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Brykulska Myroslava Volodymyrivna,
Candidate of Medical Sciences, Associate Professor,
of the Department of Physical Therapy, Ergo Therapy
Central Ukrainian Institute of Human Development
of the Open International University of Human Development «Ukraine»
ORCID: https://orcid.org/0009-0000-1446-3872

Deforzh Hanna Volodymyrivna,
Doctor of History Sciences, Professor,
Professor of the Department of Natural Sciences and Methods of their teaching
Volodymyr Vynnychenko Central Ukrainian State University.
ORCID: https://orcid.org/0000-0002-1114-3205

THREATS OF RADIOACTIVE RADIATION: FEATURES OF IMPACT ON THE ENVIRONMENT AND HUMAN HEALTH

Abstract. *Topicality.Today, during the war with the russian federation, it is extremely important to know how to act in the event of a man-made disaster, an emergency situation, for example, an explosion of a nuclear power plant, what the consequences may be in the event of such a disaster and how to prevent them.*

The purpose *of the article presents the features of the impact of radioactive radiation on the environment and human health, because under the influence of radiation, materials can become radioactive. Radiation from living cells alters their ability to repair itself, which can lead to death, damage or improper repair. The aim of this study was to identify the main threats to radiation to both public health and the environment.*

Materials and methods. *The risks of malignant tumors in the population living near nuclear facilities related to space radiation, as well as the impact of nuclear power plants on the environment have been identified.*

Research results. *The connection of radiation factor with the state of somatic morbidity of the population, indicators of prevalence of diseases among the adult population affected by the Chernobyl accident, contingents of patients with malignant neoplasms (per 100 thousand population) are considered. The biological effect of radiation is determined.*

Conclusions. *Thus, conducting research, we can say that radiation leaves many traces in our body. The effect of radiation on the body directly depends on the intensity of radiation and the length of stay in its field of action. The source of radiation can also be artificial sources, such as the use of certain industrial and medical technologies. A person cannot see, feel, hear, taste or smell ionizing radiation, but it can harm our health. This type of radiation comes from natural sources such as cosmic radiation, rocks or soil. The effects of natural radiation on humans are the cause of a number of certain pathogenic mutations and cancers.*

Key words: *radioactive radiation, cancer, human health, radioactive contamination, malignant neoplasms.*

Брикульська М. В., Деforж Г. В. ЗАГРОЗИ РАДІОАКТИВНОГО ВИПРОМІНЮВАННЯ: ОСОБЛИВОСТІ ВПЛИВУ НА НАВКОЛИШНЄ СЕРЕДОВИЩЕ ТА ЗДОРОВ'Я ЛЮДИНИ

Анотація. *Актуальність. Сьогодні, під час війни з російською федерацією, надзвичайно важливо знати, як діяти в разі техногенної катастрофи, надзвичайної ситуації, наприклад вибуху на атомній електростанції, якими можуть бути наслідки, події такого лиха та як їм запобігти.*

Мета роботи. *У статті наводяться особливості впливу радіоактивного випромінювання на навколишнє середовище та здоров'я людини, адже під впливом радіації матеріали можуть самі ставати радіоактивними. Радіоактивне опромінення клітин живих організмів змінює їх здатність відновлюватися, що може призвести до загибелі, пошкодження або неправильного відновлення. Мета дослідження – визначити основні загрози радіоактивного випромінювання як на здоров'я населення, так і на навколишнє середовище.*

Матеріали та методи. *Визначено ризики злоякісних пухлин у населення, що проживає поблизу ядерних установок, пов'язаних з космічною радіацією, а також вплив підприємств ядерно-енергетичного комплексу на стан довкілля.*

Результати дослідження. *Розглянуто зв'язок радіаційного фактору зі станом соматичної захворюваності населення, показники поширеності захворювань серед дорослого населення, що постраждали внаслідок аварії на Чорнобильській АЕС, контингенти хворих, які мають злоякісні новоутворення (на 100 тисяч населення). Визначено біологічну дію радіаційного випромінювання.*

Висновки. *Провівши дослідження, можна сказати, що радіоактивне опромінення залишає безліч слідів у нашому організмі. Вплив радіації на організм безпосередньо залежить від інтенсивності виділення радіації та тривалості перебування в полі її дії. Джерелом радіації також можуть бути штучні джерела, як-от використання певних промислових і медичних технологій. Людина не може побачити, відчути, почути, спробувати на смак або запах іонізуюче випромінювання, але воно може зашкодити нашому здоров'ю. Цей тип радіації походить з природних джерел, як-от космічне випромінювання, гірські породи або ґрунт. Вплив природної радіації на людину є причиною низки певних хвороботворних мутацій та онкологічних захворювань.*

Ключові слова: *радіоактивне випромінювання, онкологічні захворювання, здоров'я людини, радіоактивне забруднення, злоякісні новоутворення.*

Introduction. In physics, radiation is the same as radiation: from the longest radio waves, which transmit signals over long distances, to the shortest gamma rays, which, according to comics, created the Jackdaw. In everyday life, we used to call radiation from the decay of atomic nuclei, which is potentially dangerous – it is called ionizing, nuclear or radioactive. For convenience, the word «radiation» will be understood as this meaning.

