)	1(1.0)			191(3.8)
	>3.5	559(12.3)	63(17.7)	22(21.4)	5(14.7)	1(16.7)	650(12.8)
Ne ($\times 10^9$/L)	<1.4	60(1.3)		2(1.9)			62(1.2)
	>6.6	227(5.0)	15(4.2)	8(7.8)	1(2.9)		251(5.0)
Eo ($\times 10^9$/L)	>0.5	694(15.2)	73(20.5)	25(24.3)	8(23.5)	1(16.7)	801(15.8)
Mo ($\times 10^9$/L)	<0.12	395(8.7)	43(12.1)	15(14.6)	9(26.5)		462(9.1)
	>1.00	59(1.3)	14(3.9)	6(5.8)	3(8.8)	1(16.7)	83(1.6)
Number of children measured		4560	356	103	34	6	5059

[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.

Table 6B. Frequency of girls with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	47(0.9)	2(0.5)		1(5.9)	1(16.7)	51(0.9)
	>160	51(1.0)		2(2.0)			53(0.9)
WBC ($\times 10^9$/L)	<3.6	19(0.4)	1(0.3)				20(0.4)
	>11.0	221(4.3)	18(4.8)	4(4.0)	1(5.9)		244(4.4)
PLT ($\times 10^9$/L)	<100	4(0.1)					4(0.1)
	>440	110(2.2)	8(2.1)	2(2.0)			120(2.2)
MCV (fl)	<80	44(0.9)	8(2.1)				52(0.9)
	>100	8(0.2)					8(0.1)
Ly ($\times 10^9$/L)	<1.2	241(4.7)	10(2.7)	1(1.0)			252(4.5)
	>3.5	664(13.0)	71(19.0)	17(17.0)	2(11.8)	1(16.7)	755(13.5)
Ne ($\times 10^9$/L)	<1.4	47(0.9)	2(0.5)		1(5.9)		50(0.9)
	>6.6	414(8.1)	20(5.4)	4(4.0)	1(5.9)		439(7.8)
Eo ($\times 10^9$/L)	>0.5	794(15.6)	71(19.0)	16(16.0)	2(11.8)	2(33.3)	885(15.8)
Mo ($\times 10^9$/L)	<0.12	452(8.9)	55(14.7)	10(10.0)	3(17.6)		520(9.3)
	>1.00	51(1.0)	8(2.1)	5(5.0)		1(16.7)	65(1.2)
Number of children measured		5106	373	100	17	6	5602

[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.

4. Conclusion

We investigated the thyroid in more than 10 000 children residing in the affected zones and found a high prevalence of goiter (62.03%) with characteristic frequent exacerbations of localized rhinopharyngeal infections and general dental caries. Goiter endemy in children of Kiev Oblast may be related both to the impact of radiation due to a high iodine load at the time of the accident (since the Kiev Oblast is in the epicenter) and to an inadequate supply of iodine as proven by our studies on urinary iodine content.

A considerable number of children showed an increase or a decrease in blood parameters, particularly in the differential leukocyte count. Some abnormal cells were observed during investigation of blood smears using a microscope: lymphocytes with atypical nuclei, lymphocytes and monocytes with sharp basophilic cytoplasm and vacuolization, neutrophils with bizarre nuclei. These changes could be associated with frequent exacerbations of focal rhinopharyngeal infections and general dental caries, while the frequent respiratory viral infections might be induced by adaptation disorders in children subject to the long-term influence of low radiation doses.

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

Korosten Inter-Area Medical Diagnostic Center

Danilyuk V. V., Petrova A. A., Saiko A. S., Danilyuk L. V., Stotskaya L. P., Rudnitskii S. S., Sokolovskii I. N., Goncharenko O. E.

1. Introduction

The examination of children of the northern rayons (districts) of the Zhitomir Oblast (Province) has been carried out in Korosten City by two means: (a) the "Chernobyl-Sasakawa" mobile diagnostic laboratory installed in a Toyota minibus; and (b) the diagnostic center with a set of fixed equipment. The population of the territory is 500 000 people, 84 000 of whom are children. The area is contaminated with radionuclides, contamination levels ranging from 1 to 40 Ci/km^2 (Figure 1). It should also be noted that the territory of the northern rayons is considered to be thyroid endemic.

The course of the examination includes the following: (1) collection of disease history and filling in of questionnaires; (2) anthropometric data; (3) examination of children by a hematologist and an endocrinologist; (4) measurement of ^{137}Cs specific activity in the body; (5) ultrasonography of the thyroid; (6) determination of hormonal status and positive titers of antithyroid autoantibodies in the blood serum; and (7) hematological studies.

2. Materials and Methods

2.1 Study subjects

The subjects under study are children from 5 to 15 years of age who were born in the period from 26 April 1976 to 26 April 1986.

2.2 Measurement of whole body ^{137}Cs concentration

The technique of direct spectrometry of radionuclide activity based on the registration of gamma radiation in a body was used. The spectrometry was carried out with the whole body counter Model–101 manufactured by Aloka Company (Japan).

The following parameters were measured at the time of examination: specific activity, overall activity, body weight, size of chest, and average radiation rate at the height of 1 m from the surface of the ground.

2.3 Thyroid examinations

An ultrasonographic unit (arch-automatic type, Aloka SSD–520) was used in this study. Eleven cross sections of the thyroid gland were obtained by the technique of automatic scanning at 5 mm intervals.

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

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

$$LIMIT = 1.7 \times 10^{0.013 \times age + 0.0028 \times height} \times (body\ weight)^{0.15},$$

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 in *A Report on the 1993 Chernobyl Sasakawa Project Workshop*, 1993 for details.

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

2.4 Hematological studies

Blood testing was 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) mean corpuscular volume (MCV); (5) hematocrit (Ht); (6) mean corpuscular hemoglobin (MCH); (7) mean corpuscular hemoglobin concentration (MCHC); and (8) platelet count (PLT). A Sysmex NE–7000 analyzer was also used to obtain the following 23 parameters: WBC; RBC; Hb; Ht; MCV; MCH; MCHC; PLT; three parameters of the quantitative status of platelets, i.e. platelet distribution width, mean platelet volume and platelet large cell ratio; neutrophil percent and neutrophil count; lymphocyte percent and lymphocyte count; monocyte percent and monocyte count; eosinophil percent and eosinophil count; basophil percent and basophil count; and two parameters of the quantitative status of RBC distribution width, i.e. coefficient of variation and standard deviation.

The staining of peripheral blood smears was performed by the May-Grünwald-Giemsa technique with the help of a "Sakura" device. Three smears (two stained and one fixed) were made for each examined child. The hemogram was analyzed with a BH–2 "Olympus" microscope.

3. Results

3.1 Study subjects

A total of 11 306 children (5125 boys and 6181 girls) residing in 11 rayons of

Table 1. Classification of study subjects by sex and place of residence.

Place of residence	Boys	Girls	Total
Korosten City	1290 (8, 11, 13)[a]	1527 (9, 11, 13)	2817 (8, 11, 13)
Korostenskii	497 (9, 11, 13)	549 (9, 11, 14)	1046 (9, 11, 13)
Luginskii	379 (9, 11, 14)	450 (9, 11, 14)	829 (9, 11, 14)
Olevskii	455 (10, 12, 14)	554 (10, 13, 15)	1009 (10, 12, 15)
Malinskii	406 (8, 10, 12)	474 (8, 10, 12)	880 (8, 10, 12)
Emilchinskii	200 (8, 10, 12)	273 (9, 10, 12)	473 (9, 10, 12)
Ovruchskii	342 (9, 11, 13)	516 (9, 12, 13)	858 (9, 11, 13)
Narodichskii	126 (9, 11, 13)	197 (8, 11, 13)	323 (8, 11, 13)
Novograd-Volinskii	205 (9, 10, 12)	265 (9, 11, 13)	470 (9, 11, 13)
Volodar-Volinskii	1083 (9, 11, 14)	1234 (10, 12, 15)	2317 (9, 12, 14)
Brusilovskii	129 (9, 11, 12)	123 (8, 10, 13)	252 (8, 11, 13)
Radomishliskii	13 (5, 6, 6)	19 (6, 6, 6)	32 (6, 6, 6)
Total	5125 (9, 11, 13)	6181 (9, 11, 14)	11 306 (9, 11, 13)

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

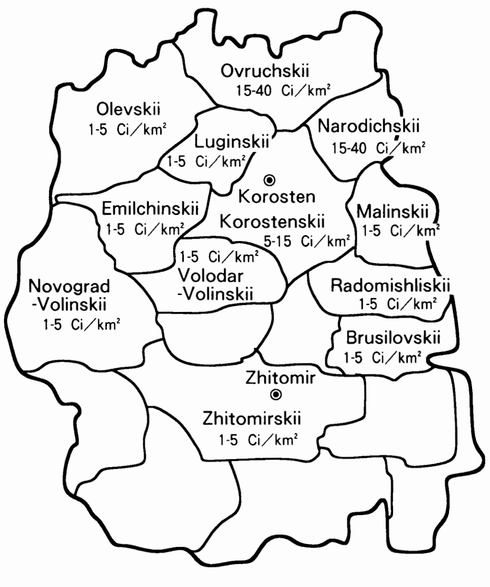

Figure 1. ^{137}Cs contamination levels (Ci/km^2) in the rayons of Zhitomir oblast as measured in 1992.

the Zhitomir Oblast were examined during the three-year period (Table 1). The largest proportion of examined children (2817) lived in Korosten City, followed by Volodar-Volinskii Rayon (2317), Korostenskii Rayon (1046) and Olevskii Rayon (1009).

Figure 1 shows ^{137}Cs contamination levels in the northern rayons of the Zhitomir Oblast. The most contaminated rayons are Narodichskii, Ovruchskii, Korostenskii and Korosten City.

3.2 Measurement of whole body ^{137}Cs concentration

Figure 2 shows whole body ^{137}Cs count per kg body weight (Bq/kg) by sex and age. The median of ^{137}Cs activity lay between 20 and 100 Bq/kg. The median of ^{137}Cs specific activity was similar in children from 6 to 16 years old, with the exception of children of 5 years old. In most cases, high ^{137}Cs specific activity prevailed in children of 9 and 11 years old. Boys of 14 and 16 years old showed a higher median of ^{137}Cs specific activity than girls of the same age.

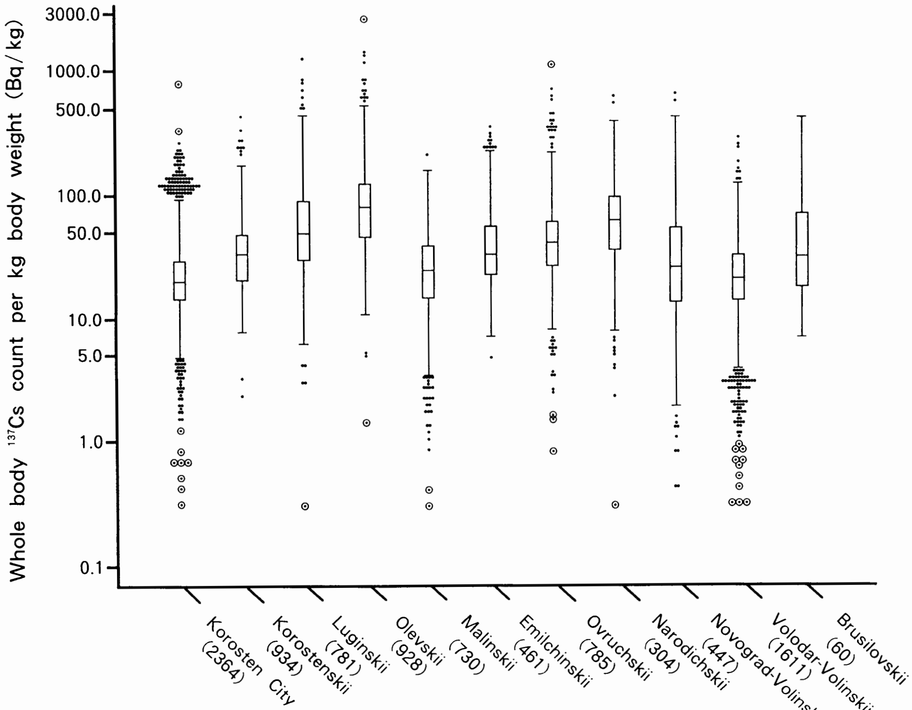

Figure 2. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by sex and age. Each pair presents the number of examined boys and girls. The bottom and top ends of the box and the bar inside the box correspond to the 25th, 75th and 50th sample percentiles, respectively. The black dot and the double circle with black dot represent extreme values, called "outside" and "far out," respectively.

Figure 3 shows the distribution of ^{137}Cs activity in children's bodies by place of residence. The maximal activity was registered in residents in the Olevskii, Ovruchskii, Korostenskii, Narodichskii and Luginskii Rayons, while minimal levels were noted in the Malinskii and Volodar-Volinskii Rayons. Five cases showed ^{137}Cs specific activity exceeding 1000 Bq/kg, while 25 showed specific activity ranging from 500 to 1000 Bq/kg.

3.3 Thyroid examinations

Figure 4 shows the relationship between thyroid volume and sex and age. An increase in thyroid volume with age was observed. The figure suggests that the mean volume of the thyroid gland was larger in girls than in boys from 8 to 14 years old.

