

ORGANIZATION OF RESEARCH AND COMPARATIVE ANALYSIS OF THE STRUCTURE OF ONCOLOGICAL DISEASES DURING THE COVID-19 PANDEMIC IN THE POPULATION LIVING IN THE CITIES OF INDUSTRIAL MINING OF URANIUM

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Abstract: Interest in the radiation effects of radon on the population arose at the beginning of the '80s of the XX century. Studies have shown that radon concentration in the air of residential buildings, especially single-story, often exceeds the permissible level set for uranium miners. Uranium also has no less harmful effects on the human body. The main dose a person receives in the premises where the city resident spends 80% of his time. The content of radon in the indoor air is determined by the specifics of the area's geological structure and the location on its territory of rock masses with high uranium content. The formation of very high radon activity indoors can lead to various natural and artificial factors, especially in areas of mineral development. The primary source of radon in the building is rocks and soils. Many houses in Kropyvnytskyi are built of building materials that include granite with high content of radon and uranium that negatively affects the health of residents of the city and region. Kropyvnytskyi is one of the three cities in Ukraine with the highest cancer mortality rate. One of the reasons is radon, a colorless, odorless, and tasteless gas. Radon is released from faults of the earth's crust and significantly affects the appearance of cancerous tumors.

Keywords: Human health, Malignant neoplasms, Oncological diseases, Radon, Uranium.

1 Introduction

Uranium ore is mined in Ukraine only in the Kirovohrad region. These are three mines: Ingul, Smolin, and Novokostyantyniv. They are part of the state enterprise "Eastern Mining and Processing Plant," located in Zhovti Vody, Dnipropetrovsk region. In the Ingulska region, the Eastern Mining and Processing Plant mine has been operating near the regional center for more than 30 years. All this time, the company mines uranium ore conducts its primary processing, and its mines are just under the housing estates. Radon dissolves quickly in the air but accumulates in closed basement rooms. This also applies to apartments on the ground floors of residential buildings.

Ionizing radiation existed on Earth long before humans appeared on it [20, 28]. However the effect of ionizing radiation on the human body was discovered only at the end of the XIX century with the discovery of the French scientist A. Becquerel and then the research of Pierre and Marie Curie on the phenomenon of radioactivity.

Modern technologies that use ionizing radiation play a major role in the development of civilization. Due to the phenomenon of radioactivity a significant breakthrough was made in medicine, various industries including energy [21]. But at the same time the negative aspects of the properties of radioactive elements began to appear more and more: it is well known that the effect of ionizing radiation on the body under certain conditions has negative and even fatal consequences [11].

Convincing and consistent evidence arises only at relatively high radiation doses more than 100 – 200 millisieverts (mSv) due to

short effects such as on the people of Japan after the nuclear bombing, the liquidators of nuclear accidents (chemical plant "Lighthouse" (Russia), nuclear power plants (NPPs) Chornobyl (Ukraine), Tri-Mile Island (USA), Fukushima (Japan)) or patients undergoing medical manipulations. But even in these cases the attention of researchers is focused mainly on carcinogenesis, mutagenicity, heredity, embryogenesis [26]

The mining industry has many factors of negative impact on the environment contributing to the emergence of a whole set of undesirable changes [8]. 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 [13]. 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 [6]. 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 [25]. In addition large areas were contaminated as a result of the Chornobyl accident [2].

In Ukraine there are areas that pose a risk of overexposure to certain categories of employees of uranium mining enterprises and the population living in the area of operation of these enterprises. Kirovohrad region is such a territory. Mine "Ingulska" – Kropyvnytskyi, "Smolinska" – small town Smolino, "Novokostyantynivska" – former Malovyskiv district of the village of Oleksiyivka. The distance to Mala Vyska is 10 km and to the regional center is 45 km. The Novokostyantyniv uranium deposit was discovered in 1975. According to the operative recalculation the reserves amount to more than 93,000 tons of uranium. In terms of uranium reserves the deposit is the most powerful in Europe and is one of the ten largest deposits in the world.

Uranium mining enterprises are located and operate in the region which create a certain man-caused radiation impact on the population living in their area of operation (Table 1-2).