In nature, there are unstable elements – radionuclides – that emit radiation. Particle fluxes from space (cosmic radiation), part of solar radiation, radionuclides in the environment are also radioactive and form a natural radiation background. Radioactive particles can also be synthesized artificially – in the process of research, the nuclear industry and more.

Under the influence of radiation, materials can themselves become radioactive, their chemical bonds weaken by changing their properties, and chemical elements transform into others. Radiation from living cells alters their ability to repair itself, which can lead to death, damage or improper repair. It can also cause mutations in DNA that, if not repaired, eventually lead to tumors.

High doses of radiation received in a short period of time from contact with radioactive materials lead to serious consequences – burns, acute radiation sickness (ARS), numerous pathologies that can occur over time, and even death. After the Chernobyl accident, 44 people died as a result of the ARS alone. Hundreds of thousands of liquidators working there in the following years experienced deteriorating health in almost all classes of diseases, rising incidence of thyroid cancer, leukemia, tumors, mental and endocrine disorders – and many other problems that affected not only them but their descendants.

The first malignant tumor – skin cancer caused by radiation, was diagnosed in 1902 by radiologists. It was further shown that radiologists have an increased risk of leukemia, myeloma, and most significant tumors. However, the use of protective measures has significantly reduced the risk of tumors among the profession.

The risk of lung cancer in miners due to the high concentration of radioactive radon gas in the mines has been studied in a number of studies in Czechoslovakia (before the country's collapse), the United States, Sweden and China. All of these studies have shown a significant increase in the risk of death from lung cancer. The dose-effect curve was strictly linear.

Data on the increased risk of developing malignant tumors among employees of various nuclear facilities are contradictory. Most epidemiological studies based on surveillance of this contingent did not show an increase in morbidity, and in some of them revealed a «deficit» of cancer, which can be explained by the so-called «healthy worker» effect. Some studies have found an increased risk of leukemia (other than chronic lymphoid) and myeloma. At the same time, a reduced risk of lung and prostate cancer has been shown.

The results of recent studies, which included primary data from employees of various nuclear plants in the United States and Canada, suggest a reduction in the risk of cancer as a result of the «healthy worker» effect, rather than an increase. It should be emphasized that the radiation dose received by employees at these enterprises did not exceed 5 cGy (0.05 Gy). A cooperative study that included American and British data on 76.000 nuclear workers showed that only 9 out of 3.976 cases of malignancies could be linked to radiation.

Purpose and tasks. The aim of this study was to identify the main threats to radiation to both public health and the environment.

Research methods. Medical scientists have the results of research conducted in different countries around nuclear plants. Most of these studies have not found an increase in cancer morbidity and mortality. Some studies have shown a slight increase in the incidence of malignancies in children. However, in most cases, these findings were not confirmed.

Studies in England have suggested that children living in the vicinity of the Sellafield nuclear plant have an increased incidence of leukemia. Leukemia affected only those children who were born in this town. It should be noted that among the employees of the nuclear plant in Sellafield there was no excess of malignant tumors in general or leukemia in particular. In addition, based on dosimetry data, it was difficult to predict an increased risk of leukemia. It has been suggested that the cause of leukemia in children was most likely parental exposure prior to conception, the mutagenic effect of radiation on germ cells. However, further research has not confirmed this hypothesis. It turned out that some parents of children with leukemia were chemists and had contact with various chemicals, the effects of which can also be explained by leukemia in children. obtained in Sellafield.

Research results. The use of ionizing radiation in medicine. The first data on the carcinogenicity of ionizing radiation were obtained from the observation of patients who were often exposed to radiation. Observations of the number of women with tuberculosis have shown that frequent fluorographic examinations to control pneumothorax, one of the treatments for tuberculosis, increase the risk of breast cancer 10–15 years after starting treatment. The highest risk rates were recorded in women who underwent frequent fluorographic examinations in adolescence and childhood. The increase in relative risk depending on the radiation dose was linear. Irradiation of the breast with a dose of 1 Gy has been shown to increase the risk of cancer of this organ by 60%. It should be noted that the breast is one of the most radiosensitive organs, the degree of which depends on age. Thus, during growth and development, the radiosensitivity of the breast is higher than after 50 years.