Figure 5 shows the prevalence of goiter by sex and place of residence. The prevalence of goiter in girls was higher than in boys with the exception of Emilchinskii Rayon. The prevalence of goiter was relatively higher in Olevskii, Luginskii, Ovruchskii, Korostenskii and Volodar-Volinskii Rayons.

Figure 6 shows the prevalence of goiter in relation to ^{137}Cs specific activity per kg body weight. The highest prevalence in boys ($37.7 \pm 2.7\%$) and in girls ($47.2 \pm 5.9\%$) was observed in subjects with a ^{137}Cs count in the range from 100

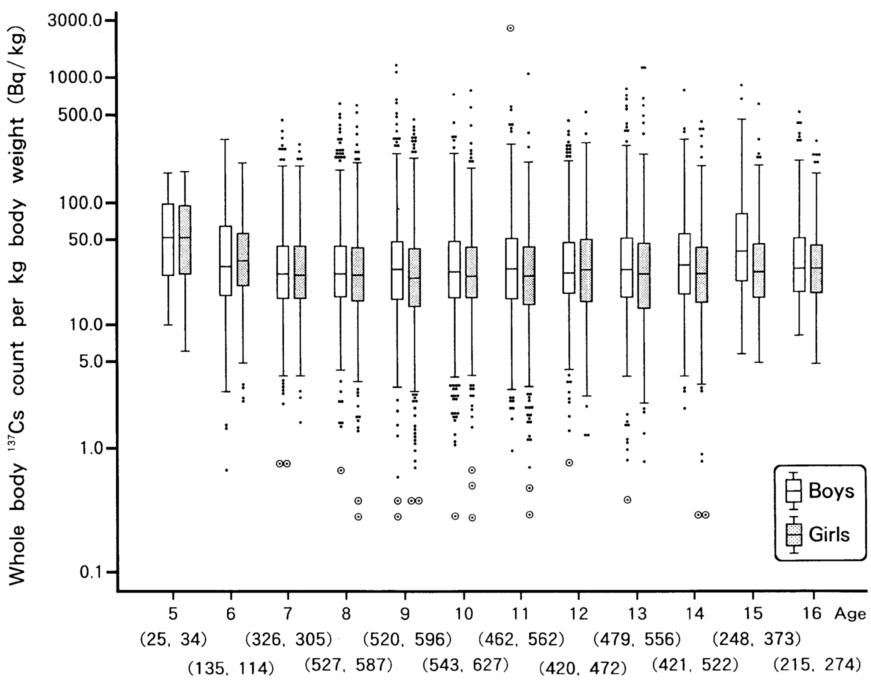

Figure 3. The box-and-whisker plots of whole body ^{137}Cs count per kg body weight by place of residence. The parenthetic entries refer to the number of examined children. See Figure 2 for details.

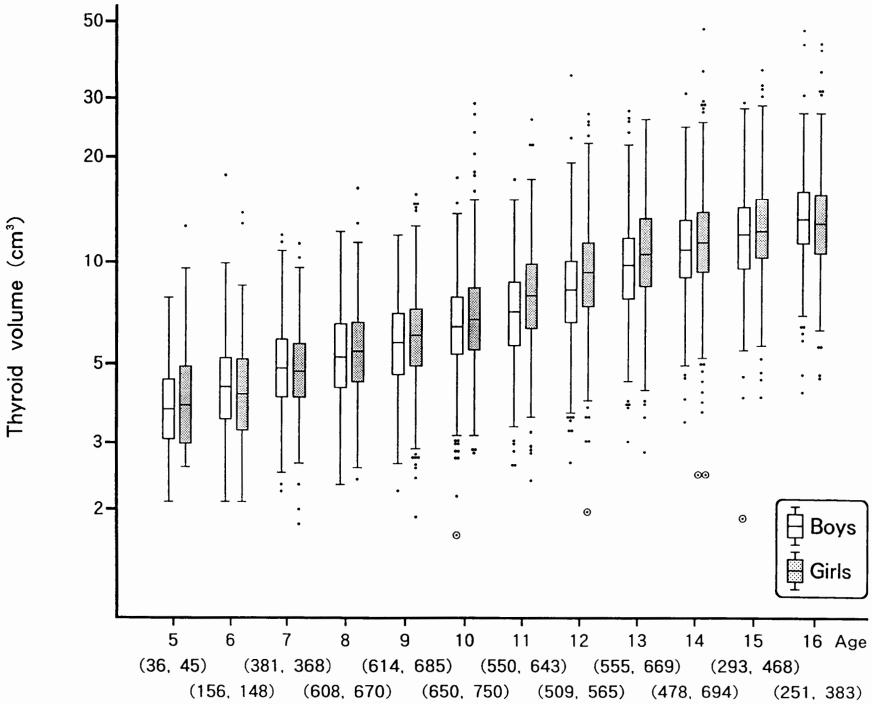

Figure 4. The box-and-whisker plots of thyroid volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

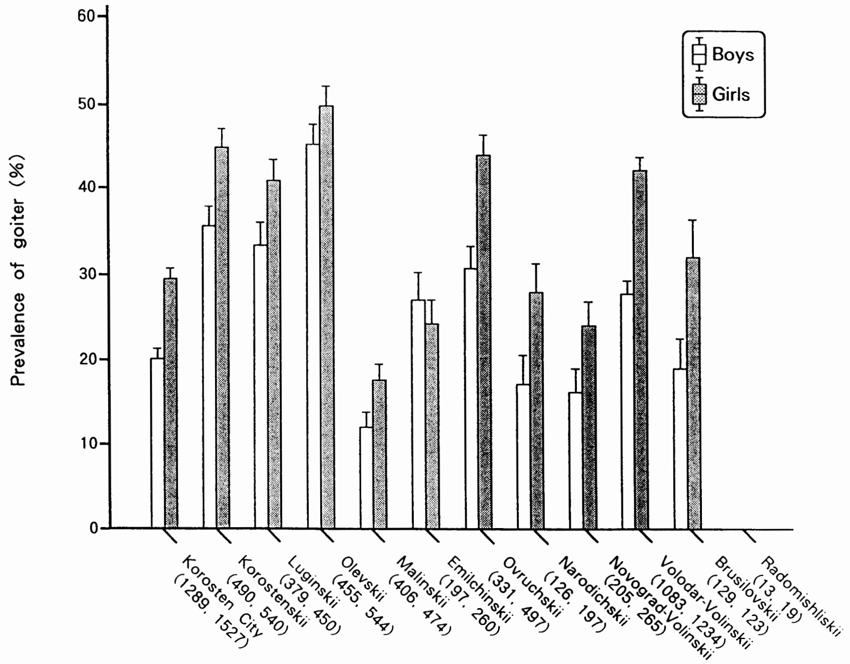

Figure 5. Prevalence of goiter by sex and place of residence. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 94 for the definition of goiter.

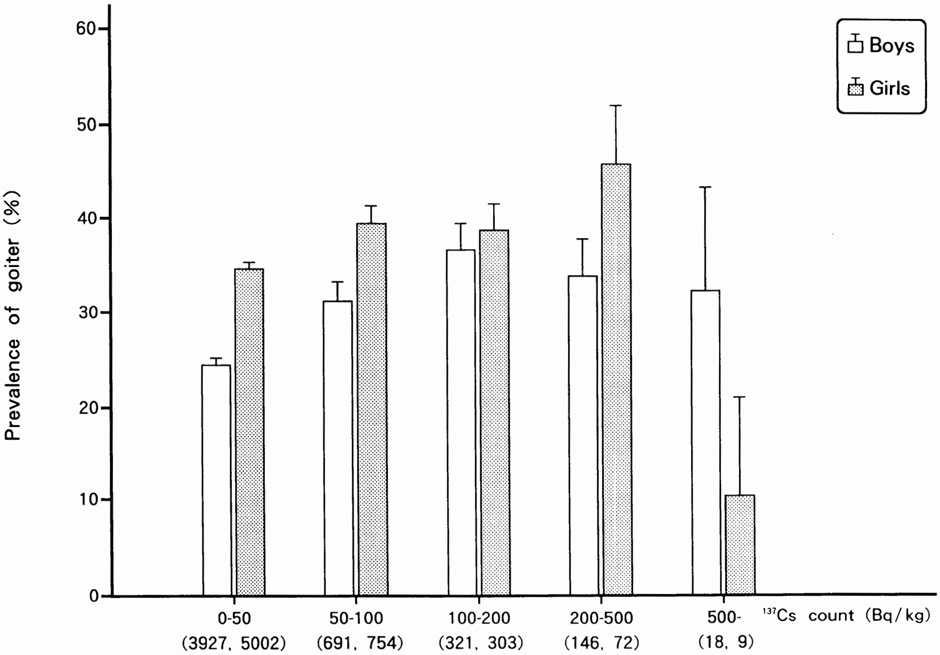

Figure 6. Prevalence of goiter by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors. See page 94 for the definition of goiter.

to 200 Bq/kg and from 200 to 500 Bq/kg, respectively.

Table 2 presents the prevalence of positive ATG and AMC titers by sex and place of residence. Girls displayed elevated ATG and AMC titers more often in all rayons.

Figure 7 shows the relationship between the prevalence of positive ATG titers and ^{137}Cs specific activity per kg body weight. The highest prevalence in boys ($5.4 \pm 1.0\%$) and in girls ($7.8 \pm 1.8\%$) was observed in subjects with a ^{137}Cs count in the range from 50 to 100 Bq/kg and from 100 to 200 Bq/kg, respectively.

Figure 8 shows the relationship between the prevalence of positive AMC titers and ^{137}Cs specific activity per kg body weight. The highest prevalence in boys ($6.2 \pm 2.1\%$) and in girls ($7.3 \pm 1.8\%$) was observed in subjects with a ^{137}Cs count in the range from 200 to 500 Bq/kg and from 100 to 200 Bq/kg, respectively.

Table 3 presents the number of subjects with simultaneously high TSH and low FT_4 levels (hypothyroidism) and with simultaneously low TSH and high FT_4 (hyperthyroidism) by sex and place of residence. Hypothyroidism was found in 19 and hyperthyroidism in 9 children. Girls showed a higher prevalence of thyroid dysfunction than boys. An increased level of FT_4 in the circulation was found in 78 children (27 boys and 51 girls). An increased level of TSH in the circulation was found in 694 children (280 boys and 414 girls). A

Table 2. Prevalence of positive ATG (anti-thyroglobulin antibody) and AMC (anti-microsome antibody) titers by sex and place of residence.[a]

Place of residence	Number of subjects measured			Antibody					
				Anti-thyroglobulin			Anti-microsome		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Korosten City	2287	1052	1235	75 (3.3)	22 (2.1)	53 (4.3)	90 (3.9)	21 (2.0)	69 (5.6)
Korostenskii	918	436	482	96 (10.5)	44 (10.1)	52 (10.8)	64 (7.0)	15 (3.4)	49 (10.2)
Luginskii	722	323	399	31 (4.3)	13 (4.0)	18 (4.5)	21 (2.9)	7 (2.2)	14 (3.5)
Olevskii	901	404	497	27 (3.0)	6 (1.5)	21 (4.2)	25 (2.8)	4 (1.0)	21 (4.2)
Malinskii	729	341	388	16 (2.2)	2 (0.6)	14 (3.6)	20 (2.7)	6 (1.8)	14 (3.6)
Emilchinskii	285	130	155	27 (9.5)	12 (9.2)	15 (9.7)	23 (8.1)	10 (7.7)	13 (8.4)
Ovruchskii	558	218	340	27 (4.8)	9 (4.1)	18 (5.3)	41 (7.3)	12 (5.5)	29 (8.5)
Narodichskii	228	96	132	38 (16.7)	16 (16.7)	22 (16.7)	29 (12.7)	12 (12.5)	17 (12.9)
Novograd-Volinskii	351	161	190	44 (45.9)	19 (11.8)	25 (13.2)	17 (4.8)	7 (4.3)	10 (5.3)
Volodar-Volinskii	2298	1075	1223	38 (1.7)	7 (0.7)	31 (2.5)	66 (2.9)	9 (0.8)	57 (4.7)
Brusilovskii	251	128	123	10 (4.0)	2 (1.6)	8 (6.5)	14 (5.6)	4 (3.1)	10 (8.1)
Radomishliskii	1	0	1	0	0	0	0	0	0
Total	9529	4364	5165	429 (4.5)	152 (3.5)	277 (5.4)	410 (4.3)	107 (2.5)	303 (5.9)

[a] Number of subjects with percentages in parentheses.

decreased level of TSH in the circulation was found in 64 children (16 boys and 48 girls). Further analysis of these data remains to be done.

Table 4 shows the number of subjects with ultrasonographically determined thyroid abnormalities by sex and place of residence. Nodular lesions were found in 29 children (0.26%) (9 boys and 20 girls). A thyroid cancer was found in one 8 year-old boy who had received surgical operation at Kiev Research Institute. The diagnosis was confirmed histologically as papillary adenocarcinoma.

Cystic lesions were found in 52 children (0.47%) (13 boys and 39 girls).

Abnormal echogenity (autoimmune thyroiditis, adenomatous goiter and others) was found in 68 subjects (0.61%) (8 boys and 60 girls). With regard to thyroid gland anomaly, hypoplasia was found in 11 children (0.10%) (7 boys and 4 girls).

Table 5 displays the results of urinary iodine excretion measurements. Among the 446 children examined (223 boys and 223 girls), a low urinary iodine excretion (<10 μg/dL) was noted in 395 children (194 boys and 201 girls).

