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COMPARATIVE ASSESSMENT OF THE CIRCULATORY SYSTEM DISEASES IN THE RECOVERY OPERATION WORKERS OF THE CHORNOBYL NUCLEAR PLANT AND EVACUATED ADULTS IN THE POST-ACCIDENT PERIOD

Kapustinska O. A.

State Institution «National Research Center for Radiation Medicine of National Academy of Medical Sciences of Ukraine», Kyiv

Introduction. According to experts from the World Health Organization, non-communicable diseases have become one of the main problems for health systems in the 21st century, negatively affecting sustainable development and the socio-economic structure of countries. Risk factors include adverse industrial and environmental factors, including ionizing radiation. A number of previous studies by Ukrainian scientists have shown a significant deterioration in the health of various contingents of the population affected by the Chornobyl accident, primarily from circulatory system diseases (CSD). Minimizing the medical consequences of the Chornobyl accident and increasing the effectiveness of medical care for persons exposed to radiation remain relevant.

The aim of the study is to investigate the dynamics and structure of the incidence of the circulatory system diseases in recovery operation workers and adults evacuated from the 30-km Chornobyl zone in the post accident period and provide a comparative assessment.

Materials and methods of research. The materials for the study were data from the State Register of Ukraine of Victims of the Chornobyl Accident. For this purpose two retrospective cohorts of recovery operation workers and adult evacuees were formed. The observation period was from 1988 to 2016. The incidence of CSD was studied depending on age and time since the accident. Epidemiological, analytical, mathematical and statistical research methods were used. The main indicators were calculated by methods used in the modern epidemiology of non-communicable diseases.

Results. It was found that the incidence of CSD in recovery operation workers and adult evacuees throughout the observation period has the same steady trend, as CSD remains the leading pathology in the structure of non-neoplastic morbidity; maximum levels of circulatory system in the remote period (1998–2007) with a further decline in the last period; higher incidence rates were found in persons aged 40–60 years at the date of the accident; the main components of CSD are traditionally represented by coronary heart disease, hypertension and cerebrovascular disease. At the same time, the results of research revealed certain differences in the structure and levels of both the overall incidence of CSD and individual classes of pathology depending on age and time elapsed after the accident in recovery operation workers and adult evacuees. One of the main factors that led to the differences is the nature of the impact of ionizing radiation on recovery operation workers (higher radiation doses and duration of action) and the adult evacuated population (urgent evacuation of the population from the adjacent 30 km area; thyroid irradiation and total external gamma irradiation of the body).

Conclusions. A comparative analysis of morbidity among different groups of the affected population makes it possible to track changes in the state of health by individual classes and groups of diseases over time since the Chornobyl accident. An important role in preventing the development of diseases should be the consideration of individual and population risk factors leading to complications of CSD.

Key words: participants in the liquidation of the Chornobyl accident, population evacuated from the 30-km zone of Chernobyl, diseases of the circulatory system

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Introduction

Morbidity, disability and mortality from noncommunicable diseases constitute one of the leading problems in modern health care. Circulatory system diseases (CSD) account for the largest proportion. The World Health Organization has a policy of supporting research projects to assess noncommunicable disease risk factors and determine the effectiveness of interventions to address them [1–3].

Risk factors include adverse occupational and environmental factors, particularly ionizing radiation. Today a significant number of studies related to the medical consequences of the Chornobyl nuclear power plant (CNPP) accident have been carried out, primarily concerning the diagnosis and treatment of diseases, to a lesser extent epidemiological studies of the patterns of disease development in the distant period after the accident. A number of previous studies by Ukrainian scientists have established a significant deterioration in the health of different contingents of the affected population, which is due to the growth of a wide range of non-tumor diseases, namely: in recovery operation workers (ROW); in population evacuated from 30 km zone of Chornobyl NPP; in population living in the radioactively contaminated territory. The possibility of manifestation of the medical consequences of radiation effects on the Chornobyl accident victims in the distant period requires continuous medical monitoring of their health status [4–7].

Taking into account the fact that today in Ukraine four nuclear power plants are functioning and a large number of enterprises and institutions that use sources of radioactive radiation in their daily activities, the threat of technogenic accidents is existent. Besides, we must not forget about the risk of nuclear and radiation terrorism in the international arena. This could be a source of radionuclide contamination of large territories inhabited by hundreds of thousands of people. Therefore, minimization of medical consequences of the Chornobyl accident and increasing the efficiency of medical care for persons exposed to radiation not only remain relevant, but also remain a priority [8].