Data on the carcinogenic risk associated with mammography indicate that despite the possible small increase in the risk of breast cancer, exposure to radiation (the dose absorbed by the gland is usually 3 mGy) ultimately reduces this type of cancer mortality body. Calculations conducted in Sweden have shown that mammography screening of 100.000 women aged 50-69 years as a result of radiation can lead to death from breast cancer from 1 to 5 women. At the same time, as a result of screening, mortality from breast cancer decreased by 25%, i.e. the lives of 560 women were saved as a result of screening.

When screening for lung cancer using low-dose spiral CT, the effective dose is 0.2–1 MeV, which can lead to the development of 1-5 deaths from cancer per 100 thousand subjects. Doses of radiation in other methods of radiological diagnosis, in particular, fluorography, are higher. Therefore, the decision on each additional radiological diagnostic procedure must be justified.

Radiation therapy increases the risk of developing a second malignancy in cancer patients. An increased risk of leukemia and lymphoma has been reported in patients receiving radiotherapy for cervical and uterine cancer and lymphogranulomatosis. Radiation therapy for breast cancer also increases the risk of lung cancer. Probably the same reason to some extent contributes to the frequent development of cancer of the second breast. Based on a careful analysis of the role of radiation therapy in the occurrence of second tumors, it was concluded that radiotherapy is responsible for 5–10% of all other tumors. The role of other factors, including chemotherapy, hormonal status, and to a greater extent lifestyle factors that were causally related to the first tumors, namely smoking, alcohol consumption, nutrition, seem to be more significant.

Observations of children exposed to retinoblastoma have shown a significant increased risk of bone, soft tissue, CNS and melanoma tumors. It is known that retinoblastoma is often combined with the above tumors, but radiation further increases the risk of their development.

Risk of malignant tumors associated with exposure to indoor radon. Radon-222 is the source of half of the total dose of ionizing radiation that people receive from natural sources, and averages 1.15 mSv/year. However, the level of radon exposure varies considerably and can exceed the average by ten times or more. It is known that miners have a significantly increased risk of lung cancer as a result of radon exposure. However, the level of radon in residential areas is much lower than in mines, and therefore the study of the carcinogenic effects of radon in the premises is extremely difficult.

A meta-analysis of epidemiological studies conducted in different countries showed that BP (relative risk) of lung cancer associated with exposure to radon in residential areas is 1.2, and the percentage of lung cancer that is etiologically related to this factor is not exceeds 2%. It should be emphasized that high levels of radon are characteristic of stone houses and especially granite, as well as the first floors of houses built in rocky terrain.

Long-term consequences of the Chernobyl accident. Epidemiological studies of the long-term consequences of the Chernobyl accident have shown a significant increase in the risk of thyroid cancer among children. This increase can be partly explained by the screening effect. However, most of these cases are undoubtedly related to radiation. In 1986-2000, the incidence of thyroid cancer increased among children living in the most polluted areas of Ukraine.

The rate of thyroid cancer was six times higher in children who received a radiation dose above 1 Gy, compared with those who received a dose less than 0.3 Gy, and this difference was statistically significant. The researchers note that thyroid cancer in children associated with the Chernobyl accident is almost exclusively papillary histological structure, tumors are more common in children exposed to radiation under 5 years, and that the latency period between exposure to radiation and cancer is extremely short.

The results of epidemiological studies examining the link between the Chernobyl accident and thyroid cancer in adults are less convincing. However, in two groups of liquidators observed in Estonia, an increase in the incidence of thyroid cancer was found compared to the expected incidence based on thyroid cancer statistics in Estonia.

Epidemiological data do not indicate a link between the Chernobyl accident and the incidence of leukemia in children. An epidemiological study examining the dynamics of leukemia and lymphoma in children in 23 countries found no link between the small increase in leukemia incidence reported by researchers and radiation. Similar studies in Ukraine and Finland did not show an increase in the incidence of childhood leukemia. Studies of the dynamics of the incidence of adult leukemia in the most polluted regions of Ukraine did not reveal an increase in the incidence, which could be explained by the effects of radiation. However, an increased risk of acute leukemia was noted among the liquidators who received the highest doses of radiation.

Risk of malignant tumors associated with cosmic radiation. This problem has attracted the attention of researchers relatively recently. Jet crews are more at risk from this source of radiation. Crews that perform passenger flights receive an average of 3-6 mSv per year, and military pilots – about 9 mSv. Epidemiological studies of these groups have shown an increased risk of skin cancer and melanoma, malignancies that may be associated with increased exposure to sunlight during non-working hours. In addition, women in jet crews were found to have an increased risk of breast cancer, which can also be explained by the peculiarities of the flight attendants' reproductive history, in particular, late first childbirth and the absence of children. One study in Denmark showed an increased risk of dying from leukemia.

The existing hygienic norms of permissible levels of radiation are quite satisfactory from the point of view of modern knowledge about the carcinogenic effect of ionizing radiation. This does not preclude the need for systematic monitoring of radioactivity in the environment and, above all, in areas adjacent to nuclear power plants and other nuclear enterprises [1].

