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## СТРУКТУРА ТА ХАРАКТЕРИСТИКА ПРИЧИН СМЕРТІ ПОСТРАЖДАЛИХ ВНАСЛІДОК АВАРІЇ НА ЧОРНОБИЛЬСЬКІЙ АЕС ЗА МАТЕРІАЛАМИ МЕДИЧНОЇ ЕКСПЕРТИЗИ ЩОДО ПРИЧИННО-НАСЛІДКОВОГО ЗВ'ЯЗКУ ЗАХВОРЮВАНЬ З ДІЄЮ ІОНІЗУЮЧОГО ВИПРОМІНЮВАННЯ У ВІДДАЛЕНИЙ ПІСЛЯАВАРІЙНИЙ ПЕРІОД (2024 рік)

Проблема причинного зв'язку захворювання, що стало причиною смерті, з дією іонізуючого випромінювання у віддалений післяаварійний період внаслідок шкідливого впливу Чорнобильської катастрофи (у тому числі радіаційного опромінення) під час виконання професійних, військових чи службових обов'язків та/або проживання на радіаційно забруднених територіях що є додатковим опроміненням не з власної вини, а внаслідок радіаційної аварії, зумовило розвиток спеціальної форми медичної експертизи в системі медичного соціально-го захисту для постраждалих контингентів населення.

**Мета.** Вивчити та охарактеризувати структуру змін категорій постраждалих внаслідок Чорнобильської катастрофи у віддаленому післяаварійному періоді (2013–2023 рр.) щодо причинно-наслідкового зв'язку захворювання, що стало причиною смерті, з наслідками дії іонізуючого випромінювання та шкідливого впливу Чорнобильської катастрофи за матеріалами експертних справ Центральної міжвідомчої експертної комісії МОЗ України (ЦМЕК).

**Матеріал і методи.** Робота виконана в дизайні ретроспективного дослідження, що базується на аналізі структури всіх категорій постраждалих від аварії на Чорнобильській АЕС (ЧАЕС) впродовж 2008–2024 рр. та вивченні 58 137 медичних експертних справ, у тому числі 19 524 посмертних, котрі були розглянуті в 2013–2023 роках для встановлення причинно-наслідкового зв'язку між хворобою та впливом радіації, а також інших шкідливих факторів і умов внаслідок аварії на ЧАЕС.

**Результати.** Загальна кількість постраждалих дорослого віку станом на 01.01.2024 порівняно з 2008 роком зменшилась на 581 170 осіб, або на 31,68 %. Чисельність ліквідаторів аварії зменшилася на 124 382 особи (45,01 %), тобто за останні 15 років помер майже кожен третій-другий учасник ліквідації наслідків аварії на ЧАЕС. Кількість потерпілих дорослого віку зменшилася на 29,41 % (458 233 особи). У структурі медичних експертних справ провідне місце як захворювання, що стало причиною смерті, посідають онкологічні захворювання – 52,10 %, хронічні хвороби системи кровообігу та їх ускладнення становлять 42,00 % (серцево-судинної системи – 19,60 %, цереброваскулярної системи – 22,40 %), хронічні захворювання дихальної системи – 3,00 %, інші захворювання в цілому – 2,90 %. У структурі онкологічних випадків (n=10 172) впродовж 2013–2024 рр. основну причину смерті становлять онкогематологічні захворювання (18,00 %), рак товстого кишківника (15,00 %), рак молочної залози у жінок (13,00 %), рак передміхурової залози у чоловіків (11,99 %), рак легень і верхніх дихальних шляхів (8,01 %).

**Висновок.** У віддалений післяаварійний період (2013–2024 рр.) зросла потреба в експертизі причинно-наслідкового зв'язку захворювання, що стало причиною смерті, з дією іонізуючого випромінювання та наслідками аварії на ЧАЕС. Впродовж 2013–2024 років мало місце прискорене скорочення всіх категорій постраждалих внаслідок аварії на Чорнобильській АЕС. У структурі медичних експертних справ протягом 2013–2023 років провідне місце захворювань, що стали причиною смерті, посідають онкологічні, серцево-судинні та цереброваскулярні захворювання.

