Current State of Epidemiological Studies in Belarus about Chernobyl Sufferers

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Introduction

The present paper is an analysis of the results of epidemiological studies in Belarus about the after-effects of the accident at the Chernobyl atomic power station (ChAPS), based on published data at scientific institutes, organs and institutions of Ministry of Health. The special system in the Republic of sanitation for the affected population and its statistical outcome allows to obtain annually the data on morbidity and mortality of different cohorts of this population. The health both of the affected by the catastrophe and of the whole population of the Republic is influenced by economic, environmental (i.e. of natural and social medium) factors connected with individual behaviours, medical and sanitary situation. The higher level of disease incidence among the affected people can be explained, in a certain degree, not only by the ChAPS accident after-effects but also by the established sanitary system and improved diagnostics quality. Meanwhile, the adduced data are of interest as a basis for long-term observation, evaluation of tendencies and choice of directions of priority in further researches.

The adduced material indicates aggravation of health state of the republican population, especially of those who suffered as a result of the ChAPS catastrophe. Undoubtedly, the higher disease incidence of the affected people (which constitute a fifth part of the total population) increases the morbidity in Belarus as a whole.

1. State Register of persons affected by radiation due to the Chernobyl APS accident

The Belarus State Register was created upon the Decree of Council of Ministers of Republic of Belarus No. 283 of 5 May 1993 following the Article No. 63 of the Law of Republic of Belarus "About Social Protection Of Citizens Affected By Chernobyl APS Catastrophe" [29].

The State Register is aimed at supervising health state of the people affected by radiation due to the Chernobyl APS accident, as well as at obtaining verifiable data on the bio-medical consequences of the accident.

The State Register consists of four levels of observation: republican, regional, district and the level of institution performing sanitation.

The responsible for holding the State Register and using its data are the next:

- On the republican level - Center of Medical Technologies, Information, Management and Economics of Health of the Ministry of Health of Republic of Belarus (BCMT);
- On the regional level - offices and departments of health of regional executive committees and Minsk Municipal Executive Committee;
- On the district level and level of medical institution - local medical organizations, central district hospitals of the system of Ministry of Health, special medical institutions of other Ministries and organs.

The Ministry of Defence, Ministry of the Interior, Committee of State Security, Administration of Belarus Railway and Belarus Administration of Civil Aviation provide the information to the State Register about the persons under control at their institutional medical organs.

The following groups of persons are to be included into the primary account of the State Register:

- First group (Group 1):
  - Group 1.1) those who took part in the liquidation of the Chernobyl APS accident consequences within the evacuation zone in 1986-1987 or who were engaged in that period in the exploitation or other works at the Station (including provisional staff), including soldiers and civil citizens mobilized and engaged in works related to the liquidation of the accident consequences;
  - Group 1.2) those who took part in the liquidation of the Chernobyl APS accident consequences within the evacuation (alienation) zone in 1988-1989 or who were engaged in that period in the exploitation or other works at the Station (including provisional staff), including soldiers and civil citizens mobilized and engaged in works related to the liquidation of the accident consequences;
  - Group 1.3) those who took part in the decontamination, construction and provision of life of people in 1986-1987 in the zones of primary and following resettlement including servicemen and civil citizens mobilized and engaged in mentioned works;
- Second group (Group 2): those who were evacuated from the evacuation zone as well as those who independently left this zone after the catastrophe;

- Third group (Group 3):
  - Group 3.1) those who live or work in the zone of primary resettlement as well as those who were resettled or independently left this zone after the catastrophe;
  - Group 3.2) those who live or work in the zone of following resettlement as well as those who were resettled or independently left this zone after the catastrophe;
- Fourth group (Group 4): children born by persons attributed to the Groups 1-3 of the primary account except for children included into the 2nd and 3d groups of primary account;
- Fifth group (Group 5):
  - Group 5.1) those who live or work in the zone with right to resettle;
  - Group 5.2) those who live or work in the zone of living under periodic radiation control;
  - Group 5.3) those who live in the settlements where the average equivalent dose or irradiation is higher than 1 mSv/year;
- Sixth group (Group 6): those who took part in the liquidation or suffered from accidents and their consequences at other civil or military nuclear objects as well as who suffered from mentioned accidents or as a result of tests, exercises and other works connected with any species of nuclear installations including nuclear weapon. This fact is to be acknowledged by the corresponding documents of institutions which supervise mentioned objects.

2. Demographic situation in polluted areas

In 1995, 1,840,951 people lived on radiocontaminated territories, including 483,869 children and adolescents. 41,282 of them lived in the zone of following resettlement, including 9,821 children and adolescents.