Table 1: The number of permanent population

	Total permanent population	Including	
		Urban population	Rural population
Kropyvnytskyi	233509	233509	
Oleksandriia	89332	87281	2051
Total by cities	322841	320790	2051
Total by districts	626994	276180	350814
Total in the region	949835	596970	352865

Table 2: Population structure (%)

	On 01.01.2019		On 01.01.2020	
	Total Number	%	Total Number	%
Total population	966,7	100,0	959,3	100,0
Including urban population	605,6	62,6	601,1	62,7
Rural population	361,1	37,4	358,2	37,3
Children 0 - 14 years	145,0	15,0	145,6	15,2
Adolescents 15-17 years	25,2	2,6	24,9	2,6
Adults 18 and older	796,5	82,4	788,8	82,2
From the total number of persons of retirement age	268,9	27,8	269,8	28,1
From the total number of persons of working age (from 18 years)	527,6	54,6	519,0	54,1

Features of the radiation situation in the region are due to the presence of uranium mines. Uranium ore is mined in mines with the help of explosives [24]. The rock is delivered to the surface

where it undergoes radiometric separation. Off-balance, low-uranium ore goes to dumps and rich in radioactive material is sent for further enrichment.

During uranium mining there are mine heaps where there are small residues of uranium. Uranium ores contain not only radionuclides but also compounds of toxic elements of arsenic, lead, vanadium, selenium [7].

2 Materials and Methods

Kropyvnytskyi and Kirovohrad regions were chosen as the scientific base of the research. Kropyvnytskyi produces uranium raw materials which are transported to Zhovti Vody the only city in Ukraine where primary uranium enrichment is carried out.

To analyze the environmental and radiation situation in Kropyvnytskyi and Kirovohrad region the used data of morbidity observations were carried out using the materials of the regional center of medical statistics, reports of the Kirovohrad regional oncology dispensary, materials for the report at the plenary session of the III session of the Kirovohrad regional council of 8 calling "Comprehensive program for environmental protection in the Kirovograd region for 2016-2020".

3 Results and Discussion

The cycle of natural radionuclides determines the increased gamma background of the area, the saturation of the underlying rocks of the earth's crust and groundwater with radon-222 and its exhalation into the environment. Unfavorable situation is in the central part of the region – the cities of Kropyvnytskyi, Znamyanka, the villages of Maryivka, Zelene, Kalynivka, Ivano-Blagodatne. Radon concentrations of up to several thousand Bq/m³ are registered in the basements of private houses and in the premises of one-storey buildings, on the first floors of multi-storey buildings the radon concentration varies from several tens to hundreds of Bq/m³. In the east of the region Petrovsky district in the balka of Shcherbakovskaya there is a tailings pond for waste of the hydrometallurgical plant of the state enterprise "Eastern Mining and Processing Plant". The main sources of radioactive effects on the environment in the uranium mining region are:

- Uranium mines located in the Kirovohrad region;
- Hydrometallurgical plant for processing uranium ore and tailings for storage of radioactive waste located in Zhovti Vody;
- Former sites of underground leaching of uranium deposits located in the Dnipropetrovsk and Mykolaiv areas. The growing level of man-made load on the environment associated with the extraction and delivery to the surface of uncompensated large masses of rocks quantitative changes in mining and geological conditions in areas of large deposits may cause the emergence of qualitatively new natural processes not previously known. Radon is actively studied from radiogenic gases formed during the decay of natural radioactive substances and used to study geodynamic processes [4, 18, 28]. It is believed that high levels of radon and its daughter decay products determine the leading role of this factor in shaping the health of the population.

The central deposit of the Ingul mine of the state enterprise "Eastern Mining and Processing Plant" has been in operation since 1972. The industrial site of the mine is located on the territory of Kropyvnytskyi district, mining branch (underground mining department) within the city of Kropyvnytskyi. The Ingul mine of the state enterprise "Eastern Mining and Processing Plant" is located within the city of Kropyvnytskyi. The total activity of emissions of uranium, thoron (radon-220) and aerosols into the atmosphere is on average $2.849 \cdot 10 + 13$ Bq. The rock dumps contain about 5.32 million tons of waste from the mining industry and off-balance ore located on an area of 223 thousand m² with a total activity of about $5.55 \cdot 10 + 13$ Bq. Ingul mine is located outside the residential area. The closest to

the emission sources (auxiliary production – repair and mechanical workshop) residential area is located in the northern direction at a distance from the fence of the industrial site of the mine "South" – 150 m (Figure 1).

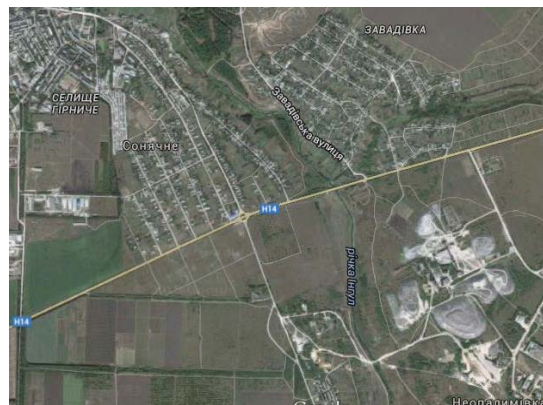


Figure 1 – Location of Ingul mine in Kropyvnytskyi

In the Kirovohrad region as well as in Ukraine according to the DALY indicator (lost years of healthy life) the highest percentage among both males and females is accounted for by cardiovascular diseases. Unintentional injuries have the second position for men and neuropsychiatric disorders for women. According to DALY the maximum disease burden among men is associated with tobacco and alcohol use and among women with high blood pressure and high cholesterol.