Radiation pollution in Ukraine. Ukraine is a country with an incomplete nuclear cycle. The share of electricity generated by nuclear power plants is approaching 60%. Uranium mining is carried out in the Kirovohrad region, processing – in the city of Zhovti Vody, Dnipropetrovsk region (SE «Vostok-GOK»). Reducing natural gas consumption is a priority for the domestic energy market, so the role of nuclear energy in the country's energy balance will continue to be significant.

If in the long history of the Earth one of the key roles in its evolution belongs to the radioactivity of natural radioelements, in the modern relationship between mankind and nature a new type of radioactivity – artificial or anthropogenic, which inevitably exacerbates the environmental situation due to environmental pollution. Anthropogenic pollution directly affects public health. The uranium mining industry is an important sector in the economy of our country, but like any other type of economic activity in the technological process has a negative impact on the ecological situation in the region where the relevant enterprises are located. The phenomenon of radio anxiety is relevant for the formation of the psychological status of ordinary citizens of these territories.

The impact of nuclear energy enterprises on the state of Ukraine's environment. The central and largest geostructural region of Ukraine, its core is the Ukrainian Crystal Shield, the area of which together with the north-eastern and south-western slopes is 237.91 thousand km^2, or 39.6% of the total territory.

The mining industry has many factors of negative impact on the environment, contributing to the emergence of a whole set of undesirable changes. In the process of hydrometallurgical processing of uranium ores from the raw material extracted useful components in the amount of 0.2% of the total mass, and 99.8% goes to industrial waste containing radioactive elements. Thus, the industrial eastern and central regions of our country additionally carry a significant man-made load due to the so-called «tails» – waste from enterprises with a high content of natural radionuclides of uranium and thorium series. The greatest danger to the environment is free radon, which spreads from the «tailings» to the surface layer of the atmosphere. Part of the tailings is located near settlements. In addition, large areas were contaminated as a result of the Chernobyl accident.

According to WHO experts, population health, or population health, is 51–52% dependent on lifestyle; environment – 20–21%; biological factors – 19–20%; medical factors – only 8-10%. According to other estimates, the state of the environment is the cause of 40-50% of diseases in the population. For our country, these studies are just as relevant [2].

Mankind has a negative experience of uncontrolled use of nuclear energy. In recent years, the radiation impact on the population of controlled sources of natural origin has increased significantly, due to human activities. Among the main ways of irradiation in the XXI century. Experts from the UN Scientific Committee on Atomic Radiation (UNSCEAR) called the exposure of the population and personnel due to the production of nuclear energy at nuclear facilities and due to an emergency.

The Chernobyl catastrophe had a significant impact on the environment not only in Ukraine but also around the world (Serdyuk AM, Los IP, Tarasyuk OE). International norms and rules of radiation protection, national strategies for the development of nuclear energy, measures to strengthen nuclear safety and radioactive waste management have been significantly revised. The accident at the Japanese nuclear power plant Fukushima-1, which occurred in 2011, its consequences have been carefully studied by Japanese scientists [3].

One of the largest in Ukraine is the Dnieper industrial region. The share of ecological load on the Dnieper for Ukraine as a whole reaches 42%. This is despite the fact that the region occupies 5% of the country's territory and has 14% of the population, 86% – the population lives in environmentally unfavorable conditions. Of particular concern to experts is the fact that a significant number of mining, metallurgical and chemical facilities are located near settlements.

Ukraine ranks sixth in the world in uranium reserves and ninth in mining. Uranium mines are an essential element of the country's energy independence, so the weight of this production for the country is obvious. Operating or already non-operating uranium mining and processing enterprises in Dnipropetrovsk region – in Zhovti Vody State Enterprise «Eastern Mining and Processing Plant» (SE «EastGOK») and in Kamyanske (in 1936–2016 – Dniprodzerzhynsk) Prydniprovsky Chemical Plant (SEP), which in 1949-1991 processed blast furnace slag, uranium-containing concentrates and uranium ore, are among the radiation-hazardous facilities in Ukraine. These are NFC enterprises. The nuclear fuel cycle is a sequence of operations and processes that begin with uranium ore mining, followed by conversion, enrichment and fabrication. The final stage of the NFC is the utilization of spent nuclear fuel [4].

When testing the dump rock of the Ingulska mine (Kropyvnytskyi, Kirovohrad in 1939–2016), it was found that virtually all dump rocks are characterized by uranium content exceeding 0.01% (low-ore dumps). A study of tree leaf dust was also conducted, which showed that its dustiness in Kropyvnytskyi is 20-50 ppm / cm^2, and in the area of dumps – from 100 to 300 ppm / cm^2.