In connection with revision of pollution maps of the republican territory with radionuclides (Decree of Council of Ministers No. 116 of 19 February of 1996 “About the Confirmation of List of Territories (Settlements and Other Objects) Related to Zones of Radiation Pollution”), the number of settlements situated on polluted territories decreased from 3,221 in 1995 to 2,930 in 1996. The number of population living there decreased correspondingly to 1,625,981 (11.7%). The number of settlements in the zone of following resettlement decreased especially - 50.6%, and the number of residents there - 40.8%. The percentage of the children of 0-14 among those who live on the polluted territories constitute 22.1% (23.7% among townspeople and 19.1% among rural population). By the regions, this rate is something different: in the Brest region the share of children of 0-14 is 27.9% among townspeople and 21.2% among rural people; in the Gomel region - 23.2% and 19.0%, in the Mogilev region - 27.3% and 17.9%, respectively. The share of children in towns on the polluted territories is registered to be higher as compared with total population. Whereas a lower share of children is registered among the rural population of the affected territories as compared with that of the total rural population.

In a considerable degree this may be attributed to so-called “ageing” of the rural population of the affected territories as a consequence of movement of working-able people. In the majority of rural settlements the population of 60 and elder constitutes more than 40%.

In 1995, the tendency to growth of mortality and decrease of birth rate continued in the Republic (Table 2.1). The natural growth of population decreased more

Table 2.1. Coefficients of birth rate, mortality and natural increase of population in the Republic of Belarus (per 1000 people)

Years	Number of new-born persons	Number of dead persons	Natural increase	Infantile death rate per 1000 of born alive persons
1980	16.0	9.9	6.1	16.3
1981	16.2	9.6	6.6	16.7
1982	16.3	9.6	6.7	15.8
1983	17.6	9.9	7.7	15.0
1984	17.0	10.5	6.5	15.1
1985	16.5	10.6	5.9	14.5
1986	17.1	9.7	7.4	13.4
1987	16.1	9.9	6.2	13.4
1988	16.1	10.1	6.0	13.1
1989	15.0	10.1	4.9	11.8
1990	13.9	10.7	3.2	11.9
1991	12.9	11.2	1.7	12.1
1992	12.4	11.3	1.1	12.3
1993	11.3	12.4	-1.1	12.5
1994	10.7	12.6	-1.9	13.2
1995	9.8	12.9	-3.1	13.2

and constituted (-3.1) per 1000 people. The same tendency was registered in the Brest, Gomel and Mogilev regions. The infantile death rate was still on the level of 1994 and increased somewhat in the Mogilev region [27, 2].

3. Dosage monitoring in Belarus

The highest average irradiation doses were registered in the participants of liquidation of ChAPS accident consequences. The whole-body irradiation doses within 50-100 mSv were obtained by 30% of "liquidators", 100-250 mSv - 47%, 250-500 mSv - 7.3%. The comparable doses were obtained by the evacuees from 30-km zone.

The residents of areas with pollution density of 555-1480 kBq/m^2 obtained average doses of irradiation of 50-60 mSv from the moment of the accident. Those who live on territories with pollution density less than 555 kBq/m^2 obtained 20-40 mSv.

The external irradiation dosage of population of radiocontaminated areas stabilized notably by 1989-1990. The average annual doses of internal irradiation of the people in the areas under strict control decreased by 10 and more times as compared with 1986, and, as a rule, do not exceed 0.2-0.5 mSv per year. The internal irradiation is, however, still a leading dose-forming factor on the territories with pollution density with Cesium-137 less than 185 kBq/m^2 [8]. The dosage of irradiation with strontium and plutonium radionuclides is not higher than 5% of total effective equivalent dose and constitutes 0.02-0.06 mSv per year.

The Catalogue of Irradiation Doses in Belarus is composed of settlements situated on the territories with soil pollution higher than 37 kBq/m^2. Some settlements with soil pollution lower than 37 kBq/m^2 are also included, where, by the data of sanitary service, the radionuclide contents in food products produced in these settlements are higher than the republican norm.

The analysis of annual effective equivalent dose (EED) confirmed the conclusion that the isoline of irradiation dose of 1 mSv/year passes in the majority of cases through the territory with the density of pollution with Cesium-137 of 148-222 kBq/m^2. Besides, a number of settlements of Belarus "Palesse" situated on the areas with soil pollution of 37-185 kBq/m^2 and lower are characterized by abnormally high coefficients of cesium transfer in "soil-milk" chain, and, as a consequence, the level of annual EED in them is higher than 1 mSv.

The collective dose of Belarus habitants in the post-accident period constituted nearly 22,000 man-Sv (Table 3.1). Whereas 16,625 man-Sv were obtained from external irradiation, and 5,343 - from internal irradiation. Nearly 80% of external irradiation of the collective dose were realized on the territory of two most polluted regions: the Gomel region with Gomel city (60%) and the Mogilev region with Mogilev city (20%). The rural population of the Republic obtained 47% of the collective dose of external irradiation. The corresponding figures in the Gomel region and in the Mogilev region are 50 % and 70%, respectively [12, 23, 34].

The analysis of collective doses of internal irradiation shows that nearly 50% of collective dose in Belarus in the post-accident period were realized in the Gomel region, and 20% - in the Mogilev region. 60% of the internal collective dose fall on the rural population of the Republic though the number of rural people constitutes 35% of the total Belarus population.