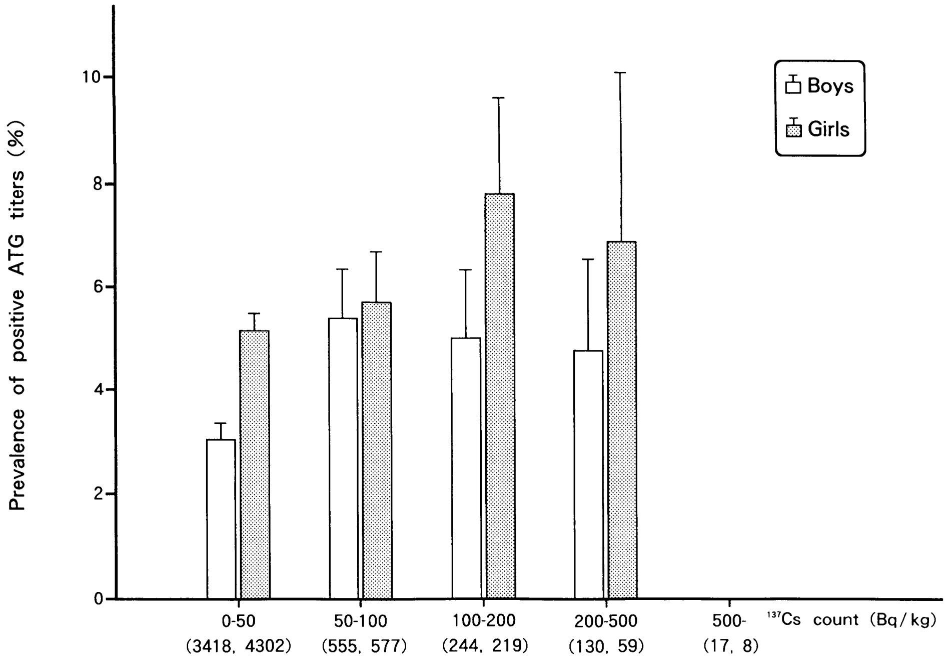

Figure 7. Prevalence of positive ATG titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

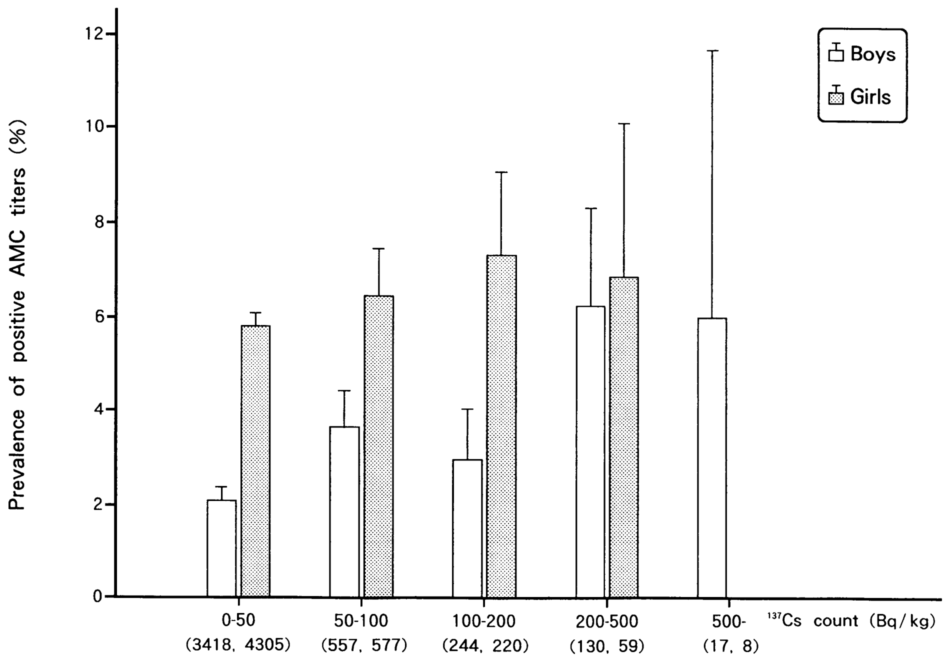

Figure 8. Prevalence of positive AMC titers by sex and whole body ^{137}Cs count per kg body weight. Each pair presents the number of examined boys and girls. The whiskers denote the standard errors.

Table 3. Number of subjects with hypothyroidism and hyperthyroidism by sex and place of residence.

Place of residence	Number of subjects with measurement			Hypothyroidism[a]			Hyperthyroidism[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Korosten City	2817	1290	1527	6	1	5	2	0	2
Korostenskii	1046	497	549	3	1	2	0	0	0
Luginskii	829	379	450	3	0	3	1	1	0
Olevskii	1009	455	554	1	1	0	3	0	3
Malinskii	880	406	474	0	0	0	0	0	0
Emilchinskii	473	200	273	0	0	0	0	0	0
Ovruchskii	858	342	516	1	1	0	0	0	0
Narodichskii	323	126	197	0	0	0	0	0	0
Novograd-Volinskii	470	205	265	0	0	0	0	0	0
Volodar-Volinskii	2317	1083	1234	5	1	4	3	0	3
Brusilovskii	252	129	123	0	0	0	0	0	0
Radomishliskii	32	13	19	0	0	0	0	0	0
Total	11 306	5125	6181	19	5	14	9	1	8

[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. Subjects with thyroid abnormalities by sex and place of residence.

Place of residence	Number of subjects examined		Diagnosis									
			Nodular lesion		Cystic lesion		Abnormal echogenity		Anomaly		Cancer	
	B[a]	G[a]	B	G	B	G	B	G	B	G	B	G
Korosten City	1266	1508	1	2	3	9	0	16	1	2	1	0
Korostenskii	482	534	3	1	0	2	0	5	1	0	0	0
Luginskii	379	450	1	1	1	5	1	4	0	0	0	0
Olevskii	455	553	2	3	4	6	1	9	0	0	0	0
Malinskii	406	473	0	0	0	2	1	1	1	0	0	0
Emilchinskii	197	260	0	1	0	0	0	1	1	0	0	0
Ovruchskii	331	497	1	4	0	1	1	5	0	0	0	0
Narodichskii	119	195	0	1	1	0	1	1	0	0	0	0
Novograd-Volinskii	166	227	0	2	1	3	1	3	0	1	0	0
Volodar-Volinskii	1081	1232	1	5	0	10	2	15	3	1	0	0
Brusilovskii	129	123	0	0	3	1	0	0	0	0	0	0
Radomishliskii	13	19	0	0	0	0	0	0	0	0	0	0
Total	5024	6071	9	20	13	39	8	60	7	4	1	0

[a] B, boys; G, girls.

Figure 9 shows the relationship between the residual of thyroid volume after adjustment for age, height and weight, and urinary iodine content. No correlation was observed between the two quantities (95% confidence interval of the correlation coefficient: $-0.14 < \rho < 0.06$).

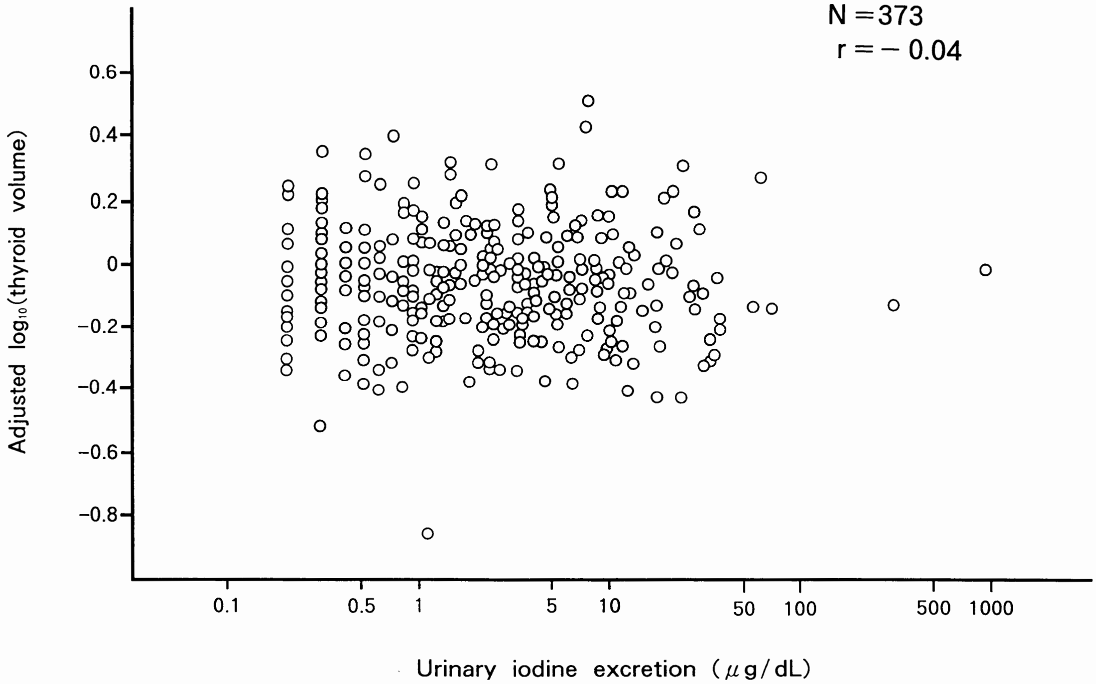

Figure 9. Scatter plots of urinary iodine excretion and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

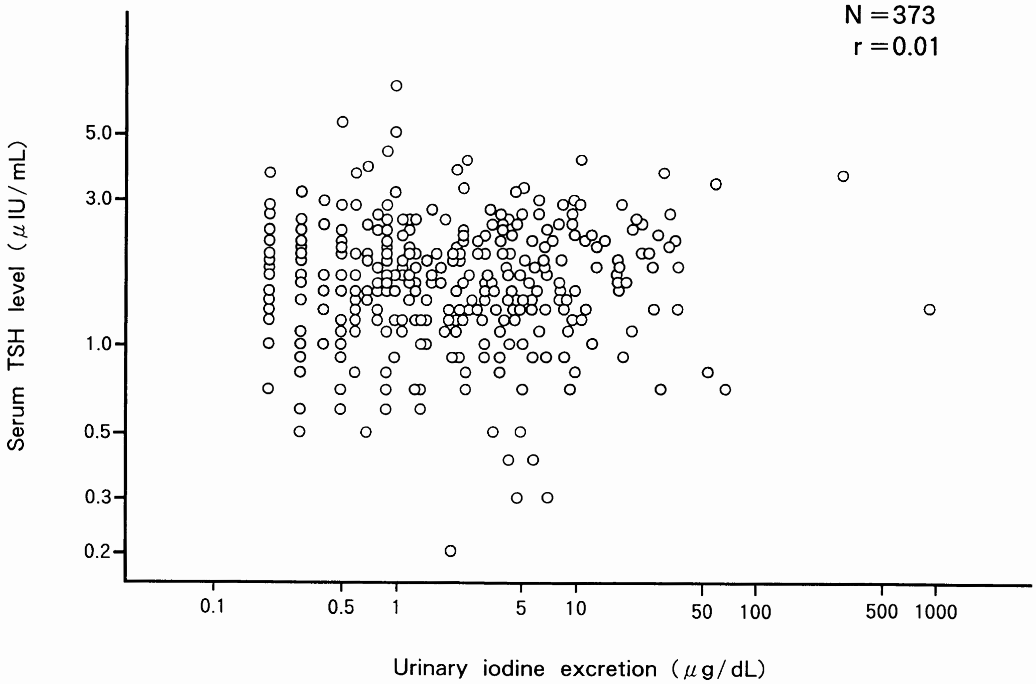

Figure 10. Scatter plots of urinary iodine excretion and serum TSH level.

Table 5. Number of subjects with low urinary iodine excretion by sex and place of residence.

Place of residence	Number of subjects examined	Subjects with low urinary iodine excretion (<10 μg/dL)		
		Total	Boys	Girls
Korosten City	212	172	89	83
Korostenskii	4	4	1	3
Luginskii	44	43	22	21
Olevskii	3	3	1	2
Malinskii	37	35	22	13
Emilchinskii	1	1	0	1
Ovruchskii	24	23	11	61
Volodar-Volinskii	88	79	37	42
Novograd-Volinskii	31	29	11	18
Total	446	395	194	201

Scatter plots of urinary iodine content and TSH level (Figure 10) and FT_4 level (Figure 11) for 373 subjects indicate that urinary iodine content was not correlated with either TSH level (95% confidence interval of the correlation coefficient: $-0.09<\rho<0.11$) or FT_4 level (95% confidence interval of the correlation coefficient: $-0.07<\rho<0.13$).

