

Interrelation Of Environmental Factors In The Magadan Region As Predictors Of The Development Of Malignant Neoplasms

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Abstract

The rate of development of malignant neoplasms (MN) is determined by the characteristics of the human environment and professional engagement, as well as by material-and-technical equipment and staff composition of the regional healthcare system. The recent yearshave been marked by a dynamic increase in the number of medical and statistical indicators of cancer among residents of the Far Eastern Federal District. The article presents the first-ever comprehensive consideration of the potential impact of environmental factors on the rate of MNdevelopment in residents of the Magadan Region.

Materials and methods

The study reviewed the state reports data on the sanitary and epidemiological well-being of the population of the Russian Federation and Magadan region for 2011-2019; particular consideration was given to the materials of regional Medical Information and Analytical Center.

Results

The structure of morbidity and mortality from malignant neoplasms among the residents of the Magadan region isheaded by the indicators of lungs and mammary neoplasms and colorectal cancer (CRC). The local dynamics of the growth in the incidence of lung cancer is ahead of the average values in the Russian Federation, which is primarily due to the atmospheric air quality in the region, polluted by traffic, large heating enterprises, and district heating plants. In 2013-2019, the concentration of nitrogen

and sulfur dioxides, phenol, and formaldehyde in the atmospheric air of the Magadan region had notably increased, most particularly due to the lack of funding for treatment facilities and the negative impact of climatic conditions. The level of morbidity and mortality from CRC is largely determined by the quality of local drinking water, which is, in fact, contaminated with organic matter, nitrogen salts, oil products, and impurities of metal salts. The regional branch of the Ministry of Environment believes that the reason behind the pollution of the sea coastal waters is the failure of sewage facilities and storm drains, which is due to the significant deterioration of the distribution networks and the violation of water treatment and processing technology.

Conclusions

The dynamics of medical and statistical indicators in lung cancer and CRC in the population of the Magadan region are characterized quite unfavorably. The current conditions cannot be amended just by the increase of doctors' alertness to cancer; joint actions of the employees of the Ministry of Health and the Ministry Environment are essential in no uncertain terms. Further, to improve the quality of early MN diagnosis, it is required to build an interactive atmospheric air and water pollution map of the districts of the Magadan region (with account taken of populated localities and enterprises of hazardous industry), while continuing measures to improve the active MN detection.

Keywords: lung cancer, colorectal cancer, malignant neoplasms, air pollution, water purification, Magadan region.

Urgency of the research

The development of malignant neoplasms (MN) leads to irreversible health disorders in people around the world [1]. The calculation of cumulative risks, concerning the complex effect on the body by several agents and including biochemical, chemical, physical, and psychosocial factors, is estimating the probability of MN development at the age of 75 at 75% in men, and only 25% - in women [2, 3]. The growing list of chemical and biological agents affecting the human body and potentially contributing to the development of inflammatory and induced oncological diseases is a serious problem for society [4].

Despite the rapid development of methods for early MN detection (resulted from molecular genetic studies of cells and modern diagnostic technologies), therapeutic (robot-assisted techniques, radiation, and drug exposure) and rehab technologies (development of reconstructive surgery, therapeutic physical training, and physiotherapy), the dynamics of morbidity rates and mortality due to MN development is still estimated unfavorably [5]. The development of tumors is determined by the characteristics of the human environment and professional engagement, sometimes to a greater extent than by the administrative resources of the healthcare system employees [6, 7].

According to the WHO, human health is 50% dependent on the lifestyle and 10% - of the surrounding environment. The features of MN progression among residents of the northern regions of the Russian Federation, especially among the population of its northeastern regions, differ significantly from other autonomous districts and republics. This difference is explained by the chronic population stress, urbanization, and extreme living conditions in a harsh environment [8].

The Government of the Russian Federation pays close attention to the figures of MN morbidity and mortality among the residents of the Far Eastern Federal District (FEFD). FEFD makes up over 40% of the size of the territory of Russia. Still, its residents are experiencing a significant increase in cancer morbidity and mortality [9]. For 2009-2019, the Russian average level manifested a decrease in MN mortality by 1.9%; however, this indicator remains stable in the regions of the Far Eastern Federal District, reaching 2.4% [9].