Table 3.1. Collective doses of irradiation of Belarus habitants in 1986-1994, man-Sv

Region, city	Age groups of rural population, years				Age groups of townspeople, years				Sum
	0-6	7-14	15-17	>18	0-6	7-14	15-17	>18	
Brest region	23	105	37	967	15	68	23	398	1,636
Vitebsk region	2	11	3	95	3	13	5	79	211
Gomel region	141	693	239	6,276	99	499	172	2,886	11,005
Grodno region	8	36	12	319	7	32	12	189	615
Minsk region	9	45	15	408	9	41	14	234	775
Mogilev region	67	315	109	2,904	23	109	38	636	4,201
Brest city					2	10	3	58	73
Vitebsk city					2	8	3	46	59
Gomel city					71	335	115	1,950	2,471
Grodno city					3	13	5	78	99
Minsk city					11	50	17	289	367
Mogilev city					13	62	21	370	456

Table 3.2. Collective doses of thyroid irradiation, man-Sv

Region	Age groups, years			
	0-6	7-14	15-17	adults
Brest	7,279	3,137	985	17,651
Vitebsk	1,156	491	152	2,566
Gomel	80,797	34,737	10913	189,301
Grodno	3,010	1,297	410	7,114
Minsk	5,983	2,579	806	13,048
Mogilev	18,810	8,088	2,540	43,643

The analysis of values of thyroid irradiation dose shows that the highest collective dose had formed in the Gomel region habitants (Table 3.2). The principal contribution into the collective dose was made by three mostly polluted districts of the Gomel region: Bragin, Narovlya and Khojniki. Their contribution constitutes 30% of the collective thyroid dose in the Gomel region, while the contribution of the rest 19 districts - 70%.

Almost 20 % of the children of 0.5-2 years and 0.64 % of adults obtained thyroid doses over 1,000 cGy among the habitants of villages of the Khojniki district of the Gomel region resettled before 5 May of 1986 [5].

The radioiodine influence over thyroid took place against the background of endemic goiter (characteristic of many areas of Belarus, especially Palesse) conditioned by the insufficiency of stable iodine in basic foods and water as well as by a number of other factors, in particular, manganese and copper deficit. This, probably, furthered the radioiodine oncogenic effect [20].

4. Cancer-register and malignant neoplasm incidence

The registration of malignant neoplasm in Belarus has been carried out since 1953. However, the registration was not complete in years 50's-60's because the number of oncological hospitals was not enough. The perfectioning of account started at the end of 60's - beginning of 70's and for the first time the full statistical data were obtained in that period. In the last years, the oncological institutions have been receiving regularly the current statistical information with a help of automated registration.

The increase of oncological diseases incidence is registered in the Republic during two decades (Table 4.1). For the 1976-1995 period, the standardized indices in the Republic as a whole increased by 54.1% in men and 35.4% in women; in the Gomel region - 66.2% and 56.1%, in the Mogilev region - 40.3% and 26.8%, respectively.

In the post-accident years, a tendency to increase of cancer incidence of separate locations continues in the regions which were mostly affected by radiocontamination. In the Gomel region, this is an increase of frequency of thyroid cancer in children and adults, tumours of lungs, rectum, colon, mammary gland, bladder and kidney. In the Mogilev region - neoplasm of thyroid, bladder, kidney and mammary gland. We must note therewith that acceleration of the disease incidence growth is reported concerning all forms of malignant neoplasm both in men and in women of the Gomel region [25, 26].

By the end of 1995, 130,541 persons were registered in Belarus: 49,298 men and 81,243 women. In the Republic on the whole, the number of oncological patients by the end of 1995 overreached by 16% the level of 1991; in the Gomel and Mogilev regions - by 29.8% and 24.9%, respectively.

The tumours of respiration and digestion organs are the principal oncological pathology of male population of Belarus (60.5% in the structure of oncological disease incidence). For women - this is the neoplasm of digestion organs, mammary gland and genitals, which constitute 56.6% in the structure of disease incidence

Table 4.1. Absolute number of newly revealed cases of malignant neoplasm in Belarus, 1976-1995

Region	Year										
	Before the accident					After the accident					
	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	1995
Brest	2247	2472	2427	2621	2781	3011	3150	3523	3741	3844	3949
Vitebsk	2852	2712	2918	2941	3303	3556	3728	4179	4241	4376	4558
Gomel	2584	2945	3001	3313	3257	3733	4004	4185	4477	4883	4964
Grodno	1985	1980	1964	2189	2285	2672	2992	2995	3092	3529	3442
Minsk	2581	2900	2926	3063	3304	3555	4002	4288	4811	5112	5061
Mogilev	2491	2527	2823	2836	3128	3310	3519	3685	3790	3788	3830
Minsk city	1897	2277	2249	2691	2902	3189	3702	4075	4529	4818	4634
Belarus	16637	17813	18308	19654	20960	23026	25097	26930	28681	30350	30438

[9].

The indices of malignant tumours incidence increased in men by 40.2 % and in women by 28.6 % during the 10 post-accident years [34]. The townspeople fall ill with malignant tumours significantly more frequently than the rural people do. Nevertheless the pace of morbidity growth is higher in the rural.