Within our study it was important to assess the incidence of marker-related environmental pathologies including oncological diseases. The incidence rate of malignant neoplasms in the Kirovohrad region is consistently high. At the same time in Kropyvnytskyi it significantly exceeds the average indicators in the region and Ukraine ($p < 0.001$) (see Table 3).

Table 3: Indicators of oncological diseases in Kropyvnytskyi for 2016 – 2020 (per 100 thousand population)

Incidence of malignant neoplasms	Territory	Years					M ± m
		2016	2017	2018	2019	2020	
Total	Kropyvnytskyi	487,5	538,1	546,1	542,7	572,3	537,3±13,81
	Kirovohrad region	425,9	434,6	452,2	449,6	448,0	442,1±5,06***
	Ukraine	341,5	347,8	357,6	360,9	344,5	350,5±3,76***
Incidence of malignant neoplasms	Territory	Years					M ± m
		2010	2011	2012	2013	2014	
Colon C18	Kirovohrad region	24,8	25,7	26,3	26,1	22,8	25,1±0,64**
	Ukraine	21,3	22,1	22,5	23,0	22,4	22,3±0,28***
Rectum, anus C19 - C21	Kropyvnytskyi	24,5	28,3	25,8	32,5	31,5	28,5±1,55
	Kirovohrad region	26,0	24,9	23,8	27,0	25,8	25,5±0,54
	Ukraine	18,9	19,5	19,7	19,8	19,0	19,4±0,18***
Trachea, bronchi, lungs C33-C34	Kropyvnytskyi	37,3	46,6	48,8	49,6	45,7	45,6±2,19
	Kirovohrad region	44,3	46,5	49,9	48,1	50,7	47,9±1,16
	Ukraine	35,9	36,0	36,4	36,1	34,2	35,7±0,39**
Breast C50	Kropyvnytskyi	97,6	124,2	90,4	105,6	108,7	105,3±5,70
	Kirovohrad region	73,6	75,8	74,5	82,3	72,9	75,8±1,69***
	Ukraine	64,8	66,0	67,1	67,9	64,6	66,1±0,64***
Body of womb C54	Kropyvnytskyi	40,1	42,4	47,1	41,0	62,0	46,5±4,05
	Kirovohrad region	35,3	33,8	38,9	38,3	46,9	38,6±2,27
	Ukraine	28,5	29,4	29,9	32,0	30,4	30,0±0,58**
Thyroid gland C73	Kropyvnytskyi	6,2	5,0	9,6	13,8	19,7	10,9±2,69

	Kirovohrad region	4,7	4,1	7,9	9,8	13,7	8,0±1,76
	Ukraine	5,7	6,5	6,6	7,5	7,4	6,7±0,33

Note: * - $p < 0.05$; ** - $p < 0.01$; *** - $p < 0.001$ compared to Kropyvnytskyi according to Student's criterion.

In the dynamics of the ten-year period the incidence of male population in Kropyvnytskyi for malignant neoplasms increases on average by 2 times in the age groups of 45-49 years, 50-54 years and 55-59 years. In contrast to the male cohort of women the double increase in the incidence of malignant neoplasms is observed only in the age group of 30-34 years although the peak incidence of malignant neoplasms of the entire population of the region falls on the age group of 70 years and older. In the Kirovohrad region the mortality rates of the entire population from malignant neoplasms significantly exceed the corresponding levels in Ukraine ($p < 0.05$). It was found that they are formed mainly due to the female cohort.

The average incidence of malignant lung neoplasms in Kropyvnytskyi and Kirovohrad regions is significantly higher compared to the same indicator in Ukraine ($p < 0.01$). The same pattern was found for the indicator of the average mortality rate for 10 years of the population of Kropyvnytskyi and Kirovohrad region from malignant lung neoplasms in comparison with the all-Ukrainian indicator ($p < 0.001$). The reduction in the mortality rates of the population of these administrative territories from malignant lung neoplasms over five-year periods which has taken place in Ukraine in recent years has not been confirmed. This determines the presence in the Kirovohrad region of a stable causal factor that determines the development of exclusively oncological pathology.

Among all the reasons that determine the development of malignant neoplasms including malignant neoplasms of the lungs the leading place is occupied by those caused by the impact on the body of harmful environmental factors. Analysis of gross man-made emissions into the environment revealed that per inhabitant of Kirovohrad region in different years accounted for from 8.2 kg to 13.4 kg of harmful substances released into the atmosphere (for comparison in Kryvyi Rih – from 890 kg to 1112 kg).