Exceeding the natural radioactive background (2 times) is observed at a distance of up to 250-300 m from the location of the dumps, the maximum excess (2.5 times) – at a distance of 100–250 m. The lowest values were observed at a distance of 1500 m from the dumps, however and they were 2.5 orders of magnitude higher than the values of the natural radiation background. These data indicate the possibility of spreading radioactive particles over long distances.

The ecological condition of the territory of Zhovti Vody, the center of primary processing of uranium raw materials, led to the adoption of the State Target Program for Radiation and Social Protection of Zhovti Vody for 2013–2021, which aims to protect residents from radiation exposure and related to harmful factors, improving social protection, as well as maintaining the health of the city's population [5].

Interest in the radiological effects of radon on the population arose in the early 1980s. Studies have shown that the concentration of radon in the air of residential buildings, especially one-story, often exceeds the permissible level set for uranium miners.

Thus, it was found that the main dose a person receives in the premises where the city dweller spends 80% of his time. The content of radon in the indoor air is determined by the specifics of the geological structure of the area, the location on its territory of rock massifs with high uranium content. The formation of very high radon activities indoors can lead to a combination of various natural and man-made factors, especially in areas of mineral development. The main source of radon in the building is rocks and soils.

Thus, the analysis of the literature shows that scientists have done a lot of work to study a range of problems arising during daily production practices at the facilities of the nuclear energy complex (NEC), as well as living in an industrial environment. A special place is occupied by research on the effects of radon on humans. However, the state of radio alarm of the population of the regions where nuclear fuel cycle enterprises (NFCs) are located has not been studied enough. Thus, the issue of studying the radio alarm of residents of settlements with nuclear fuel cycle enterprises is relevant.

Relationship of radiation factor with the state of somatic morbidity of the population. There are virtually no sources in nature with levels of ionizing radiation that would damage the health of people in contact with them. On the contrary, the natural radiation background is one of the important conditions for the normal existence and development of biological objects. Therefore, radiation exposure that is harmful to health is always the result of human activities. In the current situation, when the mechanisms of adaptation, self-regulation of natural conditions were on the verge of depletion, there is denaturation of the environment. As a result, with high man-made pollution of air, drinking water, food, including due to ionizing radiation, accumulation of significant amounts

Table 1

Indicators of the prevalence of diseases among the adult population affected by the Chernobyl accident (per 10,000 population)

Names of classes and individual diseases	№ line	Only 1, 2, 3 groups of primary accounting are adults	
		2020	2021
All diseases	1.0	44061,2	44789,2
including: some infectious and parasitic diseases	2.0	148,3	173,0
neoplasm	3.0	664,7	623,5
diseases of the blood, blood-forming organs and individual disorders involving the immune mechanism	4.0	213,2	225,2
diseases of the endocrine system, eating disorders, metabolic disorders	5.0	2923,7	3016,1
mental and behavioral disorders	6.0	160,2	156,6
diseases of the nervous system	7.0	2187,5	2050,5
diseases of the eye and its appendages	8.0	3215,0	3044,9
diseases of the ear and mammary gland	9.0	607,8	641,4
diseases of the circulatory system	10.0	14973,5	15433,3
respiratory diseases	11.0	3720,9	3851,1
digestive diseases	12.0	9098,2	9046,8
diseases of the skin and subcutaneous tissue	13.0	252,9	287,0
diseases of the musculoskeletal system and connective tissue	14.0	3653,3	3892,3
diseases of the genitourinary system	15.0	1910,7	2024,4
pregnancy, childbirth and the postpartum period	16.0		1,4
congenital anomalies (malformations, deformities and chromosomal abnormalities)	17.0	29,1	34,3
symptoms, signs and abnormalities detected in laboratory and clinical studies are not classified in other headings	18.0	1,3	0,1
injuries, poisoning and some other consequences of external causes	19.0	300,6	287,0

of hazardous waste, degradation of land resources under the influence of mining factors, there is a direct or indirect, complex negative impact on environmental factors. public health.

Studies of the risk of radiation induction of cancer have a special place in modern radiation and epidemiological studies. It is known that one of the most acute problems among the medical consequences of the Chernobyl accident is the increase in the incidence of thyroid cancer (thyroid cancer) among the population of radiation-contaminated areas (RCA). Throughout the post-accident period, the incidence of thyroid cancer increased. Among radiogenic malignancies, leukemia has the maximum radiation risk and the minimum latency period. Therefore, exceeding the possible incidence of leukemia above the spontaneous level may be the first objective indicator of the level of radiation exposure. Thus, it was found that during the first ten years of observation after the Chernobyl disaster for liquidators who received external radiation doses of 150–300 mGy, there is a doubling of the incidence of leukemia compared to the expected level. Here are the indicators of the prevalence of diseases among the adult population affected by the Chernobyl accident (Table 1) [6].