Taking into account the irradiation doses of residents of Belarus polluted areas, it is supposed that in 70 years after the accident the additional deaths from malignant neoplasm will constitute 4,250 cases. In this period, 2,345 cases of thyroid cancer will take place; 234 of them - with lethal end [11]. It is necessary to note that the real increase of this pathology presently is higher than the prognoses.

5. Peculiarities of thyroid cancer incidence in the Republic of Belarus

The Republic of Belarus in the middle of 80's occupied a place among the countries with low levels of incidence of thyroid pathologies. The average standardized index (number of cases per 100,000 persons) of morbidity in 1983-1987 constituted 1.9 for women and 0.6 for men. This was approximately the same level of disease incidence in Denmark, England, Slovakia, Poland, Yugoslavia and Latvia.

In the period from 1986 to 1994, there appeared a tendency to increase of thyroid cancer incidence (Table 5.1), especially from 1991 to 1994. By the data of Republican Oncological Thyroid Centre, only 3 cases of thyroid carcinoma in children were found during 7 pre-accident years. The considerable growth of number of cancer cases in children in Belarus began in 1990 (29 newly diagnosed patients). In 1991, 59 children were diagnosed and operated; in 1992 - 65; in 1993 - 79; in 1994 - 82 children [34].

According to pre-accident studies of thyroid carcinoma incidence in Belarus, there are considerable differences in its registered frequency by territories. The leading place on the frequency of this cancer location in Belarus in 1977-1985 was occupied by Minsk city: 0.8 patients per 100,000 men and 2.7 patients per 100,000 women. Meanwhile the average republican indices were 0.5 for men and 1.5 for women. The last place was occupied by the Brest and Grodno regions. The level of morbidity in the Mogilev region was something lower than the republican one for account of female population (1.3 against 1.5). The indices of morbidity in the Minsk, Vitebsk and Gomel regions were near to the republican level; therewith the ratio of incidence between women and men in the Gomel region was minimum (2.3:1). The maximum ratio of incidence between women and men in pre-accident period was registered in Grodno (6:1) and Brest (4:1) regions.

In the post-accident period, the situation changed abruptly. Already in 1987 the standardized index of thyroid cancer incidence in the Gomel region exceeded for the first time the level of 2.0 and constituted 2.9, against 1.7 in the Republic and 2.6 in Minsk city. This was apparently connected with increased alert of physicians and perfectioning of diagnostic means. During 1988-1989 the index of morbidity in the Gomel region lowered to 2.3. Then in 1990 it increased up to 4.0, while it was the same value in Minsk city and 2.7 in the Republic. The abrupt rise of morbidity was registered in 1991. The standardized index constituted 7.5 (4.6 for men and 10.6 for women) and was much higher than those in Minsk city (3.9) and in the Republic (3.6). Significant rise of thyroid carcinoma incidence was registered also in the Brest region: from 1.2 in 1988 to 3.4 in 1992 and to 6.1 in 1993, principally, due to the increase of share of sick children and young persons. In 1986-1994 the territorial difference within the Republic changed both in men and in women. The maximum morbidity level is registered now in the Gomel region.

The velocity of increase of morbidity in the post-accident period grew to be 1.5 times among the male population and 18 times among women as compared with the pre-accident period. In the Gomel region the velocity of increase of morbidity in men grew to be 6 times and 73 times - in women. The morbidity in the post-accident period increases more

Table 5.1. Indices of thyroid cancer incidence in the Republic of Belarus in periods from 1977 to 1985 and from 1986 to 1994 (number of cases per 100,000 persons)

No.	Age	Sex	Morbidity index	
			1977-1985	1986-1994
1	0-14	men	0.03	1.2
		women	0.1	2.0
2	15-34	men	0.3	0.8
		women	1.2	3.5
3	35-49	men	0.5	1.6
		women	2.4	8.3
4	50-64	men	1.3	2.5
		women	3.0	8.0
5	65 and elder	men	2.5	4.1
		women	3.9	7.0

slowly in men in the Vitebsk and Grodno regions, in women - in the Vitebsk and Minsk regions [1].

The post-accident period is characterized by acute increase of morbidity in children and young persons. The highest value of morbidity in women falls on the age group of 35-49 and constitutes 8.3. In men, like in 1977-1985, the peak is registered among the elderly people and constitutes 4.1. In 1986-1994, 333 children in Belarus fell ill with thyroid cancer. 180 of them lived in the Gomel region at the moment of the accident, 74 - in the Brest region, 19 - in the Grodno and Minsk regions, 6 - in the Vitebsk region, 16 - in the Mogilev region, 18 - in Minsk city. Due to migration, the morbidity index in the Gomel and Brest regions decreased somewhat and considerably increased in the Minsk region.

The notable rise of number of new cases of thyroid cancer among children began in the Gomel region in the fifth post-accident year, and in Brest region - in the seventh year [1]. Verifiable increase of thyroid carcinoma incidence is registered thereby in the Republic of Belarus in the post-accident period both in children and in adults. The highest velocity of morbidity increase is observed in children, adolescents and young adults. The mostly expressed increase is registered in the Gomel region which has undergone the pollution as a result of Iodine-131 release in the highest degree [28, 33, 34].