As part of the solution to the problem, an applied project 'Unified system of oncological care for the population of the Far Eastern Federal District' was launched within the framework of the federal project 'Fighting Cancer' (subsidiary of the 2020 National Project 'Healthcare'). The project is aimed at improving oncological care for the population of the FEFD subjects. The main package of measures has been spelled out; budgeting is provided for the updating of HR policies and material-and-technical equipment of medical institutions, which should meet the demand of realities.

Magadan Region is recognized as one of the ecologically safe regions in the structure of the Far Eastern Federal District [10]. A comparative analysis of MN incidence rate in the territory of Magadan and Chelyabinsk regions (the latter is considered to be environmentally unfavorable) has been conducted. Thus, when comparing the standardized MN incidence rates in these regions in 2006 (242.9 and 247.1 per 100 thousand residents, respectively), these values are significantly lower than the indicators of 2016 (320.1 and 256.3 per 100 thousand, respectively).

Due to official statistics, the increase in the incidence rate of MN in the Magadan region for 2006-2016 compiled + 23% [9, 10]. These facts served as the reason for analyzing MN indicators in regional populations concerning the conditions of the human environment. This is the first time such a study is being conducted.

Materials and methods

The study reviewed the state reports data on the sanitary and epidemiological well-being of the population of the Russian Federation (data obtained from available electronic sources) and Magadan region for 2011-2019 (provided by the local branch of the Ministry of Natural Resources and Environment), as well as materials from the Medical Information and Analytical Center of the Ministry of Health and Population of the Magadan region.

Results

1. MN morbidity patterns

The leading positions in the structure of the MN incidence in Magadan region are occupied by: 1. malignant neoplasms of the lungs - 13.4%; 2. mammary neoplasms - 11.1%; 3. colorectal cancer - 9.5%;

4. cervical - 8.2% and skin cancers - 8.2%; 5. prostate cancer - 6.6%. Men were largely suffering from cancers of the lungs (n = 64, 22.5%), prostate (n = 41, 13.8%) and skin (n = 29, 9.8%). The leading figures among women were represented by cancers of the breast (n = 69, 21.3%), cervix (n = 51, 15.7%) and colon (n = 23, 7.1%).

The MN mortality pattern in the Magadan region is dominated by lung cancer (19%; 'raw count' per 100 thousand residents - 36.8), breast and colorectal cancers (9.8% each; 19.1), pancreas (7.3%; 14.2), stomach (6.9%; 13.4), and cervical cancers (5.8%). As follows from the data presented, lung cancer takes the leading position in terms of morbidity and mortality in the region. The 'raw count' of lung cancer's incidence rate in the Magadan region in 2019 was 58.8 per 100 thousand residents of both genders (48.7 in 2009, an increase of + 20.74%) (Fig. 1).