Figure 12 shows the relationship between the residual of thyroid volume after adjustment for age, height and weight, and ^{137}Cs specific activity per kg body weight. A statistically significant correlation was observed between the

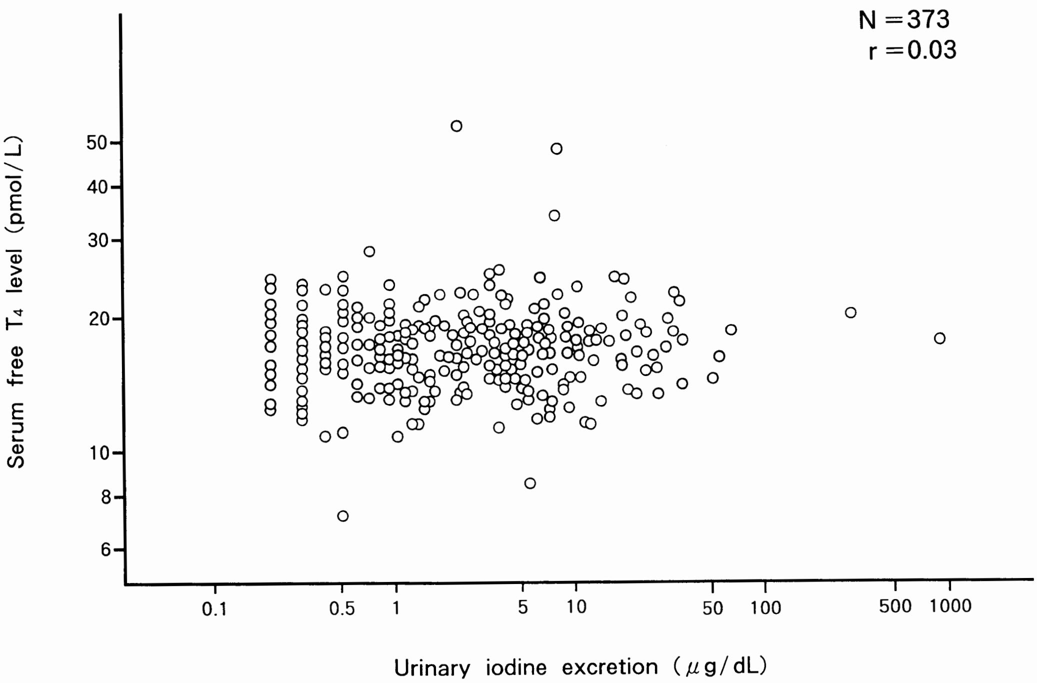

Figure 11. Scatter plots of urinary iodine excretion and serum free T_4 level.

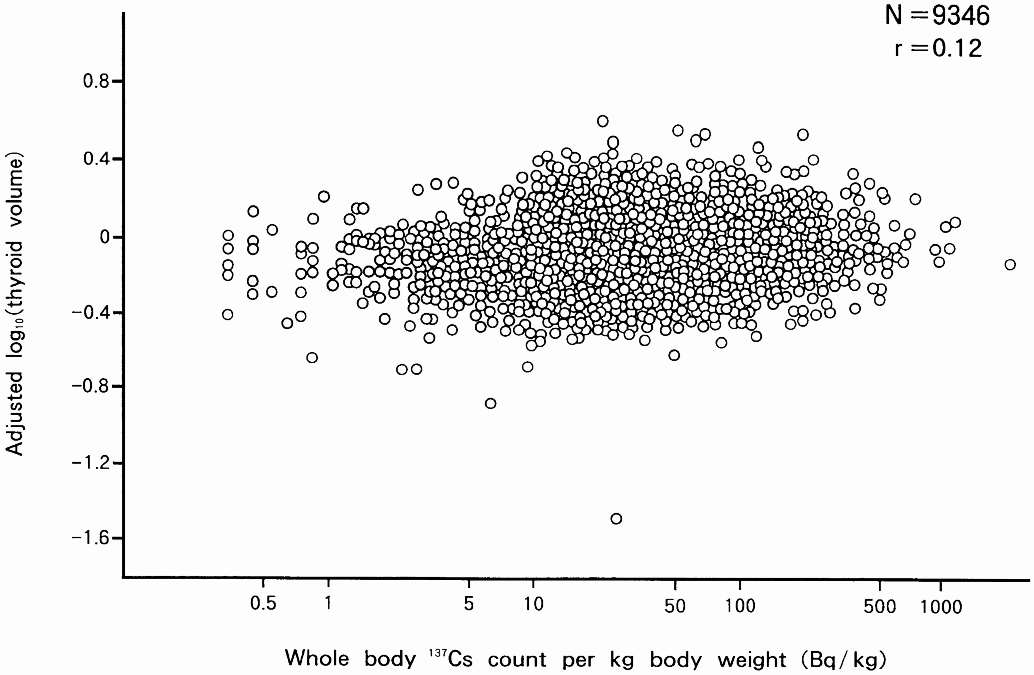

Figure 12. Scatter plots of whole body ^{137}Cs count per kg body weight and the residual of the logarithm of thyroid volume after adjustment for age, height and weight.

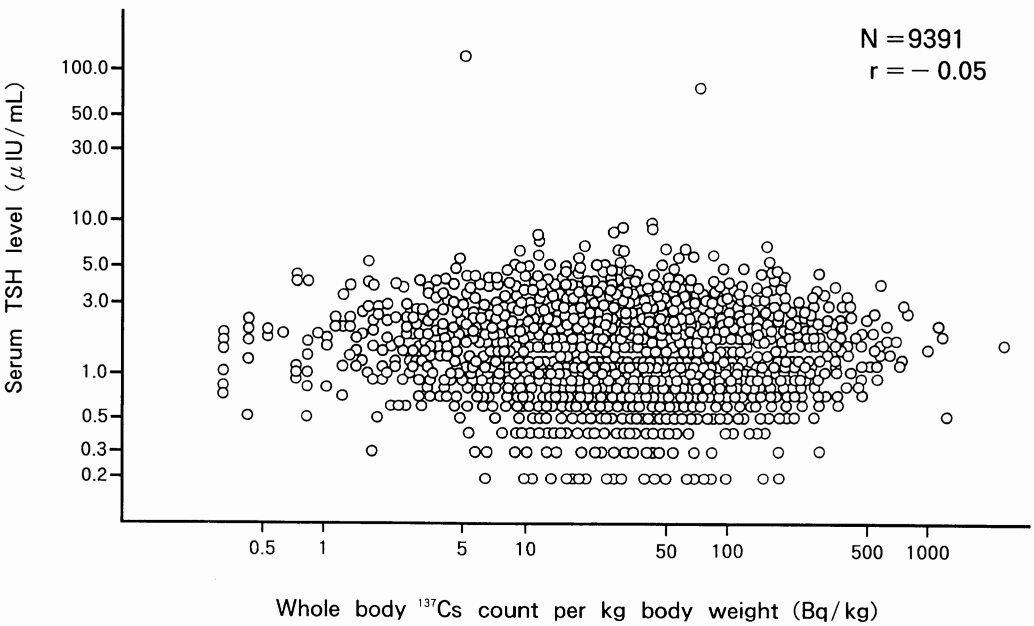

Figure 13. Scatter plots of whole body ^{137}Cs count per kg body weight and serum TSH level.

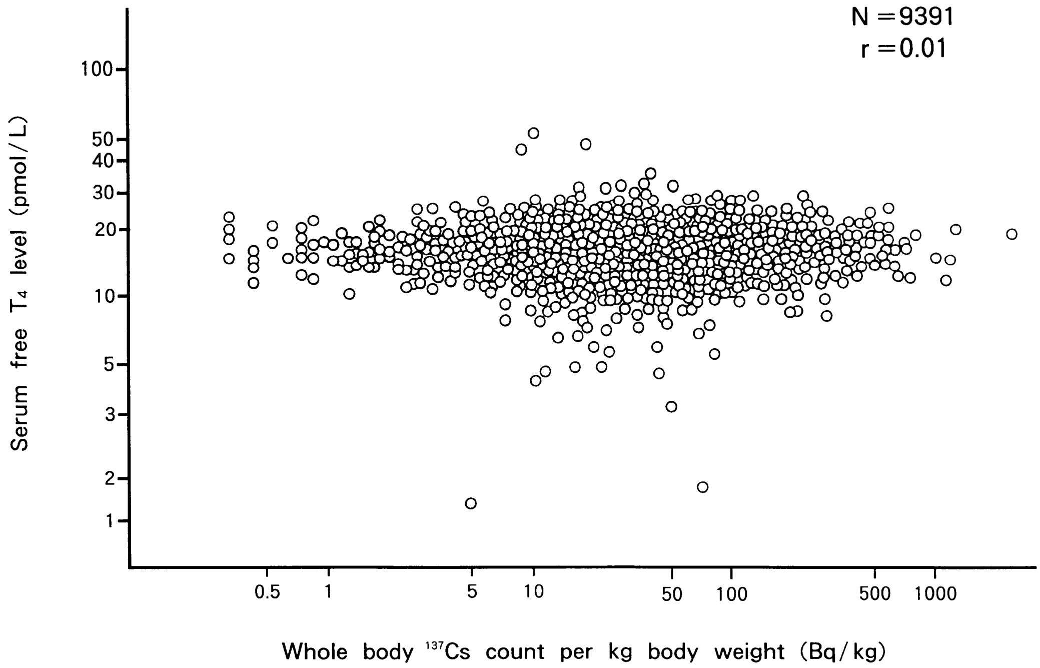

Figure 14. Scatter plots of whole body ^{137}Cs count per kg body weight and serum free T_4 level.

two quantities, but the correlation coefficient was not large (95% confidence interval of the correlation coefficient: $0.10 < \rho < 0.14$).

Figures 13 and 14 are scatter plots of ^{137}Cs specific activity per kg body weight and circulating TSH and FT_4 levels, respectively. A statistically significant correlation was observed between ^{137}Cs specific activity and TSH level but the correlation coefficient was negligible (95% confidence interval of the correlation coefficient: $-0.07 < \rho < -0.03$). No correlation was observed between ^{137}Cs specific activity and FT_4 level (95% confidence interval of the correlation coefficient: $-0.01 < \rho < 0.03$).

3.4 Hematological studies

Figure 15 shows hemoglobin levels in the blood by age and sex. The median of Hb level was within normal limits. There was a trend toward an increase in Hb level with age. A greater decrease in the median of Hb level in the blood was registered in 13–16 year old girls than in boys of the same age. We consider these changes to be associated with hormonal changes during puberty.

However, it should be noted that a reduction in Hb in the blood below the normal range was found in 16 boys and 27 girls. Low levels of Hb were registered in a girl with Werlhof disease (79 g/L) and in a child from the Luginskii Rayon (83 g/L). Another boy showed 183 g/L, but he had a history of surgery for congenital heart disease.

Figure 16 shows the relation between MCV and age and sex. The mean

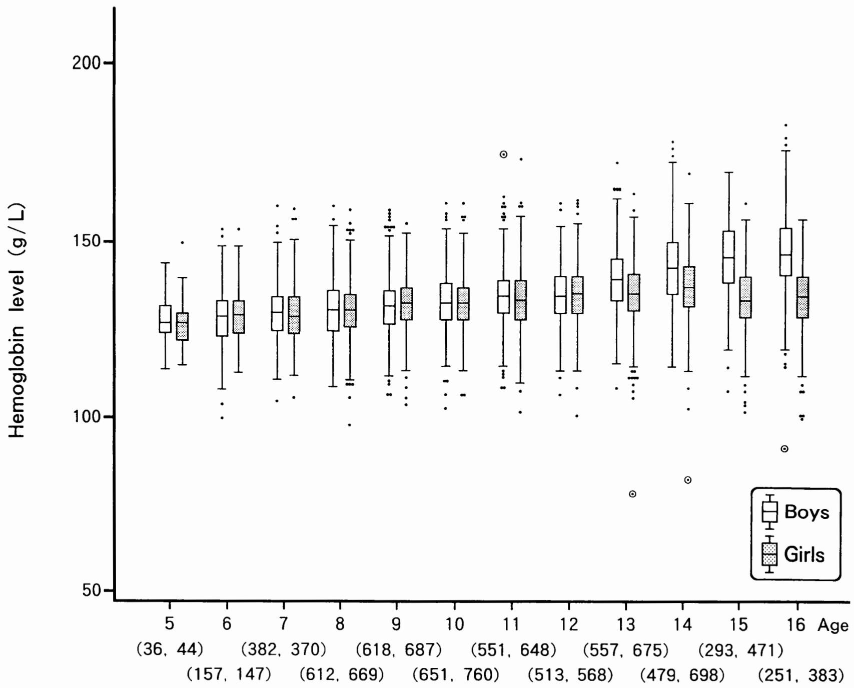

Figure 15. The box-and-whisker plots of hemoglobin level by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

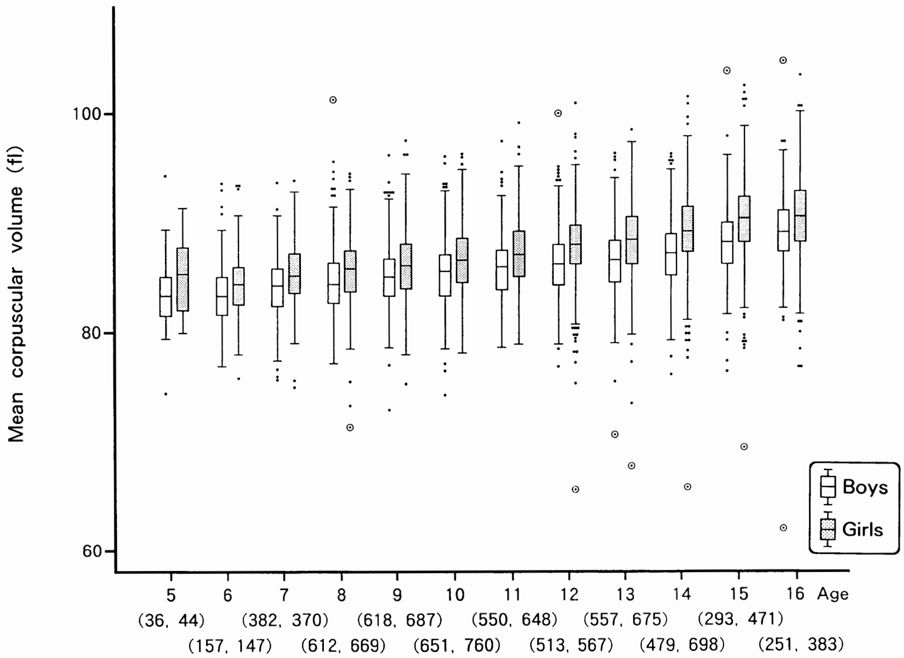

Figure 16. The box-and-whisker plots of mean corpuscular volume by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

value of MCV in all age groups was within the normal range in both boys and girls. On the whole there was a trend toward an increase in MCV with age. It should be noted that MCV was higher in girls than in boys in all age groups. 122 boys (2.4%) and 69 girls (1.1%) showed a reduction in MCV (less than 80 fl) (cf. Tables 6A and 6B, pp. 112–113). The lowest levels were 62.2 fl/Hb 92 g/L; 66 fl/Hb 88 g/L; 65.8 fl/Hb 109 g/L; and 68.0 fl/Hb 79 g/L. The highest MCV level was 104.5 fl/ Hb 131 g/L (Werlhof disease).