The aim of the study was to investigate the dynamics and structure of the morbidity of CSD among ROW and adults evacuated from 30-km Chornobyl zone in the post-accident period and to provide a comparative assessment.

Materials and methods of research

Two study cohorts were formed for epidemiological studies and estimations of post-accident health changes of the Chornobyl victims, caused by CSD, using the medical information system 'State register of victims of Chornobyl accident of Ministry of Health of Ukraine' (SRU) and data of Clinical and epidemiological register of the State Institution 'National Research Centre for Radiation Medicine of National Academy of Medical Sciences of Ukraine (NRC).

The first cohort was the ROW with a total population of 68,145; the second cohort was the adult evacuees with a total population of 42,982. All cohorts included only persons who were 18–60 years old at the date of the Chornobyl accident.

The main characteristics of the cohorts formed for the analysis are given in Table 1.

Two disease classifications were used during the study period – ICD-9 before 2002 and ICD-10 (in later years).

Studies were carried out for the whole class of CSDs as well as for the main groups and nosological forms.

To reach the purpose, the following research methods were applied: epidemiological, analytical,

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Table 1

Quantitative distribution of the victim cohort by age at the date of the accident

Cohort	Age at the moment of the accident		
	18–39 years	40–60 years	18–60 years
ROW	59 761	5784	65 545
Adult evacuees	27 376	15 606	42 982

mathematical-statistical, risk analysis. The main indicators were calculated according to the methods used in modern epidemiology of noncommunicable diseases (incidence rate by calculating the incidence rate (Incidence density) – ID/10^3 person-years, mean error (± m). Statistical results are presented as arithmetic mean (M) and standard error of the arithmetic mean (m). The significant level of statistical significance (p) was taken as < 0.05 [9].

Results of the research and their discussion

During 1988–2016, there was a definite redistribution in the structure of morbidity causes of ROW and adult evacuated population by disease classes. CSD s became the most important cause of morbidity, leading to high mortality and disability (Table 2).

In the early period, CSDs in the 18–39 age category rank third in ROWs, and in the evacuated adult population, they rank second. In the 40–60

Table 2

Structure of noncommunicable diseases in certain classes of diseases among the recovery operation workers and the adult evacuated population according to age at the date of the accident, %

Class of disease acc. to ICD-10	Observation period 1988–1992 (early)				Observation period 2013–2016 (late)			
	18–39 years		40–60 years		18–39 years		40–60 years	
	ROW	Evacuees	ROW	Evacuees	ROW	Evacuees	ROW	Evacuees
1. Circulatory system diseases (class IX)	18	16	32	48	33	27	31	29
2. Respiratory diseases (class X)	7	7	8	7	8	13	7	15
3. Diseases of digestive organs (class XI)	23	24	24	18	22	24	25	22
4. Mental and behavioral disorders (class V)	7	10	4	6	1	1	1	1
5. Diseases of the nervous system (class VI)	23	13	12	7	4	7	4	6
6. Endocrine diseases, nutritional disorders and metabolic disorders (class IV)	11	15	5	5	10	8	9	5
7. Diseases of the musculoskeletal system and connective tissue (class XIII)	8	7	3	6	11	15	12	15
8. Diseases of the genitourinary system (class XIV)	3	8	2	3	10	5	10	7

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age category, regardless of the cohort of victims, CSDs rank first. Thereafter, for many years (remote and late follow-up period), CSDs consistently rank first regardless of the cohort of casualties and age.

In the late observation period (2013–2016), the CSD contribution to ROW increased by 15.4 % in the 18–39 age group and by 11 % in the adult evacuee population. In the 40–60 age group, on the contrary, it decreased in ROW by 1.1 %, more markedly in the adult evacuee population (by 19 %).

The dynamics of the total level of morbidity in the cohorts of affected population according to the time and age at the date of the accident is shown in the Figure.

Comparative analysis of the epidemiology features of CSDs showed that the trends of morbidity are similar in ROW and adult evacuated population: throughout the observation period, the incidence rates of circulatory system (CS) in ROW exceed those of the adult evacuated population, the maximum CS incidence rates were noted in 1998–2007 regardless of the cohort of affected population. Subsequently, there has been a decrease in CS incidence rates in ROW and adult evacuees over the years, with the exception of the adult evacuee population of 18–39 years old.