Concentrations of radon-222 which often exceeded the level of 2000 Bq/m³ were detected in the air of residential premises in Kropyvnytskyi. It is the high levels of radon and its decay products that determine the leading role of this factor in shaping the health of the population. This is confirmed by the indicator of the maximum individual risk of long-term consequences (additional number of deaths from radiation-induced diseases) which in the adult population of Kropyvnytskyi is twice as high as that determined for workers of the main professions of uranium mining mines in Kirovohrad region.

Analysis of the incidence of malignant neoplasms of the male population of Kropyvnytskyi and workers of uranium mines (category A) revealed 2.4 times increase in the relative risk of malignant neoplasms in the cohort of miners compared to the male population of Kropyvnytskyi which may be due solely to exposure on their body ionizing radiation from natural radionuclides. It was found that workers of uranium mining enterprises can be exposed to double exposure to ionizing radiation both due to high levels of radon and its daughter decay products in the air of workings (in the workplace) and in residential areas where they live.

The results of calculations of radiation risk for residents of Kropyvnytskyi (additional number of deaths from radiation-induced diseases) caused by air pollution of residential premises in Kropyvnytskyi with natural radionuclides revealed that this risk is equal to 0.1226-2.8565 cases per year.

A comparison of this indicator with that calculated for residents of NPP satellite cities (0.038 cases per year) revealed an increase of almost 3-75 times. This indicates the presence of danger of natural radiation factors for the health of the residents of Kropyvnytskyi.

The analysis of radon-222 levels in the air of residential buildings and in the premises of public facilities in Kropyvnytskyi allowed identifying certain geopathogenic zones the presence of which may be due to the geological structure of the area. Monitoring conducted by the state institution "Institute of Hygiene and Medical Ecology named after O.M. Marzeeva" within the framework of the regional program "Stop Radon" testifies that the radio alarm of Kropyvnytskyi residents is not unfounded. Thus in 2017 a selective measurement of the equivalent equilibrium volume activity of radon-222 (²²²Rn) in the air of Kropyvnytskyi facilities was performed.

Found exceeding the norm established by the state sanitary rules were revealed in 53.3% of the inspected preschool educational institutions, in 71.4% of schools, in 58.3% of the investigated health care institutions. In 2018 surveys of private households in the city given disappointing results – in 76.9% of homes, the equivalent equilibrium volumetric activity of radon-222 in the air is above normal. In 2019-2020 a study of water from artesian wells and wells in the region was carried out – measurements of the equivalent equilibrium volumetric activity of radon were performed. In 2019 the norm was exceeded in 20.6% of water tests and in 2020 – in 63.6% of studies.

The state of working conditions at the industrial facilities of the state enterprise "Eastern Mining and Processing Plant" and agricultural enterprises of the region significantly affects the health of the population of the region and determines a steady trend of increasing occupational morbidity of the population.

Let's make a comparative characterization of oncological pathology in cities with uranium mining, uranium processing and mining industries.

Ukraine belongs to the countries where the level of oncological diseases and mortality is very high. Over the past ten years the country has seen a steady increase in oncological diseases. Cancer is the cause of more than 15% of all deaths and is second only to cardiovascular disease. Malignant neoplasms occupy the second place in the structure of mortality of the population of Ukraine. Its share is 11.6%. Every year about 90 thousand people die as a result of these diseases of which 35% are people of working age. A similar picture is typical for Dnipropetrovsk and Kirovohrad regions.

A comparative analysis of the incidence of malignant neoplasms in Kropyvnytskyi, Zhovti Vody and Vilnohirsik shows that the problem of oncological diseases for the regional center is urgent (see Table 4). Thus separately by years and in general the incidence of malignant neoplasms in Kropyvnytskyi is higher than the all-Ukrainian indicator and in comparison with Zhovti Vody and control Vilnohirsik.

According to the selected marker oncological diseases the incidence rate in Kropyvnytskyi is consistently higher than in Zhovti Vody, Vilnohirsik and in Ukraine as a whole. It is worth noting some differences. In 2016 the incidence of tracheal, bronchial and lung cancer in Zhovti Vody was 1.8 times higher than in Kropyvnytskyi. But starting from 2017 the incidence of this pathology in Zhovti Vody began to actively decrease and in Kropyvnytskyi on the contrary – to increase. Analysis of marker diseases indicates the presence of peaks of oncological diseases in the experimental and control cities.