Figure 17 shows that the median of WBC was within normal limits. No correlation with sex or age was observed. An increase in WBC was registered in 466 subjects (4.1%) at the time of the examination. This disorder may be caused by acute respiratory illness. Leukopenia was found in 14 boys and 4 girls. The lowest WBC ($3.3 \times 10^9/L$) observed during the three examinations was registered in a girl from Korosten City.

Figure 18 shows the relationship between PLT and age and sex. The median of PLT was within the normal range. There was a trend toward a decrease in PLT with age. This matter requires more detailed consideration.

Thrombocytopenia was found in 2 girls and 2 boys (Tables 6A and 6B). A subsequent examination of two subjects with $21 \times 10^9/L$ and $44 \times 10^9/L$ revealed Werlhof disease. Other children with thrombocytopenia are under the observation of a hematologist. Thrombocytosis was found in 61 boys and 63 girls

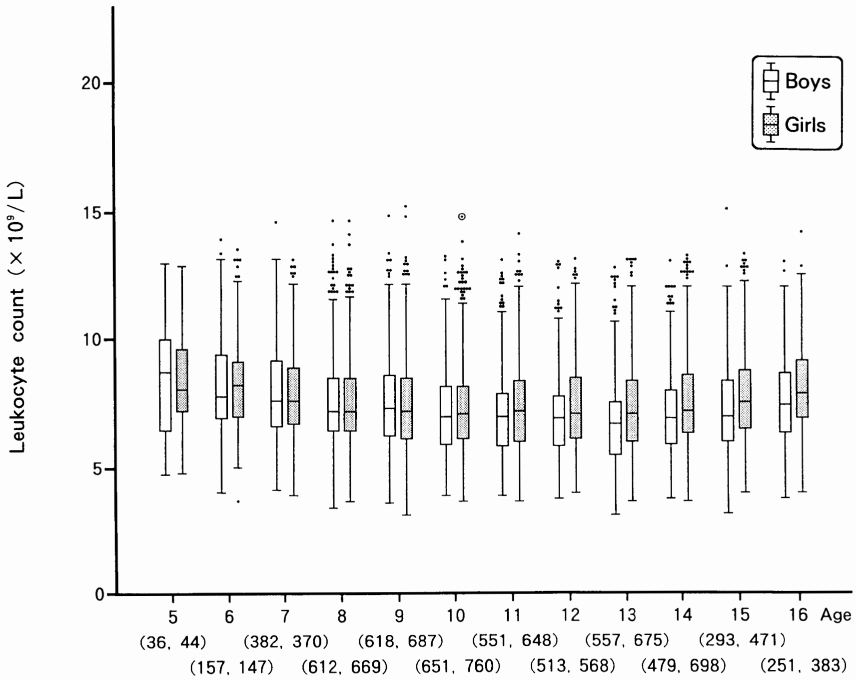

Figure 17. The box-and-whisker plots of leukocyte count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

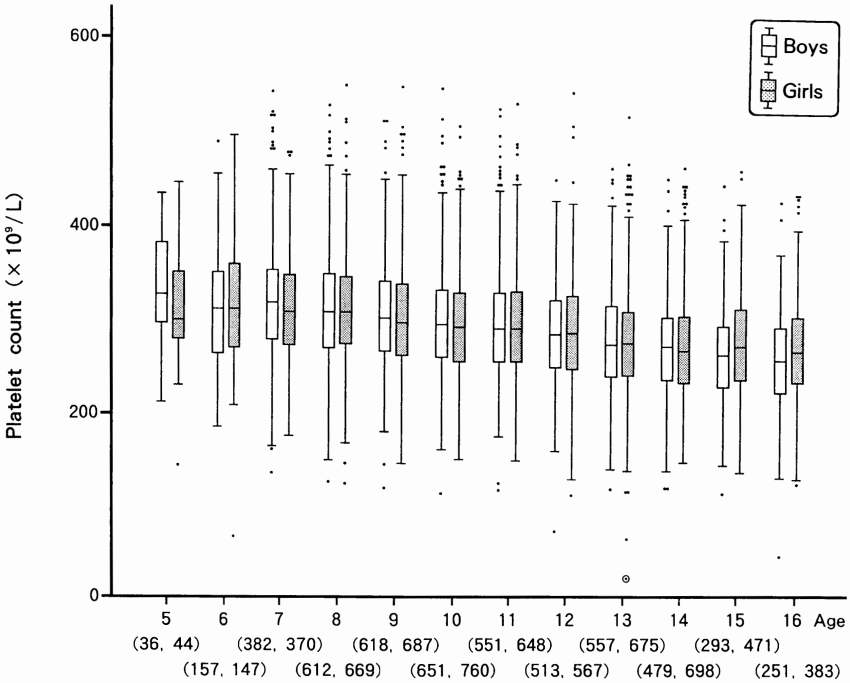

Figure 18. The box-and-whisker plots of platelet count by sex and age. Each pair presents the number of examined boys and girls. See Figure 2 for details.

or a total of 124 children (1.1%). One child showed continuous thrombocytosis after splenectomy (712×10^9/L) for congenital spherocytic hemolytic anemia. Most of the remaining thrombocytosis cases were in convalescent periods after infectious diseases, postmenstrual period and physical exertion, but in some cases further scientific studies are required to determine the final diagnosis.

2404 (21.3%) of the 11 294 examined children showed eosinophilia. A comparative analysis was conducted to establish the relationship between the prevalence of eosinophilia and the presence of domestic animals in the home, skin diseases, asthma and the seasons of the year. The prevalence of eosinophilia was higher in children with domestic animals at home (1724/7474 or 23.1%) than in those without such animals (676/3801 or 17.8%): the estimated odds ratio (±standard error) was 1.39±0.07. Children with asthma showed a higher prevalence of eosinophilia (125/476 or 26.3%) than those without asthma (1992/9570 or 20.8%): the estimated odds ratio (±standard error) was 1.35±0.15. However, no significant difference was observed in the prevalence of eosinophilia between children with and without a history of skin diseases (346/1665 or 20.8% and 1794/8513 or 21.1%, respectively): the estimated odds ratio (±standard error) was 0.98±0.06. With regard to the seasons of the year, the prevalence of eosinophilia was higher in autumn (820/3433 or 23.9%) than in spring (674/3385 or 19.9%): the estimated odds ratio (±standard error) was 1.26±0.07.

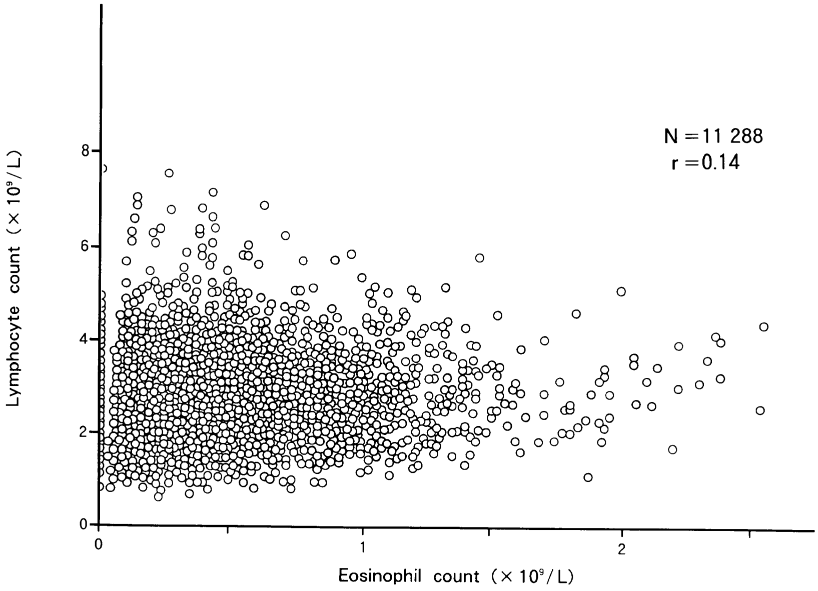

Figure 19. Scatter plots of eosinophil and lymphocyte counts.

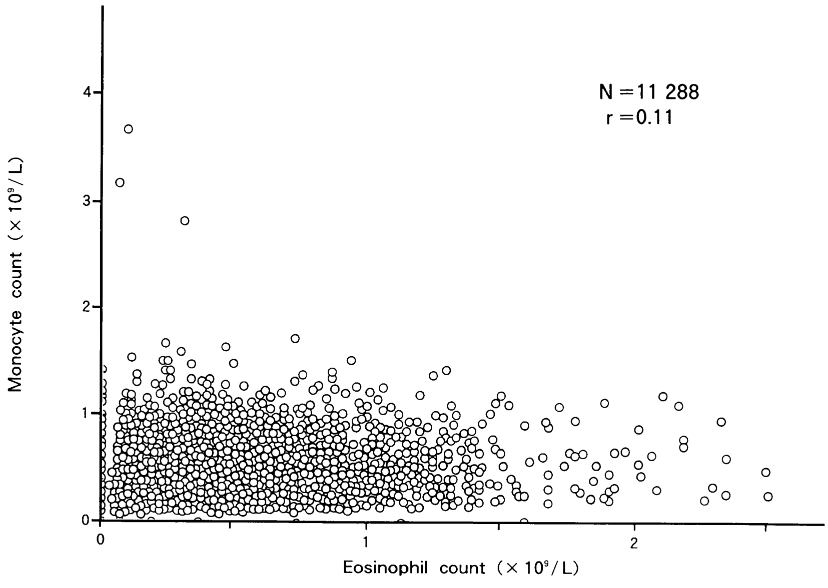

Figure 20. Scatter plots of eosinophil and monocyte counts.

A statistically significant correlation was observed between eosinophil count and lymphocyte, monocyte and platelet counts but the respective correlation coefficients were not large (Figures 19–21). The 95% confidence intervals of respective correlation coefficients were as follows: $0.12<\rho<0.16$ for eosinophil and lymphocyte counts; $0.10<\rho<0.13$ for eosinophil and monocyte counts; and $0.12<\rho<0.16$ for eosinophil and platelet counts.

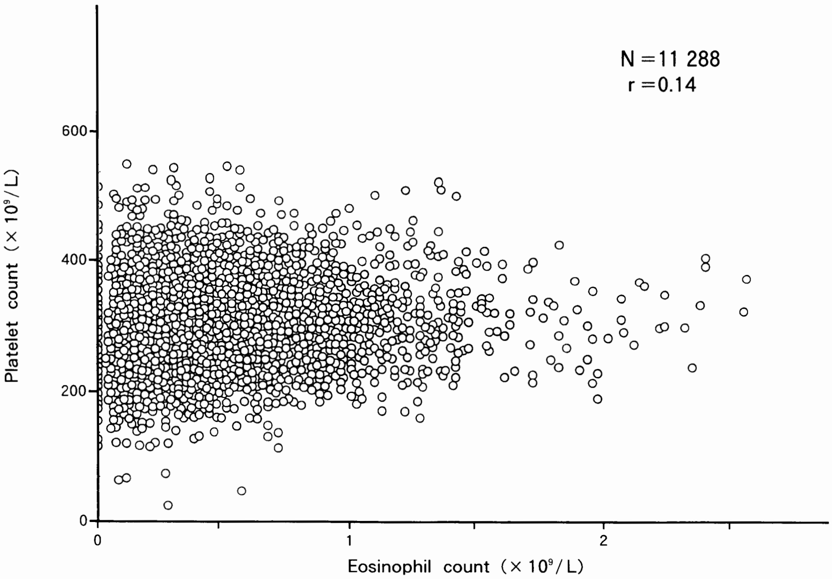

Figure 21. Scatter plots of eosinophil and platelet counts.

Tables 6A and 6B show that the largest number of children was examined in Korosten City and in the Volodar-Volinskii Rayon. These groups of children showed the largest number of deviations in hematological parameters. Out of 43 anemias, 17 were found in Volodar-Volinskii Rayon. Out of 4 pronounced thrombocytopenias, 2 were found in Volodar-Volinskii Rayon, 1 in Korosten City and 1 in Luginskii Rayon. A high level of thrombocytosis, or 16 cases (1.8%), was found in Malinskii Rayon. Lymphocytopenia was found most often in boys and girls of Emilchinskii Rayon, amounting to 2.3%. The highest prevalence of lymphocytosis was observed in Korosten City and Olevskii and Volodar-Volinskii Rayons. Leukemia was not found.