The highest incidence rates in ROWs throughout the observation period have been established at ages 40–60, with the exception of recent years when the adult evacuee population aged 18–39 years has a slightly higher incidence rate. In the first period (1988–1992), a high incidence rate was established at ages 40–60, which should be explained primarily by factors such as «age», «screening effect». In 2013–2016, there is a clear decrease in the incidence of CS in both ROWs (1.2-fold in ages 18–39 years and 2.9-fold in ages 40–60 years) and in the adult evacuee population (3.8-fold in ages 40-60 years) relative to the early period, while in the adult evacuee population aged 18–39 years there is a slight increase in incidence.

The comparison of dynamics of CS morbidity depending on age has shown that in all periods of observation irrespective of a cohort of victims the higher parameters are established at persons at the age of 40–60 years.

At the early stage (1988–1992), the incidence rate in older ROWs was almost 3 times higher than in younger ones. In the most recent phase (2013–2016), the incidence of ROWs aged 18–39 years remains at an elevated level.

The basis of CS morbidity structure is traditionally formed by: coronary heart disease (CHD), hypertension (HD), cerebrovascular disease (CVD), diseases of arteries, arterioles and capillaries (arterial diseases) and diseases of veins, lymphatic vessels and lymphatic nodes.

The results of the study revealed differences in the levels and structure of CS diseases, which are typical for the early and late periods of observation.

At the early stage, the largest proportion in the formation of CSDs is contributed by HD regardless of the casualty cohort and age, but its contribution is less in the adult evacuees compared to ROWs (40.2 % and 59.2 %, respectively).

In the late period, CHD and CVD are leading regardless of cohort and age of victims, with slightly higher rates in ROWs, while the contribution of HD decreases.

The comparative analysis of CS morbidity according to the values of separate indices in two studied cohorts allowed to determine certain differences depending on age of the victims and time after Chornobyl accident; nosological forms which form disease groups and generally the class of CVD. In each cohort identical groups are separated with high level of indicators due to which CVD formation in general takes place.

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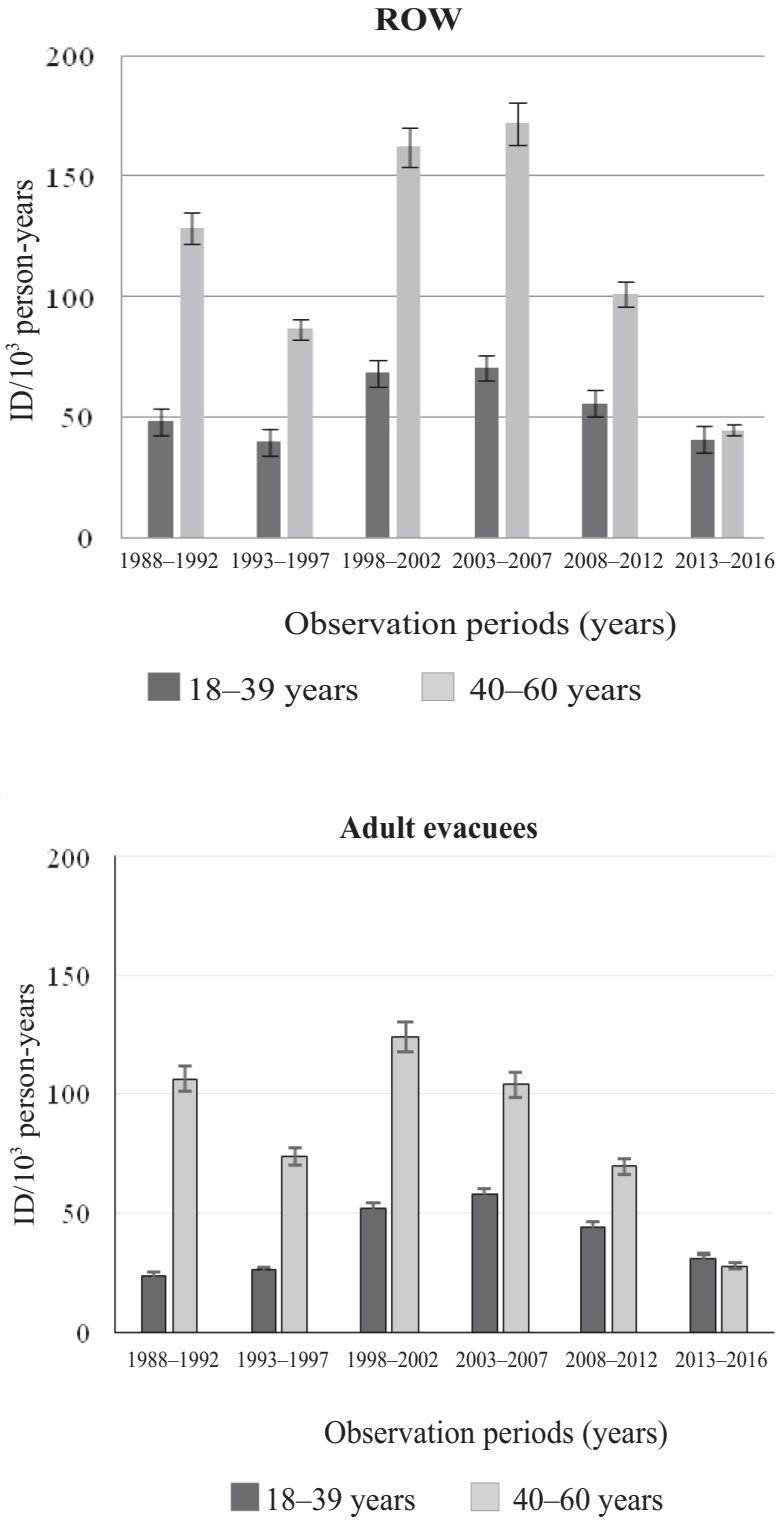