6. Haematological morbidity in the Republic of Belarus

The scientific haematological epidemiology did not exist both in the former Soviet Union and in Belarus, and the existing registers could not serve as a basis for any comparisons and conclusions of full value. Therefore, in 1988, the Republican Haematological Register was created at the Research Institute of Haematology and Transfusion of the Ministry of Health of Belarus, which is based on the requirements of international scientific haematology. The section of Register related to children's leukosology included 1,364 cases of acute leukemia from 1979 to 1992. In 1993-1994, other 156 cases of acute leukemia were registered in the Republic [34].

The frequency of acute leukemia in Belarus children (up to 14 years old) varied in separated regions and constituted in the pre-Chernobyl period 42.0 cases per 1000,000 children. After the Chernobyl accident this index constituted 43.3 cases per 1000,000 children.

Regarding to sex dependency, the frequency of acute leukemia in children before and after the Chernobyl catastrophe is distributed as follows: 46 (1979-1985) and 48 (1986-1992) cases per 1 mln of boys, and 37 and 39 per 1 mln of girls, respectively. Consequently, the boys fall ill with acute leukemia more frequently than the girls.

During 1979-1992, the highest index of chronic leukosis incidence in Belarus children was registered in the Brest region (3-4 cases per 1 mln). It varied in other regions from 0 to 1.5 (up to 3.5 in Minsk city) and had different tendencies in pre- and post-Chernobyl periods. Since 1992 the tendency to increase of leukemia incidence in children became stronger. The highest frequency of leukemia is in the Gomel region (60 cases per 1000,000 children), but it is followed by the Vitebsk region (48 cases) [22, 34]. The absolute number of children's leukemia cases (acute and chronic) is adduced in Table 6.1.

According to theoretical forecasts, the 9th, the 10th and following years after the radiation catastrophe may become critical for leukosis in children [11].

7. Hereditary pathology in Belarus and the Chernobyl catastrophe

The national genetic monitoring of congenital malformations (CM) has been functioning in Belarus since 1979. Only CM of strict criteria were studied up to 1994. Such CM are diagnosed in any institution related to child-bearing without special methods of study. The specialists in Belarus are quite familiar with them and know their heredity type; unencephaly, spinal cord hernias, cleft lip and (or) palate**,** polydactyly**,** reduction malformations of extremities**,** atresia of esophagus, Downs syndrome, multiple congenital malformations (without Downs syndrome). Besides, by the beginning of the Chernobyl accident, the monitoring of morphogenesis disturbances in embryos and early fetuses began to function in the Republic (since 1980) as well as the monitoring of syndromes of multiple congenital malformations (since 1983) and the monitoring of development

Table 6.1. Leukemia incidence in Belarus children (absolute numbers)

Before the accident		After the accident	
Year	Number	Year	Number
1979	119	1986	103
1980	97	1987	112
1981	99	1988	96
1982	86	1989	104
1983	94	1990	111
1984	92	1991	108
1985	91	1992	104
average 97		average 104	

disturbances in spontaneous abortuses (from 1968 to 1987) [18, 19, 34].

In order to study the possible genetic consequences of the Chernobyl catastrophe, a wide range of study was conducted on the people who had obtained additional irradiation due to radioactive fallout of ChAPS. That study included investigations of types and levels of chromosomal mutations in somatic cells, dynamics of development disturbance in embryos and fetuses, and analysis of congenital malformations (Table 7.1).

The frequency of dicentric and ring chromosomes in women examined immediately after the accident and in their new-born children was practically equal, but they were 10 times as high as in the control group. According to a comparative cytogenetic examination of the same persons before and after the Chernobyl accident, a 6-times increase of frequency of radiation-induced dicentric and ring chromosomes was observed too.

The level of dicentrics and rings in women and new-born children from the Mogilev region who stayed about two years on the polluted territories was higher than both the control level and the frequency of aberrations in women and children evacuated from the Gomel region two months after the accident. The investigations have shown thus that the evacuated pregnant women and their intrauterine fetuses obtained the biologically effective radiation doses as well as the women who have lived for a long time on the polluted territories. Those radiation dose manifested themselves in the growth of number of dicentric and ring chromosomes - the most important index of genetic effects of ionizing radiation on the level of chromosomes. The total mutagenic effect in the evacuated women turned out lesser than that in women living in strict control zone during two years [17, 32].

It was established based on the study of legal medical abortuses that the total frequency of development abnormalities in embryos in Minsk and Gomel cities remains on the pre-accident level. On the contrary, the frequency of development abnormalities in the mostly radiocontaminated districts of the Gomel and Mogilev regions in 1986-1992 was significantly higher than the control numbers. The frequency of all malformations increased in the polluted districts; in the highest degree - the frequency of cleft lip and palate**,** duplication of kidneys and ureters**,** polydactyly and nervous tube defects [18, 19, 34].