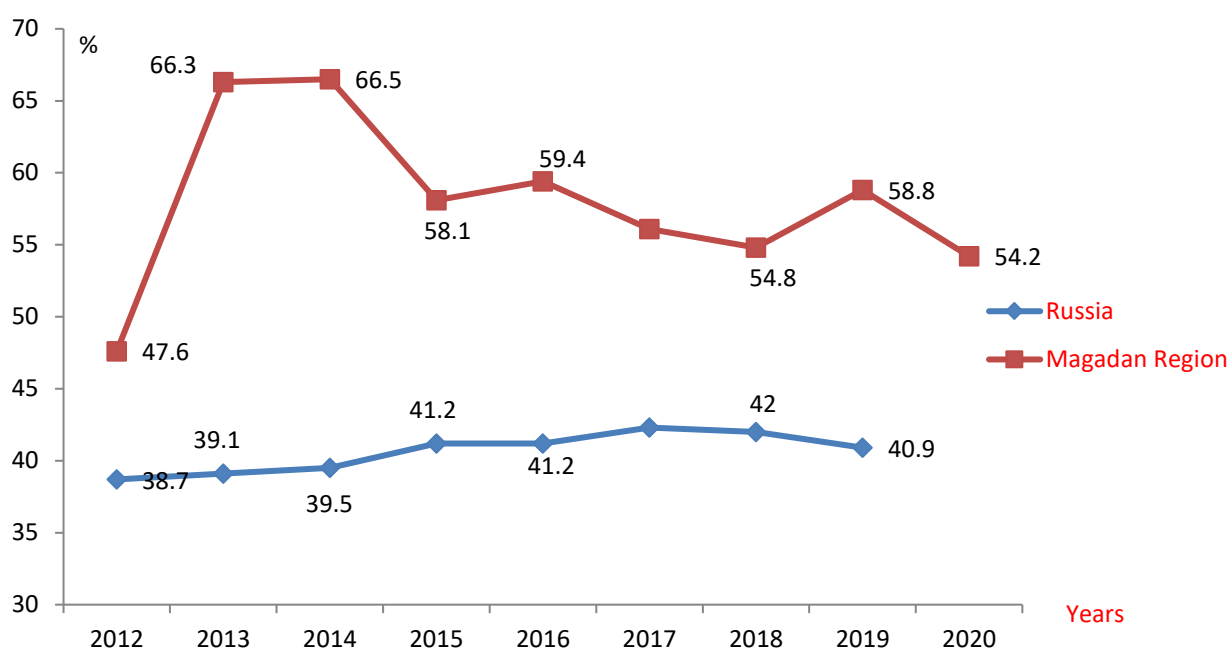


Figure 1. Comparative dynamics of lung cancer incidence rates in the Magadan region and Russian Federation in 2012-2019

Legend (top to bottom): Russian Federation; Magadan region

The growth rates of the regional incidence rate of lung cancer are significantly ahead of the average values for the Russian Federation (Fig. 1). The results of the analysis of the data on lung cancer detection in the initial (I-II) stages of the tumor process for 2009-2019 are shown in Figure 2.

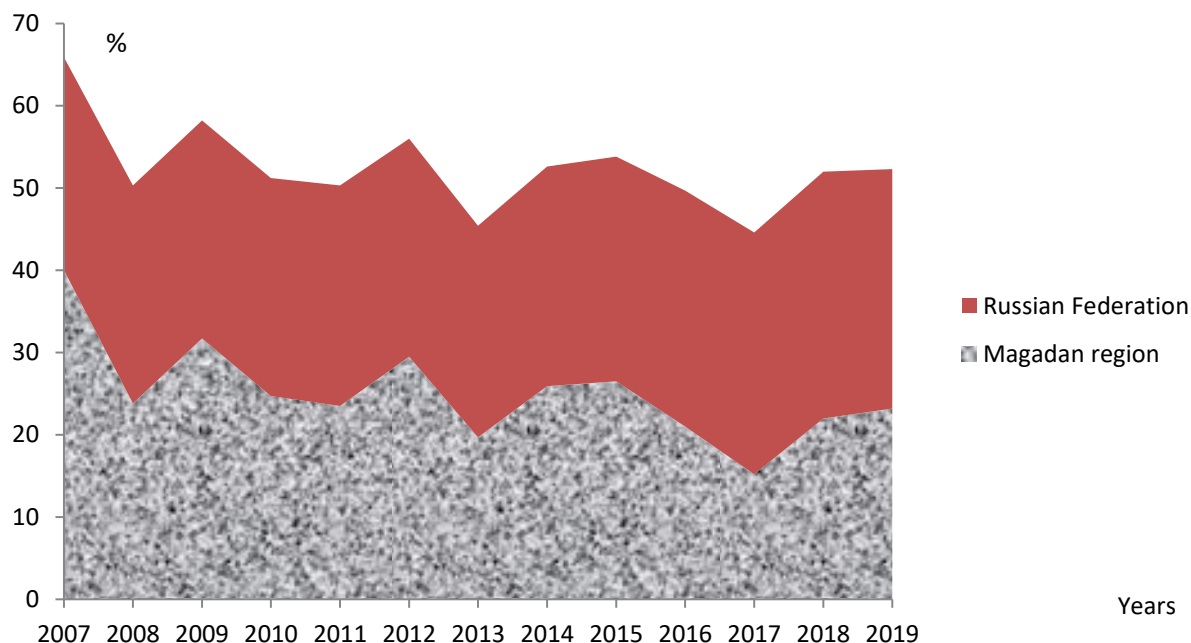


Figure 2. The proportion of cases of lung cancer detected in localized (I-II) stages in the Magadan region and Russian Federation in 2007-2019. (%%)