**Ключові слова:** іонізуюче випромінювання; учасники ліквідації наслідків аварії та потерпілі внаслідок аварії на Чорнобильській АЕС; медична експертиза причинного зв'язку захворювання з дією іонізуючого випромінювання та наслідками аварії на ЧАЕС; Чорнобильська катастрофа.

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## STRUCTURE AND CHARACTERISTICS OF THE CHORNOBYL NPP ACCIDENT SURVIVORS REASONS OF DEATH ACCORDING TO THE MATERIALS OF MEDICAL EXPERTISE FOR THE CAUSAL RELATIONSHIP OF DISEASES WITH THE EFFECT OF IONIZING RADIATION IN THE REMOTE POSTACCIDENTAL PERIOD (2024 year)

Problem of the causal relationship of disease that became the reason of death with the effect of ionizing radiation and due to harmful influence of the Chernobyl Catastrophe during performance of professional, military or official duties and / or living on radiation-contaminated areas, additional exposure not through their own fault but due to a radiation accident, caused the development of a special form of medical expertise as part of the of medical social protection system for suffered contingents in the remote postaccidental period.

**Objective.** To study and characterize the structure of the survivor categories (clean-up workers and victims) of the Chernobyl Catastrophe in the remote post-accident period (2013–2024) regarding the causal relationship of disease that became the reason of death with the effect of ionizing radiation and due to harmful influence of the Chernobyl Catastrophe based on the materials of expert cases of the Central Interdepartmental Expert Commission of the Ministry of Health of Ukraine (CIEC).

**Material and methods.** The work was performed in the design of a retrospective study that based on analysis of the structure of all categories of Chernobyl NPP accident (ChNPP) survivors during 2008–2024 years and studying of 58,137 medical expert cases, including 19,524 postmortem cases, which were considered by CIEC during 2013–2023 to establish a causal relationship between the disease and influence of radiation exposure and other harmful factors and conditions during ChNPP accident.

**Results.** The total number of adult survivors as on 01.01.2024, compared to 2008, decreased by 581,170 persons, or by 31.68 %. The number of clean-up workers of the accident decreased by 124,382 people (45.01 %), that means – during the last 15 years, almost every third-second participant in the liquidation of the consequences of the accident at the ChNPP died. The number of adult victims decreased 29.41 % (458,233 persons). In the structure of medical expert cases, the leading place as a disease that became the reason of death is occupied by oncological diseases – 52.10 %, chronic circulatory diseases and their complications make up 42.00 % (cardiovascular system – 19.60 %, cerebrovascular system – 22.40 %), chronic diseases of the respiratory system – 3.00 %, other diseases in general – 2.90 %. In the structure of oncological postmortem expert cases (n=10,172) during 2013–2024 the main reason of death belongs to oncohematological diseases (18.00 %), colon cancer (15.00 %), breast cancer for woman (13.00 %), prostate cancer for man (11.99 %), lung and upper respiratory tract cancer (8.01 %).

**Conclusion:** In the remote post-accidental period (2013–2024) has increased the necessity of expertise of the causal relationship of disease that became the reason of death with the effect of ionizing radiation and the ChNPP accident consequences. During 2013–2024 period quick reducing for all survivors' categories of the Chernobyl NPP accident taken place. In the structure of medical expert cases during 2013–2023 the leading place of the disease that became the reason of death is occupied by oncological, cardiovascular and cerebrovascular diseases.

**Key words:** ionizing radiation; clean-up workers and victims of Chernobyl NPP accident; medical expertise of the causal relationship of disease with the effect of ionizing radiation and the ChNPP accident consequences; Chernobyl catastrophe.