From the point of view of a number of specialists, the increase of hereditary pathology in Belarus can be explained just partially by the growth of mutations level under the action of additional ionizing irradiation. Apparently, the complex of negative factors in Belarus after the Chernobyl APS accident made a considerable contribution into the increase of CM frequency.

8. Morbidity and mortality of the people who suffered the ChAPS catastrophe (by the data of the State Register)

8.1. Analysis of morbidity of participants in the ChAPS accident consequences liquidation (Group 1)

The analysis of the data of liquidators in 1993-1995 was made in comparison with the morbidity of adults of the Republic in that period. 33,166 liquidators of Group 1.1 (workers in 1986-1987) in the State Register were under observation of medical institutions of Ministry of Health in 1993, as well as 19,052 liquidators of Group 1.2 (1988-1989). In 1994 - 39,682 and 20,556 liquidators, and in 1995 - 44,890 and 20,151 liquidators, respectively [3, 24].

In the assessment of health state of liquidators, it is necessary to take into account that the men of working-able age without chronic diseases were mainly sent to the liquidation of the ChAPS accident consequences. The average age of liquidators constituted 30-35 at the time of the accident.

Table 7.1. Absolute numbers / frequencies (per 1000 births) of congenital malformations of strict control in three zones of Belarus (1982-1992)

Year of observation	Zones of pollution		Control group ("clean" zone)
	1-5 Ci/km^2	>15 Ci/km^2	
1982	170/5.74	30/3.06	196/5.62
1983	123/3.96	37/3.58	167/4.52
1984	131/4.32	38/3.94	150/4.17
1985	135/4.46	46/4.76	165/4.58
1982-1985	559/4.61	151/3.87	678/4.72
1987	160/5.54	62/8.14	223/5.94
1988	134/4.62	73/8.61	190/5.25
1989	173/6.32	51/6.50	196/5.80
1990	199/7.98	40/6.00	221/6.76
1991	135/5.65	29/4.88	181/5.52
1992	141/6.22	47/7.77	175/5.89
1987-1992	942/6.01	302/7.09	1186/5.85
Coefficient of growth	1.3	1.8	1.2

Table 8.1. Comparison of morbidity of Belarus population (elder than 18) and liquidators (1995, number of cases per 100,000 persons)

Disease	Liquidators	Belarus population	Ratio
Thyroid cancer	23.06	7.10	3.24
Cataract	462.78	156.09	2.96
Malignant neoplasms of lymphatic and blood-forming tissue	26.14	18.59	1.40
Respiration organs diseases	24780.91	23830.97	1.04
Digestion organs diseases	7784.20	1650.90	4.72
Endocrine system diseases, nutritional disorders, metabolism and immunity disorders	3427.02	517.53	6.62
Blood and blood-forming tissue diseases	304.42	69.42	4.38
Mental disorders	3251.75	1090.11	2.98

Table 8.2. Comparison of morbidity of Belarus population and evacuees from alienation zone (1995, number of cases per 100,000 persons)

Disease	Evacuees	Belarus population	Ratio
Thyroid cancer	12.66	7.05	1.79
Cataract	443.15	147.34	3.01
Malignant neoplasms	215.24	345.43	0.62
Respiration organs diseases	16599.14	25656.22	0.64
Digestion organs diseases	4216.26	1817.14	2.32
Endocrine system diseases, nutritional disorders, metabolism and immunity disorders	2367.69	583.86	4.05
Blood and blood-forming tissue diseases	278.55	73.88	3.77
Mental disorders	2317.04	1124.55	2.06

Concerning neoplasms, there appears a high level of anxiety among liquidators for thyroid cancer and its increase in three years, especially among the liquidators of Group 1.1 (1986-1987).

The increase of benignant tumours in liquidators, including thyroid, also attracts attention. It is more significant in Group 1.1.

The risk to fall ill with diabetes mellitus in all liquidators in 1993-1995 was 1.9-2.2 times as high as in the adult population on the whole. In liquidators of Group 1.1 it was 2.2-2.4 times. Mental disorders are a considerable problem for liquidators (relative risk 1.5-3.0) as well as the diseases of nervous system and sense organs (relative risk 1.5-2.1) including cataracts (relative risk 2.1-3.0), especially for liquidators of Group 1.1 (relative risk 2.7-3.4). The higher incidence and its growth in liquidators, especially in Group 1.1, of cardiovascular system diseases composed of hypertension, ischemia, stenocardia, cerebrovascular diseases, endarterites and thrombocytes as well.

The most significant among the respiration organ diseases are chronic pharyngites**,** nasopharyngites**,** sinusites**,** diseases of tonsils, pneumonias, bronchitis. The risk of liquidators to fall ill with them is 1.4-5.7 times higher than the adult population on the whole [3, 15, 34, 31, 7].

In 1995, 506 liquidators were recognized as disabled (76.0 per 10,000). The disability of 276 out of them was connected with the Chernobyl accident consequences [6].

Thus the liquidators constitute a group of risk of many diseases (Table 8.1).