Legend (top to bottom): Russian Federation; Magadan region; Years

The relative proportion of malignant neoplasms of the lungs, detected in the region in 2007-2019 in the early and potentially curable stages, is inferior to a similar nationwide indicator (Fig. 2), which probably indicates the initial neglect of cases of this pathology in the Magadan region. The rate of development of this aggressive tumor is largely determined by the quality of atmospheric air, the particularities of professional engagement, and harmful addictions (smoking, etc.) [11, 12]. According to European colleagues, the unfavorable composition of atmospheric air also affects the development of malignant neoplasms of the bladder and tumors of the hematopoietic system in infancy [13].

2. Atmospheric air quality in the Magadan region

One of the main causes of MN in the lungs is the contamination of the atmospheric air by such substances as benzo[a]pyrene, benzene, metals, ozone, and combustor discharges of automobile fuel [12].

The sanitary state of atmospheric air in the region is characterized by the intake of basic (suspended solids, sulfur dioxides, dihydrosulfides, nitrogen and carbon oxides, carbon disulfide) and specific pollutants (ammonia, hydroxybenzene and its derivatives, aromatic hydrocarbons, benzene, toluene, xylene) [14]. The main sources of air pollution include motor transport, power industry enterprises, and district heating plants [15].

According to the data of the regional environmental safety supervisory authorities, a consequence of the particular geolocation of the city of Magadan (region's capital city) is the low 'self-cleansing capacity' of the atmosphere, which leads to a longstanding accumulation of harmful substances in its surface layer [14]. That, in turn, contributes to an increase in the concentration of nitrogen oxide (in terms of NO₂) and hydrocarbons (excluding volatile organic compounds) [15] (Table 1).

Table1 Air pollution emissions by type of business operations (thousand tons) in 2014-2018

Types of emissions	Indicators by year, thousand tons					Dynamics by 2018
	2014	2015	2016	2017	2018	
Air pollution - total	29.6	27.3	30.6	33.4	28.9	↓
Extraction of mineral resources	10.4	10.4	12.1	12.4	13.7	↑
Extraction of minerals other than fuel and power	10.0	10.1	11.7	12.0	13.2	↑

However, a similar situation (Table 1) was not always obvious. The analysis of the long-term (2012-2019) data of the Ministry of Natural Resources and Environment revealed that the highest average annual concentrations of phenol and its derivatives, sulfur dioxide, dust, carbon oxides and nitrogen oxides, were detected in the atmospheric air of the Magadan region in 2013, in highways area and mixed dwellings zone.

Table 2 Air pollution emissions by type, 2012-2019

Types of emissions	Indicators by year							
	2012	2013	2014	2015	2016	2017	2018	2019
phenol and its derivatives	3.7	4.2	3.6	3.2	2.7	1.5	2.7	2.4
SO ₂	2.64	2.83	2.33	2.37	2.26	2.46	2.64	2.15
dust	2.89	3.11	2.53	2.12	2.52	3.02	3.0	3.01
CO	10.8	11.3	9.6	9.5	9.3	10.2	9.9	10.1
NO ₂	1.9	1.9	1.8	1.7	1.7	1.8	1.8	1.7

This was explained by the increased number of vehicles and traffic intensity, a significant number of operational power industry enterprises with outdated dust and gas cleaning equipment, and unfavorable meteorological conditions, which generally led to deterioration in the quality of atmospheric air in residential areas.

In 2014, it was realized that the reason for the unsatisfactory state of atmospheric air was the lack of funding for the modernization of the cleaning equipment and the strengthening of production safety, which was aggravated by the negative impact of extreme climatic conditions. Further, the year 2018 brought a decrease in the level of air pollution with carbon monoxide and benzo[a]pyrene, while the pollution with suspended solids, nitrogen dioxide and oxide, and phenol had increased. The 2019 report showed that the concentrations of suspended solids, sulfur and nitrogen dioxides, phenol, and formaldehyde in atmospheric air, in the long run, had also increased (2013-2019).

3. Quality of drinking water in Magadan region

The rate of CRC development, which cases occupy third place in terms of regional morbidity and mortality, is also determined by the quality of food and drinking water. According to ecologists' reports, good-quality drinking water is accessible for 95.8% of the local population [14], but is this really so?