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## INTRODUCTION

One of the key issues to minimize the consequences of the Chernobyl NPP (ChNPP) became the problem of medical expertise of survivors [1, 2] for establish the causal relationship of disease that became the reason of death with the effect of ionizing radiation and the ChNPP accident consequences. The basis of social protection of the Chernobyl accident survivors is till our days with updating the of the Law of Ukraine «On status and social protection of citizens affected by the Chernobyl catastrophe» ratified by the Verkhovna Rada (Ukrainian Parliament) on April 1, 1991 [3]. The 12th Article of this low is dedicated to «Establishing a causal link between the disease connected to the Chernobyl catastrophe, partial or complete disability of survivors affected by the Chernobyl catastrophe and the Chernobyl catastrophe». Of significant influence on making decisions in this issue are also articles 2, 14, 27 of these documents [4]. According to the decision of Government Commission № 539 from August 13, 1988 in agreement with the Trade-Unions and Goskomtrud of USSR the order of Ministry of Health No 731 from September 28, 1988 was issued «On the organization of the Central Interdepartmental Expert Council to establish causation of disease and disability with the works at the aftermath of ChNPP accident and their professional nature at the All-Union Research Center for Radiation Medicine Academy of Medical Sciences» [4].

## OBJECTIVE

To study and characterize the structure of the survivor categories (clean-up workers and victims) of the Chernobyl Catastrophe in the remote post-accident period (2013–2024) regarding the causal relationship of disease that became the reason of death with the effect of ionizing radiation and due to harmful influence of the Chernobyl Catastrophe based on the materials of expert cases of the Central Interdepartmental Expert Commission of the Ministry of Health of Ukraine (CIEC).

## MATERIALS AND METHODS

The work was performed in the design of a retrospective study that based on analysis of the structure of all categories of ChNPP accident survivors during 2013–2023 years and studying of 58,137 medical expert cases, which were considered by CIEC during 2013–2023 to establish a causal relationship between the development and progression of disease that leads to disability and death (19,524) and influence of radia-

tion exposure and other harmful factors and conditions during ChNPP accident using a systematic analytical approach to assessing the medical and nonmedical parameters presented in medical expert documentation.

In accordance with the requirements of current regulations, the materials of expert cases included documents confirming the status (category) of the victim, passport data and information about the place of residence, professional history and experience, medical documentation regarding health before and after the ChNPP accident, results of outpatient and inpatient examination and treatment (if necessary – the results of morphological examinations, in case of death – autopsies), also a certificate of permanent disability [5–9]. The analysis of every cases was performed under the condition of the diagnosis verification by the members of the expert group, approved by the voting protocol of the CIEC members.

## RESULTS AND DISCUSSION

On 01.01.2024 the status of survivors of the Chernobyl Catastrophe in Ukraine had 1,531,893 persons, including 279,664 children (Table 1).

The total number of adult survivors as on 01.01.2024, compared to 2008, decreased by 581,170 persons, or by 31.68 % (from 1,834,536 to 1,253,366 persons).

During 2008–2024, the number of clean-up workers of the accident decreased from 276,327 to 151,945, or by 124,382 people (45.01 %), that means – during the last 15 years, almost every third-second participant in the liquidation of the consequences of the accident at the ChNPP died.

The number of adult victims decreased from 1,558,209 in 2008 to 1,099,968 in 2024, or by 29.41 % (458,233 persons). The number of children affected by the ChNPP accident has decreased from 534,568 in 2008 to 279,964 in 2024, or by 254,604 (47.62 %). Regarding the reduction of the number of this category, it is necessary to take into account the loss of the status of victims by children upon reaching the age of majority according to the current legislation.

It is impossible to miss the characteristics of the victims of the ChNPP accident such a painful and socially important indicator as 42,467 people who have the status of wife / husband of the deceased citizen whose death was related to the Chernobyl catastrophe.