The mortality of liquidators in 1993-1995 is registered to be lower than that of men of 25-59. The growth of mortality of liquidators is, however, noted. The risk of death from malignant neoplasm for liquidators Group 1.1 is 1.6-1.9 times higher than that for liquidators Group 1.2.

8.2. Analysis of morbidity of adults and adolescents who were evacuated or independently left the alienation zone (Group 2)

By the end of 1995, medical institutions of Ministry of Health had under their observation 7,795 adolescents and adults who were evacuated or independently left the evacuation (alienation) zone in 1986 (Group 2 in the Register) [3].

Like other contingents of the sufferers, the evacuees have the increased level of incidence of endocrine system diseases, digestion disorders, metabolism and immunity disturbances, mainly for account of thyroid diseases (Table 8.2). The rise of thyroidites including autoimmune ones is observed; the diabetes mellitus incidence is increased. The incidence of blood and blood-forming tissues diseases is higher as well as of mental disorders (there is a tendency to increase), diseases of nervous system and sense organs. The high number of cataract cases attracts attention (in 1995 - 443.15 against 147.34 per

Table 8.3. Health state of evacuees from alienation zone: 1993-1995

Groups of evacuees	1993	1994	1995
Healthy (D1)	16.6	13.5	11.7
Practically healthy (D2)	26.5	26.3	31.1
Those who have chronic diseases (D3)	56.9	60.2	57.2
	100%	100%	100%

100,000 of population on the whole). An anxious fact is the high incidence of cardiovascular system diseases and its growth. The risk of this disease for Group 2 in the Registry during the analysed years was 3.1-3.9 times higher than that for the adolescents and adults of the Republic; 3.3-3.7 times concerning hypertension, 3.9-5.7 times - ischemia and 2.0-2.9 times - cerebrovascular diseases [3, 34, 7].

As an integrate assessment of health state of the evacuees, we can evaluate the ratio of health groups: D1 (healthy), D2 (practically healthy) and D3 (those who have chronic diseases). It is obvious that the share of healthy people among the evacuees is lowering (Table 8.3).

Disability of 26 persons (32.5 per 10,000) was recognized in 1995. The connection with the ChAPS accident consequences was established in 8 cases of them [6].

The mortality of the evacuated adults and adolescents in 1993-1995 was higher than the mortality of the adults and adolescents of the Republic on the whole, principally, for account of cardiovascular system diseases. The major causes of death of evacuees in 1995 were the next: the first cause was cardiovascular system diseases, on the second place - neoplasm, on the third place - symptoms and undetermined states, on the 4th and 5th places - diseases of digestion organs, traumas and poisonings, on the 6th place - respiration organs diseases [4].

8.3. Analysis of morbidity and mortality of adults and adolescents who lived or are living in the territories of primary and following resettlement (Group 3)

Group 3 in the Registry who had undergone radiation exposure as a result of Chernobyl APS accident constituted 66,440 persons by the end of 1995. 60.8% of them lived in the Gomel region, 15.6% - in the Mogilev region, 8.6% - in Minsk city, 4.4% - in the Vitebsk region, 4.1% - in the Minsk region, 3.3% - in the Grodno region and 3.2% - in the Brest region[3].

The comparative analysis of morbidity of Belarus adults and adolescents and Group 3 in the Registry (Table 8.4) shows that morbidity in 1995 of the adults and adolescents who live or lived in the zones of primary and following resettlement was reliably higher than the adults and adolescents of the Republic by a number of diseases [3, 10,34].

The malignant neoplasm of the residents of Group 3 who were living in “dirty” districts of the Gomel and Mogilev regions was registered more frequently than in persons of Group 3 in the Registry on the whole (461.55 against 369.55). The mortality of adults and adolescents of Group 3 was in 1995 reliably higher than that of the adults and adolescents of the Republic on the whole (1,777.63 against 1,638.32 per 100,000 persons). This includes, first of al,l cardiovascular system diseases (1,244.49 against 821.60), ischemia (625.16 and 525.72). This regularity was observed in every of three registration years (1993-1995) [14].

In 1995, disability of 362 persons of Group 3 was recognized. In 1994 and 1993 - 391 and 472. 28 cases of disability were connected with the consequences of ChAPS accident in 1995 (in 1994 - 48 cases, in 1993 - 46) [6].

8.4 Comparative analysis of morbidity and mortality of adults and adolescents of the Republic of Belarus and of the people those who are living in the zones with right to resettlement and with periodical radiation control (Group 5)

By the end of 1995, 1,354,262 adults and adolescents who lived in the zones with right to resettlement and with periodical radiation control were attributed to Group 5 in the Registry. 75% of this contingent lived in the Gomel region, 10.2% and 10.0% - in the Mogilev and Brest regions, and 2.5% and 2.3% - in Grodno and Minsk regions, respectively [3].

The comparative analysis of morbidity of Belarus adults and adolescents and of Group 5 (Table 8.5) has shown that morbidity in 1995 of the latter was reliably higher than the former by all range of diseases as a whole (57,549.27 against 57,091.01 per 100,000 persons).