Figure. Dynamics of total circulatory morbidity in cohorts of the affected population depending on age at the date of the accident

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The dynamics of the morbidity rate for the main groups of circulatory system diseases for the evacuated population in the distant period after the Chornobyl accident depending on age is given in Table 3.

When analyzing the dynamics of HD, it was found that the highest rates were registered in the early period of observation, with ROWs 2.5 times higher than in the adult evacuated population, regardless of age. Thereafter, a gradual decrease in morbidity is observed. In the last period, the incidence of HD in the ROW decreased by a factor of 3.1, and in the adult evacuated population by a factor of 1.9. The high level of HD is due to the influence of negative factors accompanying the accident (ionizing radiation and psychological stress), which become the basis for the formation of somatic pathology afterwards. The high frequency of HD detection in the first years after the accident and its gradual decrease with time gives grounds to assert that in the early period special attention is paid to HD from the point of view of obligatory preventive measures.

The maximum incidence of CHD in the studied cohorts and in both age groups of the cohorts was found during the remote period (1998–2007). During all the following periods, the incidence rate of 40–60 year-olds exceeded the incidence rate of the 18–39 year-olds at the date of the accident. Thereafter, the rates decrease, but remain 3.4 times higher than at the early period. The high level of CHD morbidity at the early stage may indicate better detection and registration of CHD as a result of the annual targeted clinical examination of the victims of the Chornobyl accident.

The incidence of CVD is also increasing over time. At the early stage the morbidity at the age of 18–39 years is 1.4 times higher in the ROW, and at the age of 40 years it is 1.2 times higher in the adult evacuated population. During the latter period the picture changes: higher rates at the age of 18–39 years for adult evacuees, and at the age of 18–60 years for ROWs.

The findings are consistent with those obtained by other researchers in previous years [10, 11].

Conclusions

1. The comparative analysis of the features of CSD epidemiology in ROW and adult population shows that the morbidity of the Chornobyl accident victims has the same tendency, on the one hand, and certain differences, on the other hand.
2. The cohorts under study have the following in common: the leading pathology in ROW and the adult evacuated population remains CSD; the morbidity of CS is active in the first 7 years after the accident, 15–21 years later it is steadily high and 22–30 years later the morbidity decreases.
3. The study of age peculiarities of morbidity showed that in all the observation periods irrespective of cohorts of victims, higher CS morbidity rates are established at the age of 40–60 years at the date of accident. At the early stage (1988–1992), the morbidity rate of the older ROWs was almost 3 times more than that of the younger ones. At the latter stage, the difference in morbidity rates is less noticeable.
4. The 30-year dynamics of the morbidity structure of the circulatory system is characterized by the identity of the priority groups of pathology – HD, CHD, CVD, but by their different specific weight. In the early follow-up, the greatest share in the formation of CSDs is contributed by HD regardless of the casualty cohort and age, but its contribution is less in the adult evacuated population compared to ROW (respectively, 40.2 % and 59.2 %).