At the same time, (Tomaszek L., 2004) according to the results obtained at the expanded group of miners of uranium mines in the Czech Republic (n=10000), it was found that 30 cases of leukemia and 16 cases of non-Hodgkin's lymphoma were found among Czech miners. This corresponds to a standardized mortality rate. However, risk assessment has significant uncertainty due to the small number of observations and uncertainty in the assessment of doses received [7].

The experience of Japanese scientists studying the effects of the atomic bombing of Hiroshima and Nagasaki has shown that the peak effects, for example, on cancer, can be expected in years and even decades after exposure.

Due to the uranium waste disposal facilities, the additional effective dose of individual exposure of the population varies in the range of 0.45–2.7 mSv / year. The level of cancer in the city of Zhovti Vody in recent years has increased almost 2 times among men and 1.3 times among women and exceeds 12 averages, both in the region and in Ukraine as a whole; the inci-

Table 2

Contingents of patients with malignant neoplasms (per 100 thousand population)

№	Names of districts	2014	2015	2016	2017	2018	2019	2020	2021
1.	Kropyvnytskyi city	2399,1	2553,3	2664,5	2757,9	2907,0	3023,5	3132,2	3293,3
2.	Alexandria city	2363,4	2453,9	2557,4	2659,7	2765,9	2898,0	3028,3	3205,6
3.	Blahovishchenskyi	1925,4	1978,9	2138,4	2138,4	2232,7	2309,8	2370,5	2391,1
4.	Bobrynetsky	2097,8	2183,2	2302,7	2490,4	2635,4	2647,0	2690,8	2644,4
5.	Vilshansky	2204,3	2303,1	2367,8	2456,4	2585,8	2747,8	2732,3	2794,4
6.	Gaivoronsky	1965,9	1993,2	2216,5	2248,9	2178,7	2162,0	2270,6	2449,4
7.	Golovanovsky	1725,6	1684,5	1720,0	1794,7	1838,6	1923,6	2006,4	1985,6
8.	Dobrovelychkivsky	1953,8	2088,6	2182,5	2255,9	2307,7	2441,9	2601,9	2700,3
9.	Dolynsky	1494,3	1529,6	1575,2	1614,6	1665,5	1747,7	1829,0	1977,0
10.	Znamyansky	2291,6	2455,7	2488,5	2581,5	2752,0	2852,5	2894,6	3025,9
11.	Kirovograd	1714,3	1805,3	1819,9	1878,8	2020,5	2137,6	2201,1	2315,2
12.	Svitlovodsky	2321,1	2341,3	2488,2	2636,6	2731,5	2768,6	2875,2	2988,2
	Total in the region	2085,0	2174,8	2277,7	2374,2	2463,5	2553,6	2650,0	2779,1

dence of tuberculosis is almost 2 times higher than the regional average. There is a high level of congenital anomalies in children. According to the indicators of primary incidence of tuberculosis, malignant neoplasms and congenital anomalies, Kirovohrad region occupies the last (worst) 23–25 places in the ranking of regions of Ukraine. Thus, the incidence of malignant neoplasms in 2008 in the Kirovohrad region was 406.4 cases per 100 thousand population. The average level in Ukraine is much lower – 331.1 [6].

According to the Kirovohrad Oblast Oncology Service, in 2021 the incidence of malignant tumors increased from 468.4 per 100,000 population in 2020 to 478.2 in 2021, i.e. by 2.1%, and significantly exceeded the average Ukrainian figure in 2020 – 348.4 [8].

The increase was in lip cancer (3.8 vs. 2.5 in 2020), colon cancer (27.5 vs. 26.2 in 2020), skin melanoma (9.9 vs. 8.4 in 2020), esophageal cancer (5.4 vs. 4.2 in 2020), gastric cancer (24.4 vs. 23.4 in 2020), lung cancer (48.1 vs. 44.8 in 2020), breast cancer (83.8 vs. 77.5 in 2020) and ovaries – (23.4 vs. 20.3 in 2020) per 100,000 female population, skin cancer (64.3 vs. 63.7 in 2020), cervical cancer 38.2 vs. 34.7 in 2020 per 100,000 female population), prostate (61.2 vs. 48.6 per 100,000 male population in 2020), malignant lymphoma (10.4 vs. 9.4 in 2020) [9].

It should be noted that over the last decade the incidence rate in the region increased by 17.7% (478.2 in 2021 against 406.3 in 2020), and in Ukraine – by 5.2% (348.4 in 2021 against 331.1 in 2020).

In the structure of cancer among the **entire population** of the region are:

First place – skin cancer 64.3 per 100 thousand population, or 13.5%;

P place – cancer of the trachea and lungs 48.1 per 100 thousand population, or 10.6%;

W place – breast cancer 45.7 per 100 thousand population, or 9.5%;

Among the female population:

First place – breast cancer 83.8 per 100 thousand female population, or 17.6%;

P place – skin cancer 72.8 per 100 thousand female population, or 15.3%;

W place – uterine cancer 42.3 per 100 thousand female population, or 8.9%;

Among the male population:

And the place – lung cancer 80.4 per 100 thousand male population, or 16.7%;

Second place – prostate cancer 61.2 per 100 thousand male population, or 12.7%.