Table 4: The rates of oncological diseases in the cities of Kropyvnytskyi, Zhovti Vody and Vilnohirsik for 2016 - 2020 (per 100 thousand population)

Incidence of malignant neoplasms	Territory	Years					M ± m
		2016	2017	2018	2019	2020	
Total	Kropyvnytskyi	487,5	538,1	546,1	542,7	572,3	537,3±13,81
	Zhovti Vody	391,0	386,2	361,5	323,7	409,3	374,3±14,78***
	Vilnohirsik	369,7	303,7	374,3	340,8	328,3	343,4±13,15***
	Ukraine	341,5	347,8	357,6	360,9	344,5	350±3,76***

Colon C18	Kropyvnytskyi	26,1	32,4	36,7	33,3	36,9	33,1±1,96
	Zhovti Vody	21,1	32,8	17,5	33,2	49,0	30,7±5,53
	Vilnohirsk	20,8	20,8	58,2	37,4	24,9	32,4±7,13
	Ukraine	21,3	22,1	22,5	23,0	22,4	22,3±0,28 ***
Rectum, anus C19 - C21	Kropyvnytskyi	24,5	28,3	25,8	32,5	31,5	28,5±1,55
	Zhovti Vody	26,8	29,0	33,0	21,5	21,5	26,4±2,22
	Vilnohirsk	24,9	25,0	20,8	45,7	12,5	25,8±5,47
	Ukraine	18,9	19,5	19,7	19,8	19,0	19,4±0,18 ***
Trachea, bronchi, lungs C33-C34	Kropyvnytskyi	37,3	46,6	48,8	49,6	45,7	45,6±2,19
	Zhovti Vody	69,0	46,3	33,0	33,2	41,1	44,5±6,61
	Vilnohirsk	62,3	45,8	25,0	20,8	37,4	38,3±7,47
	Ukraine	35,9	36,0	36,4	36,1	34,2	35,7±0,39 **
Breast C50	Kropyvnytskyi	97,6	124,2	90,4	105,6	108,7	105,3±5,7 0
	Zhovti Vody	92,0	89,2	82,6	68,4	94,0	85,2±4,63 *
	Vilnohirsk	99,9	61,6	30,7	61,3	61,4	63,0±10,9 8**
	Ukraine	64,8	66,0	67,1	67,9	64,6	66,1±0,64 ***
Body of womb C54	Kropyvnytskyi	40,1	42,4	47,1	41,0	62,0	46,5±4,05 28,0±4,77 *
	Zhovti Vody	10,6	32,1	35,9	25,2	36,1	36,1
	Vilnohirsk	61,5	30,8	30,7	0	46,0	42,3±7,35
	Ukraine	28,5	29,4	29,9	32,0	30,4	30,0±0,58 **
Thyroid gland C73	Kropyvnytskyi	6,2	5,0	9,6	13,8	19,7	10,9±2,69
	Zhovti Vody	5,7	19,3	9,7	3,9	7,8	9,3±2,69
	Vilnohirsk	8,3	12,5	0,0	4,2	8,3	8,3±1,69
	Ukraine	5,7	6,5	6,6	7,5	7,4	6,7±0,33

Note: * - $p < 0.05$; ** - $p < 0.01$; *** - $p < 0.001$ compared to Kropyvnytskyi according to Student's criterion.

As a rule in all indicators of the incidence of malignant neoplasms the situation in the city of Kropyvnytskyi is worse than in Ukraine and the studied cities (Figure 2).

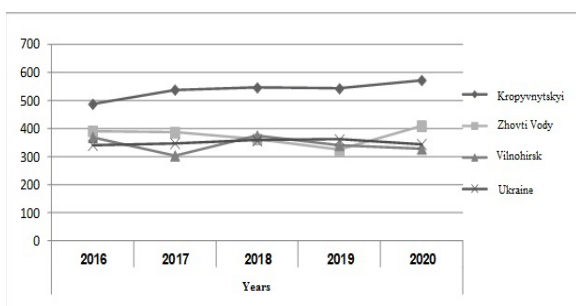


Figure 2 – Incidence of malignant neoplasms in the cities of Kropyvnytskyi, Zhovti Vody, Vilnohirsk compared to the national average

Summarizing the above data it can be argued that the level of oncological diseases in cities with nuclear fuel cycle enterprises significantly exceeds the regional and national indicators both in terms of the overall incidence of malignant neoplasms and in terms of individual pathologies. This is especially true of the city of Kropyvnytskyi where the incidence of malignant neoplasms per 100 thousand population over the past five years compared to the Ukrainian was respectively ($M \pm m$): 537.3 ± 13.81 and 350.5 ± 3.76 .