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Table 3

Dynamics of the morbidity rate for the main groups of circulatory system diseases for the evacuated population in the distant period after the Chornobyl accident in dependence on age (ID/10^3 person-years, ± m)

Group of diseases of blood circulation system	Age at the moment of the accident	Cohort of the people affected	Observation period (years)					
			1988–1992	1993–1997	1998–2002	2003–2007	2008–2012	2013–2016
Diseases of the circulatory system	18–39	ROW	49.5 ± 1.5	47.4 ± 1.3	76.6 ± 1.7	68.2 ± 1.7	49.2 ± 1.5	41.90 ± 1.88
		Evacuees	24.1 ± 0.7	26.4 ± 0.6	51.7 ± 0.8*	57.4 ± 0.8*	43.7 ± 0.8*	31.2 ± 0.8*
	40–60	ROW	115.1 ± 4.6	78.1 ± 3.2	122.2 ± 4.2	77.7 ± 3.7	55.5 ± 3.6	43.4 ± 4.3
		Evacuees	106.4 ± 1.6	73.7 ± 1.3	123.9 ± 1.6	103.9 ± 1.5	69.3 ± 1.6	28.1 ± 1.3
Hypertension disease	18–39	ROW	29.6 ± 1.2	15.8 ± 0.7	19.4 ± 0.8	16.5 ± 0.8	11.2 ± 0.7	9.5 ± 0.9
		Evacuees	12.0 ± 0.5	9.3 ± 0.4*	14.2 ± 0.4*	11.2 ± 0.4	10.6 ± 0.4*	6.2 ± 0.4*
	40–60	ROW	61.3 ± 3.4	20.1 ± 1.6	23.1 ± 1.9	12.7 ± 1.5	11.8 ± 1.7	7.4 ± 1.9
		Evacuees	24.3 ± 0.8	9.8 ± 0.5*	13.4 ± 0.5*	9.0 ± 0.5*	10.2 ± 0.6*	2.4 ± 0.4*
Coronary heart disease	18–39	ROW	4.4 ± 0.4	10.9 ± 0.6	24.2 ± 0.9	22.9 ± 1.1	19.2 ± 0.9	15.1 ± 1.1
		Evacuees	3.1 ± 0.2	4.9 ± 0.3*	12.7 ± 0.4*	15.8 ± 0.4*	13.8 ± 0.4*	11.1 ± 0.5*
	40–60	ROW	26.6 ± 2.3	29.3 ± 2.1	44.6 ± 2.6	26.9 ± 2.2	18.3 ± 2.1	12.3 ± 2.4
		Evacuees	61.7 ± 1.2	39.4 ± 0.9*	60.9 ± 1.1	38.3 ± 1.0*	28.3 ± 1.0*	6.6 ± 0.6*
Brain vessels damage	18–39	ROW	2.6 ± 0.3	8.1 ± 0.5	14.7 ± 0.7	14.8 ± 0.8	9.5 ± 0.6	8.1 ± 0.8
		Evacuees	1.8 ± 0.1	5.8 ± 0.3*	11.8 ± 0.4*	13.2 ± 0.4*	10.2 ± 0.4*	8.7 ± 0.4*
	40–60	ROW	6.2 ± 1.1	11.4 ± 1.2	31.8 ± 2.2	22.2 ± 2.1	16.1 ± 2.1	14.8 ± 2.6
		Evacuees	7.7 ± 0.4	15.3 ± 0.6*	27.6 ± 0.8*	25.1 ± 0.8*	14.4 ± 0.7*	11.7 ± 0.8*

*Note. *The difference is significant ($p < 0.05$) acc. to years 1988–1992 (the ages of 18–39 and 40–60).*

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5. In the late period, CHD and CVD dominate regardless of the cohort and age of victims, with slightly higher rates in ROWs, while the contribution of hypertension decreases.
6. Comparative analysis of morbidity among different groups of the affected population allows to trace changes in health by separate classes and groups of diseases in the time since the Chornobyl accident. Consideration of individual and population risk factors leading to CSD complications should play an important role in the prevention of disease development.

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Contact person: Kapustinska Olga Andriivna, State Institution «National Research Center for Radiation Medicine of National Academy of Medical Sciences of Ukraine», Kyiv. Tel.: + 38 0 63 757 05 05. E-mail: dianatim@ukr.net