Water quality depends largely on the season, soil geology, and industrial and agricultural discharges [16]. The main sources of pollutants entering the waters of the Kolyma River are enterprises of the gold mining industry, housing and communal services, and surface runoff from undeveloped agricultural and settlement lands during periods of seasonal flood. Typical pollutants include easily and difficultly oxidized organic substances, ammonium nitrogen, oil products, compounds of total iron, copper, zinc, lead, manganese. Ineffective sewage facilities, untreated storm drains, emergencies on cargo ships and onshore facilities, raw sewage from unsewered areas and deep-water outlets (unsatisfactory in terms of sanitary and technical condition) are recognized as a major threat and source of pollution of coastal waters. Average annual concentrations of hazardous effluents for 2011-2019 ranged from 4.92 mg/l (the upper section of the Ola and Dukchi rivers) to 33.4 mg/l (the Magadanka River within the Magadan city limits).

The employees of the Ministry of Natural Resources and Environment had confirmed the fact of unsatisfactory provision of standard water treatment by facilities of the Magadan regional center and biological treatment stations in the villages of Sokol, Ust-Omchug, and Omsukchan. This environmental failure was associated with the depreciation of facilities' equipment and the need for overhaul and modernization. According to the analysis of the data for 2015-2017, provided by the regional information fund for social and hygienic monitoring, compounds of manganese, copper, oil products, ammonium nitrogen, and iron remain the top pollutants of drinking water in the Magadan region. The

latter fact is due to the high natural content of these substances in water, significant depreciation of distribution networks, and violation of the technology of water treatment and processing.

A decrease in the content of iron, manganese, copper, synthetic surfactants, oil and oil products, chromium, and zinc was observed in the discharges of municipal water services enterprise (MUP Vodokanal) in Magadan in 2019 after the commissioning of a new biological treatment facility (September 2018). The indicators of the seawater quality in the coastal zone of the Sea of Okhotsk used for recreation are still considered unfavorable (Table 2).

Table3 The quality of seawater in the coastal recreational zone in 2017-2019

Territory	The proportion of seawater samples that do not meet the standards for sanitary and chemical parameters, %			The proportion of seawater samples that do not meet microbiological standards, %		
	2017	2018	2019	2017	2018	2019
Magadan region	33.3 (1 out of 3)	0 (1 sample)	0 (3 samples)	0 (0 out of 15)	33.3 (4 out of 12)	45.5 (4 out of 11)

4. Nutritional habits of local residents

This parameter also affects the range of MNnosologies in the Magadan region. Granting the proximity of the sea coast and multiple junctions of local rivers, fish and seafood represent the main staple of the residents' nutrition.

The carcinogens contained in natural marine products, including smoked and salted fish, were thoroughly examined [17]. Fish is a source of secondary and tertiary amines, nitrates and nitrites, which are classified as probable human carcinogens [18]. S.Poirier et al., evaluating the level of N-nitrosodimethylamine in raw salted fish, recognized high concentrations of the substance as carcinogenic and 388 µg / kg as potentially dangerous in terms of the development of high-grade malignant neoplasms of the head and neck [19]. Nitrosodimethylamine (NDMA), contained in raw fish, is a liver and gastrointestinal tract carcinogen, which has been proven by in vivo experiments on animals [20]. New scientific studies are expected to investigate the concentrations of substances obtained from organisms of marine animals and fish, the consumption of which can potentially affect the human body and initiate tumor growth.

5. Projected activities of the healthcare and environmental management bodies

The preservation of the ecological landscape of the forests and the maintenance of the high quality of drinking water are the key to reducing the mortality rate from malignant neoplasms in the Magadan region, as in any other region of the Russian Federation. As a part of the implementation of the Russian national project 'Ecology', the Government of the Magadan region implements two regional programs 'Clean Water' and 'Forests Protection' [21]. For the implementation of these programs in 2019, the federal budget allocated 9 million and 25.847 thousand rubles, respectively. In particular, the Clean Water program framework makes provision for the replacement of the cold water supply pipeline in Magadan, with an inventory reconciliation of water supply networks.