Analyzing the situation in the region we studied the prevalence of diseases among the entire population in the first place:

- Diseases of the circulatory system which account for 33.8% of all diseases;
- Respiratory diseases – 19.1%;
- Diseases of the digestive system – 9.5%;
- Diseases of the eye and appendix – 5.4%;
- Diseases of the musculoskeletal system – 5.1%;
- Diseases of the genitourinary system – 4.3%;
- Diseases of the endocrine system – 4.2%;

- Injuries, poisonings and other accidents – 3.0%;
- Mental and behavioral disorders – 2.6%;
- Diseases of the skin and subcutaneous tissue – 2.4%;
- Neoplasms – 2.5%;
- Infectious and parasitic diseases – 2.3%;
- Diseases of the nervous system – 2.2%;
- Diseases of the ear and papilla – 1.5%;
- All other diseases – 2.1%.

Among the adult population (18 years and older) the prevalence of diseases in 2020 increased from the following classes of diseases:

- Diseases of the endocrine system – in the indicator from 7708.5 in 2019 increased to 8060.5 in 2020 or 4.6% (Ukraine in 2019 – 9814.4);
- Of them: diabetes increased from 3604.9 in 2019 to 3711.0 in 2020 or by 2.9% (Ukraine 2019 – 3899.3);
- Diseases of blood, blood-forming organs – the indicator increased from 1236.8 in 2019 to 1273.6 in 2020 or by 1.3% (Ukraine 2019 – 1247.1);
- Neoplasms – in the indicator from 5193.6 in 2019 increased to 5371.4 in 2020 or by 3.4% (Ukraine 2019 – 5314.8);
- Diseases of the digestive system – in the indicator from 18367.1 in 2019 increased to 18444.2 in 2020 or by 0.4% (Ukraine 2019 – 19843.4).

Analyzing the performance of the oncology service of Kirovohrad region it should be emphasized that the incidence of malignant tumors increased from 468.4 per 100 thousand population in 2019 to 478.2 in 2020 i.e. by 2.1% and significantly exceeded the average Ukrainian figure in 2019 – 348.4.

The increase was in lip cancer (3.8 vs. 2.5 in 2019), colon cancer (27.5 vs. 26.2 in 2019), skin melanoma (9.9 vs. 8.4 in 2019), cancer esophagus (5.4 vs. 4.2 in 2019), gastric cancer (24.4 vs. 23.4 in 2019), lung cancer (48.1 vs. 44.8 in 2016), breast cancer (83, 8 vs. 77.5 in 2019) and ovaries – (23.4 vs. 20.3 in 2019) per 100,000 female population, skin cancer (64.3 vs. 63.7 in 2019), cervical cancer (38, 2 vs. 34.7 in 2019 per 100 thousand female population), prostate (61.2 vs. 48.6 per 100 thousand male population in 2019), malignant lymphoma (10.4 vs. 9.4 in 2019).

It should be noted that over the last decade in the region the incidence rate increased by 17.7% (478.2 in 2019 against 406.3 in 2008) and in Ukraine – by 5.2% (348.4 in 2019 against 331.1 in 2008).

In the structure of oncological diseases among the entire population of the region are:

- I place – skin cancer 64.3 per 100 thousand population or 13.5%;
- II place – tracheal and lung cancer 48.1 per 100 thousand population or 10.6%;
- III place – breast cancer 45.7 per 100 thousand population or 9.5%.

Among the female population:

- I place – breast cancer 83.8 per 100 thousand female population or 17.6%;
- II place – skin cancer 72.8 per 100 thousand female population or 15.3%;
- III place – cancer body of womb 42.3 per 100 thousand female population or 8.9%.

Among the male population:

- I place – lung cancer 80.4 per 100 thousand male population or 16.7%;
- II place – prostate cancer 61.2 per 100 thousand male population or 12.7%;
- III place – skin cancer 54.4 per 100 thousand male population or 11.3%.

Compared to 2020 the percentage of cancer neglect increased slightly amounting to 17.4% (2019 – 17.3%) and exceeding the average Ukrainian (16.7% in 2019). There is a high level of neglect in pharyngeal cancer – 38.5%, gastric cancer (44.3%), lung cancer (33.4%), kidney cancer (26.5%), oral cancer (32.6%), colon cancer (23.8%), esophageal cancer (29.5%), prostate cancer (26.8%).

The percentage of detection of visual localizations in an abandoned state decreased and amounted to 15.6% against 17.3% in 2019. High percentage and significantly exceeded the figure for 2020 in Golovanivskiy district (31.0% vs. 17.6% in 2019), Haivoronskyi (23.9% vs. 21.4%), Dolyna (20.9% vs. 14.6%), Novomyrhorod (25.0% vs. 13.5%), Novoukrainskyi (18.0% vs. 24.3% in 2016), Kompaniivskyi (20.8% vs. 16.7% in 2019), Znamyanskyi (20.6% against 22.9% in 2019).