Third place – skin cancer 54.4 per 100 thousand male population, or 11.3%.

The incidence of malignant tumors ranges from 590.5 per 100 thousand population in Kropyvnytskyi to 293.9 in Ustyniv district. The highest incidence rates were registered in Kropyvnytskyi – 590.5. Here are the contingents of patients with malignant neoplasms (Table 2) [6].

According to the literature, uranium in microquantities (10–5 – 10–6%) is present in all tissues of plants, animals and humans. U enters the human body with food and water to the gastrointestinal tract (GIT), with air – in the respiratory tract, as well as through the skin and mucous membranes. The medical consequences of uranium exposure are due to its chemical and radiological properties. For uranium and radon decay products, the critical organs are the lungs and upper respiratory tract, as well as red bone marrow. Uranium is often referred to in the literature as «kidney poison». The skeleton contains more than 90% of uranium deposited in the body. Relatively recently, the accumulation of uranium has been experimentally established not only in the kidneys and bones, but also in the testes, lymph nodes and brain.

The effects of radon on the human body are also diverse. Having the ability to dissolve well in blood and lymph, it is concentrated in vital organs. Its content per unit volume of the body is 50% of the content in the ambient air. The severity of pathological changes in the body depends on age and the accumulated dose of radon. Among the radon-dependent pathology are lesions of the lungs, cardiovascular, nervous, musculoskeletal systems, reproductive function, hormonal changes. According to Serdyuk A. M. and co-authors, chronic exposure to radon and other radionuclides on the human body leads to changes in the respiratory system, cardiovascular system, digestive system and genitourinary system. Thus, in the city of Zhovti Vody the incidence of angina exceeds the regional level by 2.15 times; diseases of the endocrine organs – 2.15 times; diseases of the blood and blood-forming organs – 1.55 times.

It is known that the immune system has the highest radiation sensitivity in the body. Therefore, the radiation effect on the human body is primarily the development of acquired immunodeficiency states of various nature and severity, which, in turn, are the basis for the emergence of various human pathologies. It was found that the equivalent equilibrium volume activity of radon in 43% of apartments where the surveyed persons lived exceeded the control value – 200 Bq / m^3. The contribution of radon to the total radiation dose in most cases was more than 80% [10]. Immunological examination of the population living in these conditions revealed a significant prevalence of hyposuppressive states, as well as the predominance of immunodeficiency states with lesions of the T-link of the immune system and phagocytic leukocytes of moderate nature. The obtained data indicate the presence of the initial stages of immunocompromising the population and the need for individual treatment and mass preventive immunocorrection to reduce immune-dependent morbidity.

The most important aspect of the problem is the impact on the health of children who are particularly sensitive to the effects of radon and on this basis belong to a critical group. Physical development is characterized by disproportion, from an early age. In school-age children, acceleration processes have changed to deceleration with trophic insufficiency, and in some cases not retardation. The combination of these factors is defined as the syndrome of environmental maladaptation.

In recent years, a considerable amount of work has been published proving the neurotoxicity of uranium, in contrast to the common notion that uranium targets only the kidneys, liver, and bone (depending on the route of entry and form of uranium compounds). These studies indicate that the brain is also a target organ.

Psychopathological factors worsen the course of somatic diseases, complicate their clinical picture, increase the frequency of calls for medical care, reduce the ability of patients to self-care and their commitment to treatment and overall quality of life. Pastel R. reports that the primary long-term effect of the Chernobyl accident was the formation of psychological disorders in the liquidators of the accident, evacuated residents of radioactively contaminated areas, as well as residents of «clean» areas [10]. Psychoneurological syndromes with unexplained physical symptoms, including fatigue, sleep disturbances and mood swings, impaired memory and concentration, and frequent muscle and joint pain have been reported. The author does not associate these syndromes, which resemble chronic fatigue syndrome and fibromyalgia, with the radiation effect, as they were observed in residents of both contaminated and low-radiation areas, but considers it a manifestation of radiophobia inherent in this group of patients.

Thus, given the proven impact of radiation on the environment and somatic morbidity, it is obvious the need to study various aspects of the impact of NFC enterprises on the psycho-emotional status of residents located in regions of production of these enterprises [11, 12].

Conclusions. Thus, conducting research, we can say that the issue of human protection from the negative effects of ionizing radiation arose almost simultaneously with the discovery of X-rays and radioactive decay. This is due to the following factors: first, the extremely rapid development of the use of open radiation in science and practice, and secondly, the detection of the negative effects of radiation on the body. Radiation safety measures are used in enterprises and, as a rule, require a range of various protective measures, depending on the specific conditions of work with sources of ionizing radiation and, above all, the type of radiation source.