In June 2020, the Government of the Magadan Region approved the text of the Program 'Natural Resources and Ecology of the Magadan Region' [22]. The main objectives of the Program are the stabilization and improvement of the ecological situation in the region, as well as the preservation and restoration of water bodies to a state that ensures ecologically favorable living conditions for the population. One of the most expected results of the implementation of the Program is the provision of favorable environmental conditions in the Magadan region with the restoration of disturbed ecological systems for the period until 2022. Also, the implementation of these federal projects through state funding is expected to affect the improvement of the environmental situation and reduce the regional rate of mortality from MN development.

Discussion

The etiopathogenesis of malignant neoplasms is quite complicated due to the multifactorial nature of the combined effects of not only genetic but also environmental characteristics [23].

The relationship between the risk of developing cancer and the conditions of a person's professional activity has been proven since the 50s of the last century when mesothelioma in asbestos workers was identified as the first occupational cancer. Currently, malignant neoplasms caused by exposure to occupational hazards are classified as the most significant but also preventable causes [23]. The number of such production-related malignant tumors is steadily growing among the population of developed countries due to the increase in the number of hazardous industries within the framework of global industrialization. When assessing the risk of developing cancer, exposure to agents such as asbestos, crystalline silica, heavy metals, mustard gas, 2-naphthylamine, dichloromethane, inorganic lead compounds, formaldehyde, 1,3-butadiene, etc. is of particular importance [24].

Unfavorable natural factors, including human habitat, air, water, soil, are of particular importance as MN predictors. Also, one of the obvious causes of lung cancer is the level of air pollution: the concentration of complex gases and their components, as well as benzo[a]pyrene, benzene, a number of metals, products of combustion of automobile fuel (benzene, toluene, xylenes, and acetylene), nitrogen oxides and microparticles of solid substances (carbon, adsorbed organic substances, trace amounts of

metal compounds) [12]. The atmospheric air quality in regions with an unfavorable climate, in particular in the Magadan region, is in a poor state, inter alia, due to the high concentration of fuel combustion products.

Another problem closely related to the growth of cancer indicators is the quality of drinking water [25]. This indicator is associated with seasonal effect, the peculiarities of soil geology, and certainly with the industrial and agricultural wastewater discharges containing chlorine, hypochlorite, chloramine, nitrites, nitrates, radionuclides, and asbestos [16]. Such changes in the quality of drinking water lead, among other things, to the development of urothelial tumors [26]. An increased risk of developing CRC, gastric and hematopoietic cancers is observed in regions with increased levels of nitrates and radium in drinking water [27, 28]. The quality of atmospheric air and drinking water largely depends on the well-coordinated work of production staff and regional Ministries of Environment.

Thus, there is a close relationship between the disturbance of the ecological landscape of the region, pollution of the air, soil, drinking water and the development of malignant neoplasms in the residents of the Magadan region. It was established while studying the official statistical data that the unfolding situation in the Magadan region with the morbidity, early diagnosis, and mortality of lung cancer and CRC is characterized unfavorably. An increase in the levels of air and water pollution noted in the region indicates the feasibility of implementing preventive and diagnostic measures for primary prevention and early detection of new cases of aggressive forms of cancer development.

The main tasks of increasing the efficiency of state supervision of air quality are close interaction of the Government of the Magadan region with the regional department for hydrometeorology and environmental monitoring and activities on the nomenclature of laboratory studies of atmospheric air as part of social and hygienic monitoring. In turn, it should be stated with confidence that the pollution of water bodies of the Magadan region is caused by the activities of mining enterprises, housing and communal services, and surface washout from undeveloped agricultural and settlement lands during the thawing season and raining period. Also, wastewater treatment plants require regular maintenance and replacement of worn-out components.

Conclusions

Improving the quality of early diagnosis of lung cancer and CRC requires joint efforts of government officials (the Ministry of Natural Resources and Environment and the Ministry of Health) in compiling atmospheric air and water pollution map of the districts of the region, with account taken of populated localities and enterprises of the hazardous industry. Also, this project can be supplemented by a targeted oncological program for the active detection of lung cancer and CRC; the program should be carried out by mobile medical teams, following the cartographic data. The forehanded implementation of these measures may improve a number of oncological indicators, including lung cancer and CRC, but

most importantly, it will contribute to saving precious years of the life of the residents of the North-Eastern region.

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