Expertise to establish the causal relationship of diseases, disabilities and causes of death with the action of ionizing radiation and other harmful factors of the ChNPP accident are provided for all citi-

**Table 1**  
**The number of people who have the status of affected under the Chernobyl Catastrophe on January 1, 2024**

<b>Name of indicators</b>	<b>Number</b>
<b>total number of survivor persons:</b>	<b>1,531,893</b>
of them:	
<b>► clean-up workers of the Chernobyl NPP accident:</b>	<b>151,945</b>
including the following categories:	
► <b>category 1 A</b> from the number of clean-up workers of the Chernobyl NPP accident (persons with disabilities (invalids):	<b>47,324</b>
I <sup>st</sup> group of disability	1,802
II <sup>nd</sup> group of disability	30,226
III <sup>rd</sup> group of disability	15,299
► <b>category 2 A</b> from the number of clean-up workers of the Chernobyl NPP accident	<b>83,024</b>
► <b>category 3 A</b> from the number of clean-up workers of the Chernobyl NPP accident	<b>21,597</b>
<b>► victims of the Chernobyl Catastrophe:</b>	<b>1,379,948</b>
including the following categories:	
► <b>category 1 Б</b> from the number of victims of the Chernobyl catastrophe (persons with disabilities (invalids):	<b>49,335</b>
I <sup>st</sup> group of disability	2,469
II <sup>nd</sup> group of disability	25,858
III <sup>rd</sup> group of disability	21,008
► <b>category 2 Б</b> from the number of victims of the Chernobyl catastrophe	<b>47,302</b>
► <b>category 3 Б</b> from the number of victims of the Chernobyl catastrophe	<b>331,581</b>
► <b>category 4 В</b> from the number of victims of the Chernobyl catastrophe	<b>670,519</b>
► <b>category 4 Г</b> from the number of victims of the Chernobyl catastrophe (persons who worked outside the exclusion zone in particularly harmful working conditions – ionizing radiation and open sources of ionizing radiation)	<b>1,249</b>
► <b>series category Д</b> (victim children)	<b>279,964</b>
category D with disabilities (children-invalids):	1,060

zens of Ukraine who, according to current legislation, have the status of survivors of the Chernobyl catastrophe [4–9].

Category 1 of survivors of the accident at the Chernobyl NPP is the most critical in terms of loss of health and workability, as it consists of persons who have the status of survivors of the ChNPP accident and have lost workability due to diseases for which has been established a causal relationship with the impact of radiation exposure and other harmful consequences of the ChNPP accident.

During the period 1995–2014, there was a fast increase in the number of survivors of category 1 (from 40,106 to 117,158). In 2015–2023 there is a gradual decrease in the number of survivors of this category from 113,268 on January 1, 2015 to 97,719 on January 1, 2024.

When significant decrease in the total number of clean-up workers of ChNPP accident taken place from 243,456 persons in 2013 to 151,945 in 2024 (or by 91,511 persons, 37.59 %), the number of clean-up workers who have the 1st category decreased by 20,185 persons (from 67,509 in 2013 to 47,24 in 2024, or by 29.90 %). At the same time the relative number of clean-up workers who have the 1st category was 27.73 % in 2013 and 31.14 % in 2024.

The total number of adult victims also significantly decreased during 2013–2024: from 1,426,427 persons

in 2013 to 1,099,968 in 2023 (or by 326,459, 22.87 %). At the same time the absolute number of victims of the 1<sup>st</sup> category significantly didn't change – increased by 86 people (from 49,249 in 2013 to 49,335 people in 2024). The relative number of victims who have the 1st category was 3.45 % in 2013 and 4.48 % in 2024.

Thus, during 2013–2024, there is a fast decrease in the total number of all categories of survivors with a significant reduction in the absolute number of clean-up workers of ChNPP accident who have the 1st category and the relative stability of the number of the cohort of adult victims of the 1st category. It should be taken into account that this relative stability of the number of victims of adult age who have the 1st category is formed from the ratio of losses of persons of this cohort and its replenishment due to the establishment of causation of disease, leading to loss of health, disability and death with the action of ionizing radiation and other harmful factors of the ChNPP accident in the remote post-accidental period from categories 2 A and 2 Б, 3 A and Б, 4 B.

The main reasons leading to these changes are the increase in the incidence and prevalence of severe chronic disabling diseases, which quickly lead to a decompensated course and the development of complications, which, accordingly, leads to an increase in the mortality rate of the survived population [10].