The indicator of contingents of patients with malignant neoplasms increased from 2647.9 per 100 thousand population in 2019 to 2779.1 in 2020 (in Ukraine 2543.3 in 2019) and indicates the quality and effectiveness of the treatment and diagnostic process in oncology.

The percentage of patients who have not lived one year since the diagnosis decreased compared to last year and amounted to 28.9% (in 2019 – 30.0%). In Ukraine last year it amounted to 30.5% and it is an integral indicator of the organization and quality of preventive examinations, timeliness of diagnosis and adequate treatment provided by treatment and prevention facilities. That is the mortality rate up to one year is used as an indicator of the quality of medical care.

The highest rate is registered annually in esophageal cancer which in the reporting year amounted to 59.9% (in Ukraine 66.3% last year), lung cancer 60.9% (in Ukraine 61.8%), and gastric cancer 59.9% (59.4% in Ukraine). It should be noted the high mortality rate up to one year in Ustynivskiy district 41.2%, in Znamyanskyi 36.7%, Novgorodskyi 39.2%, Novomyrhorodskyi 35.7%, Alexandria 35.1%, Novoukrainskyi 31.8%, Svitlovodsk 31.3%.

The percentage of patients diagnosed for the first time in the reporting year that received special treatment was 69.1%, 30.9% of patients with malignant neoplasms were not covered by special treatment.

The mortality rate from malignant tumors decreased and amounted to 202.0 in 2020 against 213.5 per 100 thousand population in 2019 (in Ukraine in 2019 – 174.5).

In 2020 54.4% of women were examined using cytological screening (in 2019, 56.8%). Stably low level of cytological screening implementation in Svitlovodsk district – 36.7%, Oleksandrivskyi district – 34.9%, Bobrynetskyi – 40.7%, Vilshanskyi – 43.7%, Oleksandriyskyi – 46.3%, Ustynivskyi – 44.2% , in Blagoveshchensk – 47.2%, Kompaniivskyi – 41.0%. We conducted a statistical study of cancer among residents of Kirovohrad region, Kropyvnytskyi district and Kropyvnytskyi

The incidence of malignant tumors ranges from 590.5 per 100 thousand population in Kropyvnytskyi to 293.9 in Ustynivka district. The highest incidence rates were registered in the city of Kropyvnytskyi – 590.5. Here are the contingents of patients with malignant neoplasms (Table 5).

Table 5: Contingents of patients with malignant neoplasms (per 100 thousand population)

No.	Names of districts	2012	2013	2014	2015	2016	2017	2018	2019
1.	Kropyvnytskyi	2399,1	2553,3	2664,5	2757,9	2907,0	3023,5	3132,2	3293,3
2.	Oleksandriia	2363,4	2453,9	2557,4	2659,7	2765,9	2898,0	3028,3	3205,6
3.	Blahovishchenske	1925,4	1978,9	2138,4	2138,4	2232,7	2309,8	2370,5	2391,1
4.	Bobrynetskyi	2097,8	2183,2	2302,7	2490,4	2635,4	2647,0	2690,8	2644,4
5.	Vilshanskyi	2204,3	2303,1	2367,8	2456,4	2585,8	2747,8	2732,3	2794,4
6.	Gaivoronskyi	1965,9	1993,2	2216,5	2248,9	2178,7	2162,0	2270,6	2449,4
7.	Golovanivskyi	1725,6	1684,5	1720,0	1794,7	1838,6	1923,6	2006,4	1985,6
8.	Dobrovelychkivskyi	1953,8	2088,6	2182,5	2255,9	2307,7	2441,9	2601,9	2700,3
9.	Dolynskyi	1494,3	1529,6	1575,2	1614,6	1665,5	1747,7	1829,0	1977,0
10.	Znamyanskyi	2291,6	2455,7	2488,5	2581,5	2752,0	2852,5	2894,6	3025,9
11.	Kirovohrad	1714,3	1805,3	1819,9	1878,8	2020,5	2137,6	2201,1	2315,2
12.	Kompaniivskyi	2022,5	2133,6	2259,4	2256,6	2307,6	2326,4	2402,5	2504,8
13.	Malovykovskiy	2221,6	2257,4	2479,4	2699,4	2693,4	2636,3	2822,1	2949,2
14.	Novgorodskyi	1697,5	1769,0	1831,4	1903,7	1988,3	2166,2	1989,2	2011,9
15.	Novoarkhangel'skyi	1720,9	1867,0	1911,5	1982,8	2029,9	2061,9	2224,4	2371,5
16.	Novomyrhorodskyi	1957,9	2029,8	2062,1	2078,9	2248,0	2265,8	2343,7	2467,0
17.	Novoukrainskyi	1827,9	1951,0	2037,2	2156,6	2152,3	2343,2	2434,2	2667,2
18.	Oleksandriyskyi	1925,1	2144,2	2280,1	2422,7	2518,4	2643,8	2785,3	2977,6
19.	Oleksandriyskyi	1587,1	1676,1	1760,1	1828,5	1859,1	1921,7	2024,2	2127,5
20.	Onufriivskyi	1484,4	1542,4	1658,7	1680,0	1781,6	1871,7	2053,3	2059,2
21.	Petrovskyi	1537,0	1563,9	1606,8	1566,6	1686,0	1800,2	1870,0	1976,0
22.	Svitlovodsk	2321,1	2341,3	2488,2	2636,6	2731,5	2768,6	2875,2	2988,2
23.	Ustynivskyi	1648,6	1774,4	1919,8	1949,0	2116,4	2196,6	2056,4	2165,3
	Total in the region	2085,0	2174,8	2277,7	2374,2	2463,5	2553,6	2650,0	2779,1
	Ukraine	2161,6	2227,2	2314,8	2402,6	2478,9	2507,7	2543,3	2608,7