Tables 7A and 7B present hematological abnormalities by ^{137}Cs level. The group of children with a ^{137}Cs specific activity in the range of 0 to 50 Bq/kg was the largest (8966 children). The largest number of deviations from the normal range was registered in this group. Because of the small size of the other groups it is difficult to compare the obtained data.

4. Conclusions

The results of the study are of great importance for both practical and research purposes. They provide an opportunity to detect abnormalities, to treat children at the early stages of disease, and to arrange for follow-up studies. The results have enormous scientific value because they facilitate the assessment of the health status of children residing in the exposed areas.

Table 7A. Frequency of boys with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	12(0.3)	2(0.3)	2(0.6)			16(0.3)
	>180				1(0.7)		1(0.02)
WBC (×10^9/L)	<3.8	12(0.3)	1(0.1)	1(0.3)			14(0.3)
	>10.6	174(4.4)	31(4.4)	15(4.7)	12(8.2)	2(11.1)	234(4.6)
PLT (×10^9/L)	<100	2(0.1)					2(0.1)
	>440	54(1.4)	5(0.7)	2(0.6)			61(1.2)
MCV (fl)	<80	96(2.4)	13(1.9)	9(2.8)	4(2.7)		122(2.4)
	>100	3(0.1)					3(0.1)
Ly (×10^9/L)	<1.2	32(0.8)	5(0.7)	5(1.6)	2(1.4)	1(5.6)	45(0.9)
	>3.5	392(9.9)	70(10.0)	29(9.0)	18(12.3)	2(11.1)	511(10.0)
Ne (×10^9/L)	<1.4	21(0.5)	4(0.6)	1(0.3)			26(0.5)
	>6.6	155(3.9)	33(4.7)	9(2.8)	9(6.2)	2(11.1)	208(4.1)
Eo (×10^9/L)	>0.5	854(21.7)	160(23.0)	72(22.4)	41(28.1)	4(22.2)	1131(22.1)
Mo (×10^9/L)	<0.12	75(1.9)	5(0.7)	7(2.2)	1(0.7)		88(1.7)
	>1.00	78(2.0)	15(2.2)	9(2.8)	3(2.1)	1(5.6)	106(2.1)
Number of children measured		3940	697	321	146	18	5122

[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.

Table 7B. Frequency of girls with hematological abnormalities by ^{137}Cs level.[a]

Blood analysis		Whole body ^{137}Cs 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	23(0.5)	2(0.3)	1(0.3)	1(1.4)		27(0.4)
	>160	8(0.2)	1(0.1)		1(1.4)		10(0.2)
WBC (×10^9/L)	<3.6	4(0.1)					4(0.1)
	>11.0	180(3.6)	40(5.3)	8(2.6)	4(5.6)		232(3.8)
PLT (×10^9/L)	<100		2(0.3)				2(0.03)
	>440	58(1.2)	5(0.7)				63(1.0)
MCV (fl)	<80	55(1.1)	10(1.3)	3(1.0)	1(1.4)		69(1.1)
	>100	12(0.2)	1(0.1)				13(0.2)
Ly (×10^9/L)	<1.2	54(1.1)	16(2.1)	2(0.7)	1(1.4)		73(1.2)
	>3.5	521(10.4)	100(13.2)	41(13.4)	14(19.4)	1(11.1)	677(11.0)
Ne (×10^9/L)	<1.4	21(0.4)	2(0.3)				23(0.4)
	>6.6	306(6.1)	56(7.4)	11(3.6)	3(4.2)		376(6.1)
Eo (×10^9/L)	>0.5	1013(20.2)	176(23.2)	67(21.8)	14(19.4)	3(33.3)	1273(20.6)
Mo (×10^9/L)	<0.12	71(1.4)	18(2.4)	7(2.3)	4(5.6)		100(1.6)
	>1.00	103(2.0)	20(2.6)	4(1.3)	2(2.8)		129(2.1)
Number of children measured		5026	758	307	72	9	6172

[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.

Table 6A. Frequency of boys with hematological abnormalities by place of residence.[a]

Blood analysis		Place of residence[b]												Total
Item (unit)[c]	Abnormality criteria	KOR	KRR	LUG	OLE	MAL	EMI	OVR	NAR	NVL	VVL	BRU	RAD	
Hb (g/L)	<110		2 (0.4)		1 (0.2)	3 (0.7)	1 (0.5)	1 (0.3)			8 (0.7)			16 (0.3)
	>180				1 (0.2)									1 (0.02)
WBC ($\times 10^9$/L)	<3.8	3 (0.2)	1 (0.2)	2 (0.5)		2 (0.5)			1 (0.8)	3 (1.5)	2 (0.2)			14 (0.3)
	>10.6	43 (3.3)	16 (3.2)	14 (3.7)	20 (4.4)	13 (3.2)	9 (4.5)	20 (5.8)	7 (5.6)	12 (5.9)	62 (5.7)	14 (10.9)	4 (30.8)	234 (4.6)
PLT ($\times 10^9$/L)	<100										2 (0.2)			2 (0.04)
	>440	12 (0.9)	7 (1.4)	4 (1.1)	3 (0.7)	11 (2.7)	3 (1.5)	5 (1.5)		1 (0.5)	13 (1.2)	1 (0.8)	1 (7.7)	61 (1.2)
MCV (fl)	<80	32 (2.5)	5 (1.0)	8 (2.1)	11 (2.4)	11 (2.7)	6 (3.0)	9 (2.6)		6 (2.9)	30 (2.8)	4 (3.1)		122 (2.4)
	>100			2 (0.5)							1 (0.1)			3 (0.1)
Ly ($\times 10^9$/L)	<1.2	8 (0.6)	4 (0.8)	2 (0.5)	5 (1.1)	9 (2.2)	5 (2.5)	2 (0.6)	2 (1.6)	3 (1.5)	3 (0.3)	2 (1.6)		45 (0.9)
	>3.5	120 (9.3)	39 (7.9)	35 (9.3)	57 (12.5)	42 (10.3)	29 (14.5)	35 (10.2)	10 (7.9)	35 (17.1)	86 (7.9)	15 (11.6)	8 (61.5)	511 (10.0)
Ne ($\times 10^9$/L)	<1.4	13 (1.0)	4 (0.8)	1 (0.3)		3 (0.7)		1 (0.3)	1 (0.8)	1 (0.5)	2 (0.2)			26 (0.5)
	>6.6	31 (2.4)	14 (2.8)	11 (2.9)	24 (5.3)	16 (3.9)	6 (3.0)	13 (3.8)	7 (5.6)	6 (2.9)	69 (6.4)	9 (7.0)	2 (15.4)	208 (4.1)
Eo ($\times 10^9$/L)	>0.5	202 (15.7)	90 (18.1)	110 (29.1)	89 (19.6)	139 (34.2)	53 (26.5)	87 (25.4)	25 (19.8)	76 (37.1)	209 (19.3)	42 (32.6)	9 (69.2)	1131 (22.1)
Mo ($\times 10^9$/L)	<0.12	25 (1.9)	5 (1.0)	4 (1.1)	7 (1.5)	13 (3.2)	6 (3.0)	9 (2.6)	1 (0.8)	2 (1.0)	14 (1.3)	2 (1.6)		88 (1.7)
	>1.00	29 (2.2)	7 (1.4)	15 (4.0)	10 (2.2)	5 (1.2)	5 (2.5)	10 (2.9)	2 (1.6)	2 (1.0)	13 (1.2)	6 (4.7)	2 (15.4)	106 (2.1)
Number of children measured		1290	496	378	455	406	200	342	126	205	1082	129	13	5122

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

[b] KOR, Korosten City; KRR, Korostenskii; LUG, Luginskii; OLE, Olevskii; MAL, Malinskii; EMI, Emilchinskii; OVR, Ovruchskii; NAR, Narodichskii; NVL, Novograd-Volinskii; VVL, Volodar-Volinskii; BRU, Brusilovskii; RAD, Radomishliskii.

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

Table 6B. Frequency of girls with hematological abnormalities by place of residence.[a]

Blood analysis: Item (unit)[c]	Abnormality criteria	Place of residence[b]: KOR	KRR	LUG	OLE	MAL	EMI	OVR	NAR	NVL	VVL	BRU	RAD	Total
Hb (g/L)	<110	5 (0.3)	1 (0.2)	1 (0.2)	4 (0.7)	3 (0.6)		3 (0.6)			9 (0.7)	1 (0.8)		27 (0.4)
	>160	6 (0.4)	1 (0.2)			1 (0.2)	1 (0.4)	1 (0.2)						10 (0.2)
WBC ($\times 10^9$/L)	<3.6	1 (0.1)	1 (0.2)							1 (0.4)	1 (0.1)			4 (0.1)
	>11.0	34 (2.2)	13 (2.4)	11 (2.4)	15 (2.7)	15 (3.2)	8 (2.9)	29 (5.6)	9 (4.6)	12 (4.5)	72 (5.8)	8 (6.5)	6 (31.6)	232 (3.8)
PLT ($\times 10^9$/L)	<100	1 (0.1)		1 (0.2)										2 (0.03)
	>440	14 (0.9)	2 (0.4)	3 (0.7)	4 (0.7)	5 (1.1)	2 (0.7)	4 (0.8)	2 (1.0)	2 (0.8)	19 (1.5)	6 (4.9)		63 (1.0)
MCV (fl)	<80	19 (1.2)	6 (1.1)	7 (1.6)	5 (0.9)	4 (0.8)	1 (0.4)	6 (1.2)	1 (0.5)	3 (1.1)	15 (1.2)	2 (1.6)		69 (1.1)
	>100	2 (0.1)	1 (0.2)		1 (0.2)						8 (0.6)	1 (0.8)		13 (0.2)
Ly ($\times 10^9$/L)	<1.2	9 (0.6)	16 (2.9)	6 (1.3)	5 (0.9)	10 (2.1)	6 (2.2)	6 (1.2)	3 (1.5)	5 (1.9)	6 (0.5)	1 (0.8)		73 (1.2)
	>3.5	151 (9.9)	71 (13.0)	48 (10.7)	69 (12.5)	48 (10.1)	41 (15.0)	62 (12.2)	25 (12.7)	37 (14.0)	103 (8.4)	12 (9.8)	10 (52.6)	677 (11.0)
Ne ($\times 10^9$/L)	<1.4	12 (0.8)	1 (0.2)		1 (0.2)	1 (0.2)	1 (0.4)	1 (0.2)		1 (0.4)	5 (0.4)			23 (0.4)
	>6.6	52 (3.4)	31 (5.7)	17 (3.8)	25 (4.5)	26 (5.5)	12 (4.4)	36 (7.0)	11 (5.6)	15 (5.7)	131 (10.6)	18 (14.6)	2 (10.5)	376 (6.1)
Eo ($\times 10^9$/L)	>0.5	242 (15.9)	116 (21.2)	118 (26.3)	107 (19.3)	138 (29.2)	49 (17.9)	111 (21.5)	47 (23.9)	91 (34.3)	207 (16.8)	35 (28.5)	12 (63.2)	1273 (20.6)
Mo ($\times 10^9$/L)	<0.12	22 (1.4)	8 (1.5)	4 (0.9)	4 (0.7)	11 (2.3)	10 (3.7)	18 (3.5)	9 (4.6)	2 (0.8)	12 (1.0)			100 (1.6)
	>1.00	37 (2.4)	13 (2.4)	8 (1.8)	13 (2.3)	11 (2.3)	3 (1.1)	8 (1.6)	6 (3.0)	4 (1.5)	16 (1.3)	9 (7.3)	1 (5.3)	129 (2.1)
Number of children measured		1522	548	449	554	473	273	516	197	265	1233	123	19	6172

[a] Parenthetic entries refer to the percentage of the subjects while empty spaces denote the absence of subjects with abnormalities.
[b] KOR, Korosten City; KRR, Korostenskii; LUG, Luginskii; OLE, Olevskii; MAL, Malinskii; EMI, Emilchinskii; OVR, Ovruchskii; NAR, Narodichskii; NVL, Novograd-Volinskii; VVL, Volodar-Volinskii; BRU, Brusilovskii; RAD, Radomishliskii.
[c] Hb, hemoglobin; WBC, white blood cell (leukocyte); PLT, platelet; MCV, mean corpuscular volume; Ly, lymphocyte; Ne, neutrophil; Eo, eosinophil; Mo, monocyte.

II. Comments by Japanese Scientists

Comments on the 1994 Chernobyl Sasakawa Project Workshop on Thyroid-related Studies

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The third workshop was held on May 16 and 17, 1994 at the sanatorium called "Fields of Russia" in the suburbs of Moscow. The scientists involved in examinations at the five centers gathered again this year and reported on the results of a total of approximately 50,000 persons examined between May 1991 and December 31, 1993. From their experience at the workshop last year, the centers have paid special attention to the management of data quality and conducted re-examinations in cases of abnormalities. Consequently, there has been a dramatic improvement in diagnostic techniques over the past three years and a deepening sense of personal responsibility in each field of interest. In particular, the physicians who underwent training in Nagasaki have adopted an aggressive approach to the thyroid examinations of children and, in this field, have developed diagnostic abilities on a par with international standards. It was especially gratifying to see this development demonstrated so clearly at the sub-meetings and presentations. These fundamental improvements and the energy of the staff members have naturally resulted in an enhancement of the reliability of the data. I would like to express my heartfelt respect to the staff of each center, who have done an exemplary job again this year despite great political and economic difficulties.