As compared with 1994, morbidity of Group 5 in 1995 was higher by all range of diseases as a whole (57,549.27 against 56,827.63) [30, 16, 7 ,10]. The tendency to increase of morbidity in three years (1993-1995) was registered by all range of diseases as a whole, by neoplasms, and by urogenital system diseases. The number of common unspecified goiter was increasing constantly.

Table 8.4. The comparison of morbidity of Belarus population and of Group 3 (residents or migrants of primary and following resettlement) (1995, cases per 100,000 persons)

Diseases	Residents or migrants from polluted zones	Belarus population	Ratio
Thyroid cancer	2.92	7.05	0.41
Cataract	321.55	147.34	2.18
Malignant neoplasms	369.55	345.63	1.07
Respiration organs diseases	17479.77	25656.22	0.68
Digestion organs diseases	3298.18	1817.14	1.82
Diseases of endocrine system, nutritional disorders, metabolism and immunity disorders	1272.24	583.86	2.18
Diseases of blood and blood-forming tissue	175.28	73.88	2.37
Cardiovascular system diseases	4859.63	1629.90	2.98
Diseases of bone-muscle system and connective tissue	5166.37	3720.13	1.39
Symptoms and undetermined states	365.17	134.09	2.72
Mental disorders	1326.28	1124.55	1.18

Table 8.5. Comparison of morbidity of Belarus population and Group5, residents of zones with right to resettlement and periodic radiation control (1995, of cases per 100,000 persons)

Diseases	Residents of polluted zones	Belarus population	Ratio
Thyroid cancer	9.72	7.05	1.38
Cataract	194.34	147.34	1.32
Malignant neoplasms	328.25	345.63	0.95
Respiration organs diseases	24292.87	25656.22	0.95
Digestion organs diseases	2283.21	1817.14	1.26
Diseases of endocrine system, nutritional disorders, metabolism and immunity disorders	722.54	583.86	1.24
Diseases of blood and blood-forming tissue	100.84	73.88	1.36
Mental disorders	1014.96	1124.55	0.90
Urogenital system diseases	4176.90	2891.15	1.44

The mortality of adults and adolescents of Group 5 was in 1995 verifiably higher than the republican level by urogenital system diseases (20.50 against 16.67 per 100,000 persons) and blood and blood-forming tissues diseases (2.92 and 1.11). The verifiable growth of death rate in 1995 as compared with 1994 was registered in the adults and adolescents of Group 5 from all causes as a whole (1,605.10 and 1,556.79) and especially from the following four classes of diseases:
- neoplasm (228.16 and 216.80), including malignant (212.30 and 190.26);
- digestion organs diseases (28.13 and 23.77);
- urogenital system diseases (20.50 and 15.77);
- symptoms and undetermined states (194.87 and 153.56).

The principal causes of death of Group 5 in 1995 were the diseases of cardiovascular system (53.9% in the structure of mortality), neoplasm (14.2%), symptoms and undetermined states (12.1%), traumas and poisonings (9.2%), respiration organs diseases (4.8%). The number of patients with chronic diseases in Group 5 grew during last three years.

8,112 persons were recognized as disable in 1995 (in 1994 and 1993 - 7,780 and 8,952, respectively). The connection with radiation effects was found in 129 invalids in 1995, in 81 - in 1994, in 27 - in 1993 [6].

Conclusion

In the last years the affected population showed thereby more significant - as compared with republican indices - growth of incidence in the majority of diseases (first of all: digestion, urogenital, nervous, endocrine systems, diseases of ear, throat, nose both among adults and among children). Aggravation of health state continues in the participants of liquidation of the ChAPS accident consequences and the evacuees from the alienation zone which have obtained considerable radiation load to organism (rise of incidence of diseases of endocrine, cardiovascular, nervous system etc.).

Considerable growth of thyroid cancer incidence is registered in Belarus children and adolescents, especially in the Gomel and Brest regions. This is conditioned by dose commitments on thyroid gland due to iodine radionuclides in first period after the

accident, incorrect iodine prophylaxy, and goitre endemic,. The rise of hereditary pathology is registered too. An expressed increase of oncological diseases is observed therewith mainly in the Gomel region, especially in the districts with high level of radiocontamination and, consequently, significant radiation load. First of all, this relates to the growth of incidence of cancer of lungs, mammary gland, bladder.

The analysis of epidemiological studies performed in Belarus after the ChAPS catastrophe and comparison of them with data obtained in the pre-Chernobyl period testify to the aggravation of health state of Belarus population. The specialists unambiguously recognize the direct influence of radioactive pollution in the environment on rise of thyroid pathologies, hereditary and congenital diseases, and cancers of different localizations. There is no unique opinion about the dynamics of haematological diseases and their causes. The increase is observed therewith of those diseases which can not be simply attributed to radiation-induced ones. Probably, the cause of this is concluded in the combined action of the complex of unfavourable factors existing in Belarus such as;

- radiation factor,
- general aggravation of social-economical situation, decrease of level of life, irrational nutrition,
- psycho-emotional stresses,
- unfavourable ecological factors with non-radiation nature etc.

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