The nosological structure of those initially recognized as disabled among the adult population is as follows: neoplasms – 27.6%, diseases of the circulatory system – 16.5%, injuries, poisoning and some other consequences of external factors – 11.2%, musculoskeletal diseases systems – 10.4%, some infectious and parasitic diseases – 7.3% (including tuberculosis - 4.7%).

Last year the nosological structure of the initially recognized disabled among the adult population was as follows: neoplasms – 25.1%, diseases of the circulatory system – 15.3%, injuries, poisoning and some other consequences of external factors – 14.2%, some infectious and parasitic diseases – 9.1% (including tuberculosis – 5.5%), diseases of the musculoskeletal system – 8.4%.

The nosological structure of those initially recognized as disabled among the working population has the following composition: neoplasms – 26.8%, diseases of the circulatory system – 13.4%, injuries, poisoning and some other consequences of external factors – 11.2%, some infectious and

parasitic diseases – 9.8% (including tuberculosis – 6.2%), diseases of the musculoskeletal system – 9.6%.

Last year the nosological structure of the initially recognized disabled among the working population has the following composition: tumors – 25.4%, injuries, poisoning and some other consequences of external factors – 13.8%, diseases of the circulatory system – 12.2%, some infectious and parasitic diseases – 10.7% (including tuberculosis – 7.3%), diseases of the musculoskeletal system - 8.4%.

Studies of the risk of radiation induction of oncological diseases have a special place in modern radiation and epidemiological studies [16, 23].

Among radiogenic malignancies leukemia has the maximum radiation risk and the minimum latency period. Therefore the excess of the possible incidence of leukemia above the level of the spontaneous level may be the first objective indicator of the level of radiation exposure [12].

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 [5].

It is known that the immune system has the highest radiation sensitivity in the body so the radiation effect on the human body primarily causes the development of acquired immunodeficiency states of various nature and severity which in turn are the basis for various human pathologies. According to the Center for Public Health of the Ministry of Health of Ukraine the main organ through which radon enters our body is the lungs. Radon causes them the most damage. Researchers have found that radon gas is the second most common cause of lung cancer after smoking. But radon and its decay products affect not only the human lungs. Radon gas has been shown to adversely affect immune, germ and hematopoietic cells. Radon damage can lead to loss of natural protection of the human body which of course provokes the development of various diseases; namely against the background of immunosuppression and the background of unfavorable ecological and epidemiological situation. The most common pathology is tuberculosis of the pulmonary system. This leads to disability of the working population [3, 17].

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 the critical group [15]. 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 - to retardation [14]. The combination of these factors is defined as the syndrome of environmental maladaptation [27].

The Government of Ukraine is taking steps to improve the environmental situation in Ukraine. At one time in the Kirovohrad region as part of the regional program "Stop Radon" preliminary studies of the content of radon-222 were performed. According to environmental activists, the expediency and effectiveness of the program method of solving these problems is unquestionable. After all it is confirmed by both international and domestic experience in all member states of the European Union in accordance with the requirements of the Directive of December 5, 2013 "Laying down basic safety standards for protection against the risks arising from exposure to ionising radiation" [1]. Such plans are an effective component in combating oncological diseases and improving quality and life expectancy.

4 Conclusion

Analyzing the current findings of scientists there are virtually no sources in nature with such a level of ionizing radiation that would lead to health problems 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 activity.

If we analyze the indicators of the Kirovohrad region we see the long-term effects of radiation in the structure of the rate of disability of oncological diseases. An in-depth analysis of the health of the population of Kirovohrad region needs further study by conducting specialized medical epidemiological studies for a more detailed differentiation of the impact of ionizing radiation on the population.

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