Tables 1 to 3 show the total figures presented by each center at the workshop.

Table 1. Frequency of hypothyroidism and hyperthyroidism.[a]

Center	Subjects			Hypothyroidism			Hyperthyroidism		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Mogilev	11 213	5518	5695	10	4	6	8	3	5
Gomel	8949	4271	4678	31	12	19	10	4	6
Kiev	10 598	5032	5566	5	2	3	10	2	8
Korosten	11 158	5046	6112	18	5	13	9	1	8
Klincy	11 823	5923	5900	12	5	7	6	1	5
Total[b]	53 741	25 790	27 951	76	28	48	43	11	32
				(0.14)	(0.11)	(0.17)	(0.08)	(0.04)	(0.11)

[a] The number of subjects under treatment with T_4 or TSH abnormalities and clinical symptoms.
[b] Percentage of subjects in parentheses.

The use of the Amerlite kit has facilitated the quality management of the measurement of serum FT_4 and TSH concentrations, but FT_4–35 pmol/L and TSH3–5 μIU/mL, although within normal range, showed an uneven distribution and therefore requires further efforts. However, there may also be a problem with the quality of the kit, and its normal limits may not be absolutely accurate. In other words, the values exceeding the normal limits may not be due solely to inaccurate measurements at the centers. It is necessary in the future to calculate a standard titer on the basis of these results. Actually, I think the skilled scientists at each center should be praised for producing these data so efficiently. Amerlite is planning to change the kit, and therefore we must reconsider the use of the kit with respect to problems such as the price of the kit and the supply of reagents.

Positive auto-antibody titers were found most frequently in Korosten. The average among the five centers was 1.5% for ATG and 2.3% for AMC. An increasing trend was reported in the contaminated areas of one part of Klincy. Investigations are also being conducted to determine whether or not the frequency of auto-antibody positive children in the Chernobyl is correct on the basis of a comparison with the other reports.

The ultrasonographic equipment in the mobile diagnostic laboratories and the stationary equipment in each center are in full operation and are producing excellent results in the screening of thyroid disorders. It is an enormous undertaking, with daily examinations being conducted on children to detect asymptomatic thyroid disorders. A double-check method in which a Japanese specialist and local physician separately check any abnormalities is being implemented. The diagnostic techniques have improved dramatically as a

Table 2. Frequency of subjects with positive thyroid auto-antibody titers.

Center	Number of subjects			ATG[a]			AMC[b]		
	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
Mogilev	9930	4890	5040	73 (0.7)	20	53	160 (1.6)	35	125
Gomel	8949	4271	4678	73 (0.8)	24	49	228 (2.5)	81	147
Kiev	10 603	5032	5571	89 (0.8)	23	66	169 (1.5)	40	129
Korosten	9399	4294	5105	420 (4.5)	148	272	408 (4.3)	107	301
Klincy	11 964	5988	5976	130 (1.0)	37	93	220 (1.8)	54	166
Total[c]	50 845	19 945	26 370	785 (1.5)	252 (1.3)	533 (2.0)	1185 (2.3)	371 (1.6)	868 (3.3)

[a] Anti-thyroglobulin antibody.
[b] Anti-microsomal antibody.
[c] Percentage of subjets in parentheses.

Table 3. Frequency of abnormalities in ultrasonographic findings.

Center	Number of Subjects			Diagnosis											
				Nodular lesion			Cystic lesion			Abnormal echogenity			Anomaly		
	Total	Boys	Girls	T[a]	B[a]	G[a]	T	B	G	T	B	G	T	B	G
Mogilev	12 285	6009	6276	11	5	6	19	9	10	94	26	68	36	19	17
Gomel	8949	4271	4678	169	67	102	20	8	12	198	67	131	39	12	27
Kiev	10 578	5022	5556	15	3	12	12	5	7	242	—	—	0	0	0
Korosten	11 095	5024	6071	30	9	21	52	13	39	68	8	60	11	7	4
Klincy	12 147	6080	6067	70	32	38	22	7	15	344	144	200	19	10	9
Total[b]	55 054	26 406	28 648	295 (0.5)	116 (0.4)	179 (0.6)	125 (0.2)	42 (0.2)	83 (0.3)	946 (1.7)	245 (0.9)	459 (1.6)	105 (0.2)	48 (0.2)	57 (0.2)

[a] T, total; B, boys; G, girls.
[b] Percentage of subjects in parentheses.

result, and the 11 ultrasonograms taken from each subject (not just those with abnormal findings) are preserved permanently and thus provide an epoch-making data source for prospective studies. The frequency of thyroid nodules was 0.5%, and although fine needle aspiration biopsy (FNB) has not been performed in all cases, most of these are thought to be either adenomatous goiter or adenoma. The 1.8% frequency of abnormal echogenity, meanwhile, is more or less consistent with the frequency of auto-antibody positive subjects. This matter is currently under investigation.

As of May 18, 1994, a total of 21 children in Mogilev (0), Gomel (13), Kiev (4), Korosten (2) and Klincy (2) have received diagnoses of papillary adenocarcinoma, and most have undergone surgery. Our screening tests have therefore disclosed thyroid cancer at a rate of about one per 10,000 children, but the frequency is remarkably high in Gomel. The new techniques introduced in the thyroid field at each center this year are FNB and cytology. During the past year, we conducted cytological diagnoses on more than 200 subjects with the cooperation of Dr. Ito, who is in charge of pathological studies. Details on the results of these diagnoses will be reported at the workshop next year, but I would like to take the opportunity to praise the energetic efforts of the five centers in this undertaking as well. FNB with an extremely high level of diagnostic accuracy is being conducted at the examination sites using biopsy equipment with detachable metal needles on the 630-type 7.5 MHz mechanical sector being developed jointly with Aloka. However, careful attention must still be paid to misdiagnoses, oversights and other medical mistakes. The above diagnostic items and unified standards are shared by all five centers, and the introduction of FNB has facilitated comprehensive diagnoses including treatment. Although the centers had to start from scratch on many points, the supervisors and their staff are now fully aware of the importance of the project and I am confident that this will result in a further enhancement of the work at each center and ever greater efforts aimed primarily at the welfare of local residents.

As outlined above, the thyroid studies on children have produced steady results in the examination of hormone, antibody and ultrasonographic abnormalities, and this has led to the development of a system for treatment and follow-up studies after the confirmation of diagnoses. However, investigations are still insufficient to conclude whether or not the thyroid disorders are due simply to the impact of the Chernobyl accident on radiosensitive children in the Chernobyl vicinity. Further improvements and investigations are needed.

This means, for example, the thoroughgoing and accurate recording of residential history and other questionnaire items and the codification of place of residence in order to achieve individual dose estimates immediately after the accident. At present, it is obvious from the results of examinations that no correlation exists between ^{137}Cs (Bq/Kg) in the body or in the soil at the current place of residence and thyroid hormone concentrations, antibody abnormalities or goiter. Aside from a tiny proportion of abnormalities, therefore, the food and environment in the regions of residence can be declared safe. Needless to say, this information from the examination results is highly contributive to the peace of mind of local residents.

The measurements of urinary iodine are also proceeding smoothly, leading to the confirmation of endemic goiter in the Ukraine and to the collection of data showing the substantial replenishment of iodine in Belarus. However, although these regions are considered intrinsically iodine deficient, no correlation whatever has been found between urinary iodine levels and goiter or hormones. Each center is now performing FNB and the systematic measurement of thyroglobulin titers on subjects with ultrasonographic abnormalities, and so we can expect an even greater accumulation of valuable data. Moreover, facilities such as the Kiev Diagnostic Center which enjoy the cooperation of thyroid specialists in endocrinology laboratories are fully capable of establishing definitive diagnoses.

Rather than commenting on the strong points and shortcomings of each center, I would like to emphasize the fact that there has been an improvement in the project as a whole and that the thyroid-related data is approaching a level of quality high enough to merit any statistical analysis. I hope that the preserved samples and films will be used widely and provide the basis for a system of long-term follow-up studies, and I will continue to join the staff members in conscientious efforts to this end. I am confident that these examinations, which started as a five-year, five billion-yen project, will provide basic data for ongoing international medical cooperation.

Finally, I would like to express thanks to all the persons in Moscow and the examination sites who have assisted in the present workshop and in the work of the Japanese specialists.

Comments on the Results of the Blood Examinations

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The data from the approximately two and a half-year period from May 1991 to December 1993 was reported at the workshop. In May and June 1993, each center was equipped with an automatic blood cell analyzer NE–7000 (Sysmex) to improve examination efficiency, to reduce the disparity in white blood cell analysis at the screening stage and to facilitate the swift detection of abnormalities. At the present workshop, the report included the examination data obtained by NE–7000. In the past, the blood examinations were conducted by blood counting using mainly a K–1000 (Sysmex). But this time, since K-1000 tended to be used in the buses and NE–7000 to be used in the centers, the disparity between the K–1000 and NE–7000 levels was set at 3% or less.

The following are our comments on the problems in the examination results and the measures to be taken. The examination results are essentially the same as those of last year, but we would like to present a synopsis of the features of this year's study.

1) With the increase in the length of the study period, the examination subjects now range in age from 5–7 years to 16–17 years and the previous changes in peripheral blood examination results—particularly Hb and mean corpuscular volume (MCV)—have become increasingly prominent.

It has become clearer at each center that both boys and girls show a rise in Hb level from the age of 10. On the other hand, however, girls tend to show a gradual decrease from around the age of 12. It is also interesting that in Klincy and Gomel, MCV rises with Hb level in boys but decreases with the decline in Hb level in girls. In Mogilev, Korosten and Kiev, meanwhile, Hb levels show similar changes in boys and girls, but MCV is higher in girls than in boys from the age of 12. As we pointed out last year, this is thought to be due to a silent iron deficiency state accompanying the promotion of hematopoiesis by male hormones. The decline in MCV and Hb levels in girls 12 years of age or over in Gomel and Klincy can also be attributed to physiological changes, that is, an iron deficiency state associated with menarche. This conjecture is supported by the fact that there is also an increase in platelet count in these age groups at the two centers. At the other three centers, however, MCV shows an increase in girls 12 years of age or over despite the decrease in Hb level. Although the reasons remain unknown, this tendency was recognized at all five centers up to last year and is continuing in the above three centers. We plan to analyze the phenomenon by the assay of serum-Fe, ferritin, erythropoietin, etc.

2) Analysis of eosinophilia

In the past, eosinophilia was attributed to allergic, parasitic and other diseases. This year, we made it a goal to find some method to investigate this correlation. By means of a questionnaire, we collected information on the presence of asthma, skin disease, history of contact with domestic animals, etc. As a result, eosinophilia was found to occur frequently in these groups, but the factor which showed a statistically significant association in every center was contact with domestic animals alone. The results of the other factors were difficult to interpret because they differed among centers and the reliability of the answers to questions was uncertain. Moreover, it was difficult to determine the influence of the seasons on changes in eosinophilia because the study does not focus on individual cases. Next year, each center is scheduled to ascertain the seasonal changes in 50 to 100 individual cases of eosinophilia.

Personal communication from a staff member of the Korosten center indicated that there was a large number of cases in which eosinophil count returned to normal after administration of antihelmintic agents. This finding combined with the significantly high prevalence of eosinophilia observed in children with domestic animals suggests the involvement of parasites in these eosinophilia cases. No correlation was noted with malignant tumors such as malignant lymphoma (ML). In view of the report that eosinophil chemotactic factor is excreted by the platelets (Blood, 81, 49, 1993; Burgers, J. A. *et al.*), we also studied the correlation between eosinophil and platelet counts. Although a correlation existed between the two counts, the correlation coefficient was not large (thrombocytosis was observed in 1 to 2% of the subjects). It seems likely, therefore, that different mechanisms are responsible for the eosinophilia and thrombocytosis observed this time.

3) The relationship between rate of hematological abnormalities and i) dose (^{137}Cs level) and ii) area of residence

We did not observe any particular correlation between ^{137}Cs specific activity of the whole body and the rate of hematological abnormalities. This is thought to be due to insufficient statistical analysis resulting from the fact that more than about 80% of the cases had ^{137}Cs levels less than 50 Bq/kg and that there were very few cases in the 200 Bq/kg or more group. With regard to the correlation between ^{137}Cs levels and area of residence, the assessment based on current address may not be accurate because many of the subjects moved from contaminated to uncontaminated areas or are living in the relatively uncontaminated parts of contaminated areas. In future questionnaires, therefore, it is necessary to obtain accurate information about place of residence at the time of the accident and to investigate the above correlation on the basis of this information.

4) The detection of hematological diseases

In the present survey, we found hematological diseases such as leukemia, idiopathic thrombocytopenic purpura (ITP) and hemolytic anemia among the subjects. This is undoubtedly a result of improvements in the diagnostic capabilities and understanding about hematological diseases at each center. These efforts must be maintained to ensure that no hematological disease goes undetected. The above cases did not exhibit a correlation with either ^{137}Cs specific activity or area of residence.

In some of the anemia cases, MCV was not necessarily low and there were specimens in which spherocytes and elliptocytes were observed. It will be necessary in the future to pay attention to the morphology of erythrocytes and to begin examinations with a careful check for reticulocytes and other structures.

5) The handling of subjects with hematological abnormalities

Our basic stance from the beginning has been to conduct re-examinations and to accurately determine the causes of abnormalities in subjects presenting abnormal findings in various blood tests. However, the reality of the situation is that inconvenient transportation, summer vacations, financial problems and other factors have made it difficult to improve the rate of re-examination. Still, as shown by the detection of leukemia in the present survey, re-examinations are vitally important and ongoing efforts should be made to conduct as many as possible. Follow-up studies are particularly necessary in subjects showing abnormal findings at a single blood examination.