**Table 2**

**Consideration by the CIEC the medical cases of the survivors (by category) regarding the establishment of causal relationship with the impact of radiation exposure and the consequences of the ChNPP accident**

Year	Categories of survivors							total
	survivors cat. 1 (A, B)	category of clean-up workers		evacuees and residents of the mandatory resettlement zone (cat. 2 B)	residents of the guaranteed voluntary resettlement zone (cat. 3 B)	residents of the zone of enhanced radiological control (cat. 4 B)	victims cat. Д	
		2 A	3 A					
2013	662	281	17	15	103	514	0	1,592
2014	825	373	23	16	100	524	1	1,862
2015	990	431	45	20	165	433	0	2,084
2016	921	481	34	18	90	303	0	1,847
2017	955	351	40	20	112	285	0	1,763
2018	974	438	36	20	126	237	0	1,831
2019	902	461	35	15	125	323	0	1,861
2020	857	357	28	15	90	268	1	1,616
2021	1,113	453	28	51	64	225	1	1,935
2022	894	290	15	72	59	184	1	1,515
2023	881	356	21	33	64	262	1	1,618
Total 2013–2023	9,974	4272	322	295	1098	3558	5	19,524

**Table 3**

**Structure of nosological forms of oncological postmortem expert cases**

Nosological forms	Number of cases (n=10,172)	Portion in %
Oncohematological diseases	1,831	18.00
Lung and upper respiratory tract cancer	814	8.01
Thyroid cancer	407	4.00
Stomach cancer	698	6.86
Pancreatic cancer	203	1.99
Colon cancer	1,526	15.00
Prostate cancer	1,220	11.99
Breast cancer	1,323	13.00
Cancer of the uterus and ovaries	305	2.99
Skin cancer and melanoma	1,119	11.01
Kidney and urine bladder cancer	726	7.15

In total, during 2013–2024, medical expert cases were considered: victims with disabilities – 42,078 cases, cancer patients – 30,459 cases, deceased – 19,524 cases.

In the structure of postmortem expert cases the absolutely dominated category is survivors of the 1<sup>st</sup> (A and B) category (51.08 %), who, as patients with an expertly verified a causal relationship with the impact of radiation exposure and the consequences of the ChNPP accident and confirmed loss of workability, have a more severe decompensated course of the disease. On the second place there are clean-up workers of 2 A category (21.89 %), who participated in clean-up works, relatively, at the first stages of the accident and receive higher doses of irradiation (Table 2).

Today, in the structure of medical expert cases, the leading place as a disease that became the reason of death is occupied by oncological diseases – 52.1 %, chronic circulatory diseases and their complications

make up 42.00 % (cardiovascular system – 19.6 %, cerebrovascular system – 22.4 %), chronic diseases of the respiratory system – 3.0 %, other diseases in total – 2.9 %.

In the structure of oncological postmortem expert cases (n=10,172) during 2013–2024 the main reason of death belongs to oncohematological diseases (18.00 %), colon cancer (15.00 %), breast cancer for woman (13.00 %), prostate cancer for man (11.99 %), lung and upper respiratory tract cancer (8.01 %) (Table 3).

### CONCLUSIONS

1. In the remote post-accidental period (2008–2024) has increased the necessity of expertise of the causal relationship of disease that became the reason of death with the effect of ionizing radiation and the ChNPP accident consequences.
2. Quick reducing for all categories of survivors of the ChNPP accident taken place. The total number of

adult survivors as on 01.01.2024, compared to 2008, decreased by 581,170 persons, or by 31.68 % (from 1,834,536 to 1,253,366 persons).

3. The number of clean-up workers during 2008–2024 decreased from 276,327 to 151,945, or by 124,382 people (45.01 %), that means – during the last 15 years, almost every third-second participant in the liquidation of the consequences of the accident at the ChNPP died.

4. The number of adult victims decreased from 1,558,209 in 2008 to 1,099,968 in 2024, or by 29.41 % (458,233 persons).

5. In the structure of medical expert cases during 2013–2023, the leading place as a disease that became the reason of death is occupied by oncological diseases – 52.1 %, chronic circulatory diseases and their complications make up 42.00 % (cardiovascular system – 19.6 %, cerebrovascular system – 22.4 %).

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