Closed are any sources of ionizing radiation, the device of which excludes the penetration of radioactive substances into the environment under the conditions of their operation and wear. These are gamma installations for various purposes; neutrons, beta and gamma emitters; X-ray machines and charged particle accelerators. When working with closed sources of ionizing radiation, personnel may only be exposed to external radiation.

Protective measures to ensure the conditions of radiation safety in the use of sealed sources, based on knowledge of the laws of propagation of ionizing radiation and the nature of their interaction with matter. The main ones are: the dose of external radiation is proportional to the intensity of radiation and exposure time; the intensity of radiation from a point source is proportional to the number of quanta or particles that occur in it per unit time, and inversely proportional to the square of the distance; the intensity of the radiation can be reduced with the help of screens.

From these laws follow the basic principles of radiation safety: reducing the power of sources to a minimum («protection by quantity»); reduction of time of work with a source («protection of time»); increasing the distance from sources to people («protection of distance»); shielding of radiation sources with materials that absorb ionizing radiation («screen protection»).

Lead and uranium are best for protection against X-rays and gamma radiation. However, due to the high cost of lead and uranium, screens made of lighter materials can be used – leaded glass, iron, concrete, reinforced concrete and even water. In this case, naturally, the equivalent screen thickness increases significantly.

To protect against beta streams, it is advisable to use screens that are made of materials with a low atomic number. In this case, the output of bremsstrahlung is small. Organic glass, plastic, and aluminum are usually used as screens to protect against beta radiation. Open sources are those sources of ionizing radiation, the use of which may allow the entry of radioactive substances into the environment.

At the same time there can be not only external, but also additional internal irradiation of the personnel. This can occur when radioactive isotopes enter the working environment in the form of gases, aerosols, and solid and liquid radioactive waste: Sources of aerosols can be not only production operations, but also contaminated work surfaces, clothing and footwear.

Basic principles of protection: use of protection principles used when working with radiation sources in a closed form; sealing of production equipment in order to isolate processes that may become sources of radioactive substances in the environment; planning activities; application of sanitary means and equipment, use of special protective materials; use of personal protective equipment and sanitation of personnel; compliance with the rules of personal hygiene; cleaning of surfaces of building structures, equipment and personal protective equipment from radioactive contamination; use of radioprotectors (biological protection).

Radioactive contamination of overalls, personal protective equipment and skin of personnel should not exceed the permissible levels provided by the Radiation Safety Standards NRBU-97.

In case of contamination with radioactive substances, personal clothing and footwear must be decontaminated under the control of the radiation safety service, and in case of impossibility of decontamination they should be disposed of as radioactive waste. X-ray radiological procedures are among the most effective methods for diagnosing human diseases. This determines the further increase in the use of X-ray and radiological procedures or their use on a larger scale. However, patient safety concerns require that we minimize exposure levels, as exposure to ionizing radiation at any dose is associated with an additional, non-zero risk of remote, stochastic effects.

Currently, in order to reduce individual and collective radiation doses of the population through diagnostics, organizational and technical measures are widely used: as an exception, unfounded (without evidence) research; changing the structure of research in favor of those that give a lower dose of load; introduction of new equipment equipped with modern electronic equipment for enhanced visual imaging; the use of screens to protect areas of the body to be studied, etc.

These measures, however, do not address the problem of ensuring maximum patient safety and optimal use of these diagnostic methods. The system of ensuring the radiation safety of patients can be complete and effective if it is supplemented by hygienic regulations of permissible radiation doses.

Ways to increase life in conditions of radiation danger. The issue of survival in conditions of high radiation is relevant for residents of many regions of Ukraine. As radionuclides that enter the human body with food are currently the main threat, precautionary and preventive measures should be taken to promote the elimination of these harmful substances from the body.

The modern concept of radioprotective nutrition is based on three principles: limiting the intake of radionuclides with food; inhibition of absorption, accumulation and acceleration of their removal; increase the body's defenses. The third direction involves the search for and creation of radioprotective nutrients and products that have antioxidant and immunostimulatory activity and are able to increase the body's resistance to the adverse effects of radioactive radiation (antimutagens and radioprotectors). Natural «defenders» come to the rescue. These substances include: tea leaves, grapes, black currants, chokeberry, sea buckthorn, bananas, lemons, dates, grapefruits, pomegranates; from vegetables – spinach, brussels sprouts and cauliflower, beans, parsley.

To prevent radionuclides from being absorbed by the body, you need to constantly eat foods that contain pectins, including apples. Sunflower seeds belong to the group of radioprotective products. Rich in bioregulators seafood, very useful honey and fresh fruit juices.

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