It is our plan now to determine whether or not the Sasakawa Project subjects are included in the registry of hematological malignancies in each republic and then to investigate the annual incidence of each hematological disease.

From the above results, we intend to pay special attention to the following issues during the remaining time. i) Since the current examination system provides few opportunities to detect acute hematopoietic disorders such as acute leukemia, efforts must be made to improve the re-examination rate for abnormal subjects and to achieve early detection. ii) Diagnoses must be confirmed through the repeated follow-up examinations of abnormal subjects. iii) Questionnaires must be filled in accurately, particularly the sections on the place of residence at the time of the accident, the results of tuberculin reaction test, the presence of allergic diseases, etc. iv) Thoroughgoing observations must be made on all the forms of blood cells in the peripheral blood picture, especially that of lymphocytes and red blood cells. Care must be taken to ensure that the introduction of NE-7000 does not result in neglect concerning the classification of blood cells in the peripheral blood picture by direct microscopic examination.

Comments on the Workshop in Moscow

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Hiroshima University

1. Introduction

Three years have passed since the start of the five-year Chernobyl Sasakawa Health and Medical Cooperation Project. The results of the past three years were discussed at the present workshop in Moscow, particularly the results of measurements for ^{137}Cs specific activity in the whole body of the examined children. The ^{137}Cs per unit body weight was expressed in graphs according to 1) age and sex and 2) place of residence. No remarkable differences were observed between this year's results and those reported previously. Moreover, the difference with regard to place of residence was particularly prominent in Gomel Oblast.

For these results to serve a useful purpose, the establishment of individual dose estimates is indispensable. Research is being directed toward this end because no effective method has been found to date. Among other things, we are investigating the contamination of fields and cesium levels in the body to determine the role of soil contamination, and also attempting to estimate external radiation doses using bricks.

2. The reports at the workshop

As readers will see in this booklet, each center presented three different figures to illustrate the data on dose. These are 1) a map of each rayon showing the state of contamination in the oblast in which the center is located; 2) the differences in ^{137}Cs specific activity in the whole body by age and sex; and 3) the differences in ^{137}Cs specific activity in the whole body by rayon of residence. Both 2) and 3) were presented by means of box-and-whisker plots.

As in past years, the results showed no differences by age or sex, and the regional difference was most prominent in Gomel Oblast. Generally speaking, the ^{137}Cs specific activity in the whole body tended to be higher in the severely contaminated areas, and in certain centers there were areas where the level was higher in lower age groups and areas where it was higher among boys than girls in the older age groups. Although negligible in all instances, the differences deserve ongoing attention, not only because they might reflect actual trends but also because it is possible that errors have occurred in the various estimates.

3. The collection of bricks in Mogilev and Gomel

Research concerning the relationship between ^{137}Cs in the soil and in the body has been underway since last year. From this year we have also been collecting bricks. I would like to describe this first collection and also the plans concerning this research.

[Purpose]

Bricks are used to estimate external radiation doses. Estimates of above-ground radiation levels and radiation levels of soil collected simultaneously are also conducted.

[Methods and Collection]

With regard to bricks, estimates are conducted by the thermofluorescence method in Japan and then used to estimate the accumulated radiation levels after the Chernobyl accident. At the present collection site, we are employing a survey meter and the thermofluorescence method or glass dosimeter to measure accumulated radiation in bricks, soil contamination and above-ground radiation. If we find an interesting correlation among these three levels using these two methods, we will be able to determine accumulated radiation levels from the soil or above-ground radiation levels at other sites.

On May 11, we traveled about one and a half hours by car to an evacuated area in the suburbs of Mogilev to collect bricks. In all, we collected 15 bricks from three houses (three each and two each from the exterior and interior of the houses, respectively). We also obtained soil samples from 25 points in a 3 $\times$5 m area at each collection site. Survey meter readings were taken at eight points per house. Glass thermofluorescence meters were installed at three locations on the exterior and two locations in the interior of each house and will be collected after one year. On May 12, we visited the local government office to do the paperwork necessary to ensure that the samples did not undergo X-ray examination at Sheremetyevo Airport when we carried them back to Japan (X-ray exposure would affect subsequent radiation measurements). In the afternoon, we traveled to the Gomel Center.

On May 13, we traveled to uninhabited areas within a 30-kilometer radius of the Gomel Center and found many appropriate houses, but because of insufficient equipment we collected samples at only one site, and that was not a house but the entrance to a food storage cellar.

The next day we finished the procedures necessary to take the samples back to Japan. A diamond cutter and other special tools are necessary.

We carried the bricks to Moscow on the bus used by the Gomel Center to transport conference participants. We were able to bring the samples through Sheremetyevo Airport without X-ray examinations, and when we arrived in Japan the customs officials allowed us into the country without opening the boxes.

[Future Plans]

In the near future, a Japanese scientist will visit Russia again to give a diamond cutter to the persons in charge at Mogilev and Gomel and to provide instructions about collection methods. A group of Japanese specialists will visit Russia again in the autumn to obtain samples, but we hope to have the Russian specialists carry out the collections beforehand.

4. Conclusion

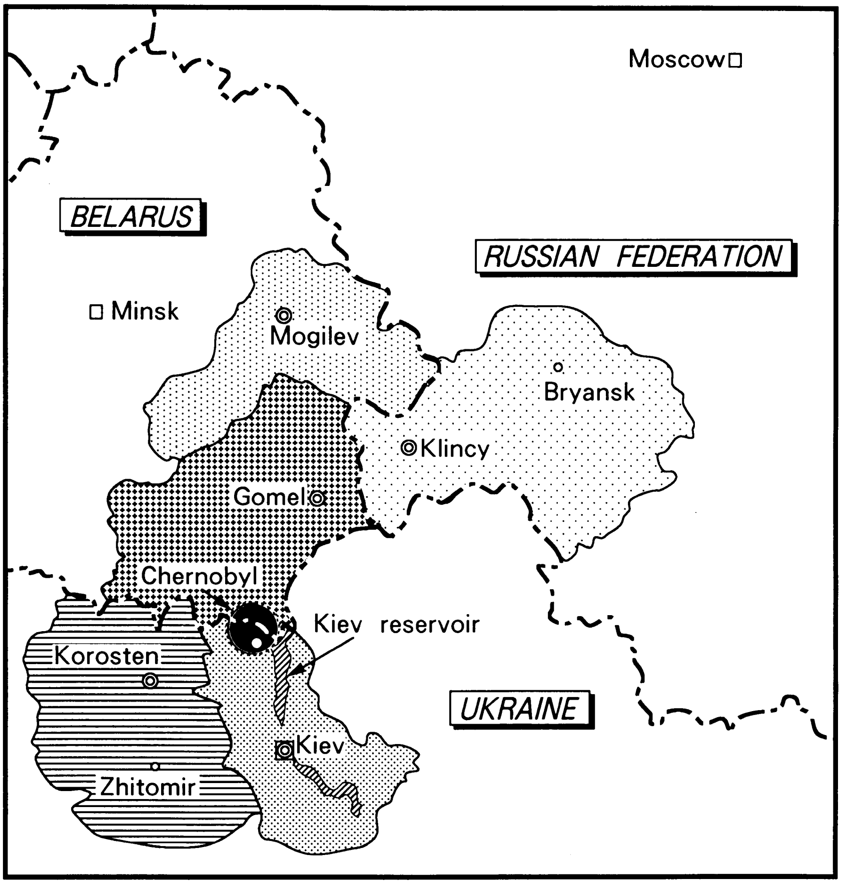
The examinations using mobile laboratories is proceeding well at all five centers, and we are hopeful that no major problems will arise in the future.

Although by no means an easy task, we intend to continue in our efforts to obtain individual dose estimates. It is important to estimate the status of iodine contamination, but we cannot measure ^{131}I because it has a half-life of only eight days. Instead, we are considering the possibility of measuring ^{129}I, which is also generated by nuclear reactors and was probably emitted in the accident and which, moreover, has a long half-life.

III. Appendix

Appendix A

Location of the Five Centers



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

Appendix B

Directory of Five Centers and Coordinating Office

Republic of Belarus

Gomel Specialized Medical Dispensary
Bratyev Lizyukovich 5, Gomel, Belarus 246029
Head Doctor: Dr. Viktor E. Derzhitsky
Tel: 7-0232-48-7120 Fax: 7-0232-53-1903

Mogilev Regional Medical Diagnostic Center
Pervomayskaya 59, Mogilev, Belarus 212030
Head Doctor: Dr. Tadeush A. Krupnik
Tel: 7-0222-22-4745 Fax: 7-0222-22-2997

Russian Federation

Klincy City Children's Hospital
Sverdlovskaya 76, Klincy, Bryansk Area, Russian Federation 243100
Head Doctor: Dr. Alexey A. Averichev
Tel: 7-08336-2-0454 Fax: 7-08336-2-2411

Ukraine

Kiev Regional Hospital No. 2
Nesterovsky per 13/19, Kiev, Ukraine 253053
Head Doctor: Dr. Vladimir V. Elagin
Tel: 7-044-225-5025 Fax: 7-044-212-3412

Korosten Inter-Area Medical Diagnostic Center
Kievskaya 21b, Korosten, Zhitomir Area, Ukraine 260100
Head Doctor: Dr. Valeriy V. Danilyuk
Tel: 7-04142-3-2001 Fax: 7-04142-3-0459

Coordinating Office

Moscow Office of Sasakawa Memorial Health Foundation
117049 Mytnaya Street 1, Moscow, Russian Federation
Manager: Mr. Mikhail B. Bondarenko
Tel: 7-095-237-1518/1306 Fax: 7-095-230-2605

Appendix C

Major Activities of the Chernobyl Sasakawa Health and Medical Cooperation Project: 1991–1993

Date	Event
Early 1990	A request is received from the former USSR to Sasakawa Memorial Health Foundation for direct humanitarian assistance
August	A group of Japanese scientists headed by Mr. Y. Sasakawa visits Chernobyl and the related areas and medical institutions.
November	Japanese specialists visit the then All Union Scientific Center of Radiation Medicine in Kiev
26 April 1991	Five mobile diagnostic buses are donated
May	The project staff of the five centers receives training at Obninsk.
May-July	Japanese scientists and staff visit and stay at the five centers
September	The project staff of the five centers receives training in Hiroshima and Nagasaki
October	Working group conference is held in Moscow
December	Japanese staff visits the five centers
January 1992	Japanese scientists visit the five centers
	The Memorandum of Understanding between the Foundation and five centers is signed in Moscow
June	The First Chernobyl Sasakawa Medical Symposium is held in Mogilev
	Japanese scientists visit the five centers
November	Japanese scientists visit the five centers
January-February 1993	Japanese scientists visit the five centers
April	The First Workshop is held in Moscow
	The project staff of the five centers receives training in Hyogo
June-July	Japanese scientists visit the five centers
	The Second Workshop is held in Moscow
October	The Second Chernobyl Sasakaws Medical Symposium is held in Korosten
	Japanese scientists visit the five centers

Postscript

The 3rd workshop was held in the suburbs of Moscow and the reports by the staff of each center and the sub-meetings in the respective specialties proceeded smoothly. All the centers were very well prepared, but unfortunately schedule limitations hindered exhaustive discussion on some topics.

The year-long efforts of the centers to elevate the level of medical treatment in the examination sites and to improve the quality of pediatric examinations despite enormous social and economic difficulties are certainly worthy of praise. And, as always, the present workshop was made possible through the support of numerous people behind the scenes. The reports by each center are accompanied by comments from specialists in the fields of thyroid studies, hematology and dosimetry. Strictly speaking, there may be serious problems in each field of study. But in view of the circumstances in the examination sites and the situation in each country, the persons involved in the project deserve admiration and gratitude for the amazing speed and level of quality at which the pediatric examinations have been conducted.

The past year has seen the steady accumulation of the results of our investigations. Although generated by a tragic accident, these results concerning the "effects of radiation on humanity" are indeed a valuable asset to all mankind. The reports in this volume present details on the health status of approximately 55,000 persons examined between May 1991 and December 31, 1993. The results were collected and edited independently by each center as part of a unique international medical cooperation project conducted jointly by Belarus, Russia, Ukraine and Japan.

In the future the project will probably shift from an exclusively humanitarian undertaking to a sophisticated examination program with greater emphasis on scientific analysis. This shift will be aided by the excellent reputation that the project enjoys among the various international conferences on Chernobyl. It is our great pleasure, by the way, to report that we were recently honored with an unexpected special commendation from United Nations Secretary-General Boutros Boutros-Ghali. Along with all the other persons involved in the project, we renew our determination to provide accurate information and appropriate diagnoses and treatment to the residents of the affected areas on the basis of this report and further scientific analyses.

The fact that we were able to prepare this workshop report in a short period of three months is due in large part to the selfless efforts of the staff at the Mogilev Center. We would like to extend special thanks to Mr. N. Dolbeshkin, P. Gaiduk and V. Kovalev, who performed data processing and prepared the tables and graphs for all five centers, and to Ms. L. Godum who translated

the Russian manuscripts into English.

Editors
Shunichi Yamashita
Kingo Fujimura
Masaharu Hoshi
Yoshisada Shibata

August 1994

CHERNOBYL SASAKAWA HEALTH AND MEDICAL COOPERATION PROJECT