Spatio-Temporal Analysis of the Disease Incidence in the population of Lviv region

Ruslana VLASENKO[1], Oleksandr HARBAR[1], Vitalij KOSTIUK[1], Tamara ANDRIJCHUK[1], Nataliia DEMCHUK[1,*]

[1] Zhytomyr Ivan Franko State University, Faculty of Natural Sciences, Department of Ecology and Geography, V. Berdychivska Str. 40, Zhytomyr, Ukraine
* *Corresponding author*: o.v.harbar@gmail.com

Abstract

The paper focuses on the spatio-temporal analysis of the dynamics of the incidence in the population in Lviv region by the main classes of diseases for 2009-2018. Groups of factors influencing the incidence in the population and the demographic situation in general have been investigated. It was found out that each group of factors can have positive and negative effects in certain regions. The structure of the disease incidence in the population of Lviv region by classes of diseases for the period 2010-2018 has not changed. It is traditionally formed by diseases of the respiratory system, blood and blood-forming organs, circulatory system, endocrine system and neoplasms. The quantitative indicators of changes in the incidence in the population of the region until 2018 by the main classes of diseases in the context of administrative districts are calculated and analyzed. A cluster analysis was carried out to determine the spatial differentiation of the incidence in the population of Lviv region. For clustering, the main indicators were selected by classes of diseases that have the largest specific weight in the structure of morbidity. The cluster analysis made it possible to distinguish two clusters within the region, for which the characteristics in the population morbidity indicators were identified. The analysis of variance (LSD-test) showed the presence of significant differences between the incidences in the population in Lviv region on respiratory diseases. The study of the disease incidence in certain areas makes it possible to predict the state of health and to work out measures to improve the health in the population.

Keywords: *Lviv region, morbidity, cluster analysis, spatial distribution*

Rezumat. Analiza spaţio-temporală a incidenţei bolilor populaţiei din regiunea Liov

Lucrarea prezintă o analiză spaţio-temporală a dinamicii incidenţei bolilor populaţiei din regiunea Liov, pe principalele clase de boli, în perioada 2009-2018. Au fost analizaţi principalii factori care influenţează această incidenţă şi situaţia demografică generală. Studiul indică că fiecare grup de factori influenţează în mod particular, fie pozitiv, fie negativ, anumite aspecte din diferite zone. Structura incidenţei bolilor din regiunea Liov pe clase de boli pentru perioada 2010-2018 nu s-a modificat. În mod tradiţional, include boli ale sistemului respirator, bolile hematologice, cele ale sistemului circulator endocrin şi neoplasm. Au fost calculaţi şi analizaţi indici ai schimbărilor din incidenţa bolilor în cadrul populaţiei din regiune până în anul 2018 pe principalele clase de valori în contextul unităţilor teritorial-administrative. S-a recurs la o analiză cluster pentru a determina diferenţele spaţiale ale incidenţei în cadrul regiunii Liov. Pentru cluster, principalii indicatori ai incidenţei în cadrul populaţiei au fost aleşi pe clase de boli care au cea mai mare pondere în cadrul morbidităţii. Această analiză a permis identificarea a două clustere în cadrul regiunii, pentru care au fost discutate caracteristicile indicatorilor de morbiditate. Analiza variaţiei (LSD-test) indică prezenţa unor diferenţieri semnificative în ceea ce priveşte incidenţa bolilor aparatului respirator în cadrul populaţiei din regiunea Liov. Studiul incidenţei bolilor într-o anumită zonă permite elaborarea unor previziuni privind starea de sănătate a populaţiei şi identificarea unor soluţii şi măsuri pentru îmbunătăţirea sănătăţii.

Cuvinte-cheie: *regiunea Liov, morbiditate, analiză cluster, distribuţie spaţială*

Introduction

The state of human health determines its social outlook, well-being, ability to fully realize its potential, since it is an indicator of the country's socio-economic development, and occupies a leading place in the value system of any civilized country. A wide range of sciences are engaged in the study of the health in the population, but it is social geography that reveals the territorial features and patterns of the spread of the incidence in the population. One of the indicators that can be used to estimate the health is the incidence rate in the population. It is the incidence rate in the population that is the main cause of death. Therefore, the study of the incidence in the population is an urgent issue both for the whole country and for Lviv region.

Theoretical background

In recent decades the regional medical and geographical research has been actively developing. Medical and geographical research of V.M. Hutsuliak is based on the ecological and geographical concept (Gutsuliak, 2008). The ecological component of the study of the public health is also dominant in the paper of Shyian (2012).

A comparative study on the characteristics of the state of occupational morbidity in Ukraine and the world as a whole has been carried out indicating that in Ukraine the main type of occupational pathology is represented by lung diseases in mining workers, and by dermatoses, diseases of the

musculoskeletal system, hearing impairment of employees in machine-building industry, and in-service sector in the EU and the USA. Differences are associated with the peculiarities of the distribution of workers in the economic field of different countries and differences in methodological approaches to diseases (Kundiev et.al., 2009).

The analysis of the incidence of coronary heart disease in Ukraine indicates that this disease occupies a leading position in the structure of morbidity, disability and mortality in all regions of Ukraine. Ukraine scores one of the first places in Europe in terms of mortality from circulatory diseases, significantly higher than those in France, Germany, Poland, and Great Britain. (Gandzyuk, 2014).

A group of authors analyzed the trends in morbidity and mortality from tuberculosis in Eastern Europe and the former USSR. The quality of TB case surveillance varies widely from country to country. The incidence of tuberculosis in most of the countries of Eastern Europe and the former USSR is higher than in other countries of Western Europe. The lowest tuberculosis rate is registered in the Czech Republic and the highest in Romania and Kazakhstan. While this indicator continued to decrease in Albania, Croatia and Slovenia, this trend to the decrease has recently stopped in the remaining countries of Eastern Europe (Raviglione et.al., 1994).

Using the method of demographic zoning, changes in the prevalence and incidence of cardiovascular diseases in Ukraine and individual regions for 1996-2014 were estimated. The trend of further growth of CVD in Ukraine as a whole and in some regions is predicted. Over the past 20 years, the prevalence and incidence of CVD in Ukraine has increased significantly 2.5 times and 1.5 times respectively. These figures have changed the most in the Southern region of Ukraine. Projected data on the prevalence and incidence of CVD show an upward trend, especially in the Southern and Southeastern regions (Terenda et.al., 2018).

Medical and demographic research is actively carried out by the group of scientists from Uzhgorod State University, including V. Meshchenko, L. Kachala, S. Pop, V. Sabov, M. Fatula (Mezentseva et. al., 2018).

The medical and geographical analysis of the health status in the population of Chernihiv region was carried out by Shovkun (2012), who of the region's population using the correlation analysis.

The analysis of the dynamics of the incidence in the population of the Chernihiv region by the main classes of diseases was carried out, as well as a study on the current state in the context of administrative units, which made it possible to identify the administrative districts of the region that have incidence rates that significantly differ from the regional average. Since these areas are not geographically connected, the authors argue about the complex impact of various factors on the incidence in the region's population (Shovkun & Myron, 2020)

The study of the medical and demographic framework of the health of the child population of Khmelnytsky region is devoted by Romaniv (2003).

The territorial differentiation of the regional indicators of the incidences of the diseases in the population of Sumy region and the peculiarities of their dynamics were analyzed by Kornus et.al. (2015), who emphasize the need for medical and environmental monitoring of the territory. The method of the medical and geographical research of the region, proposed by Molikevych (2016), is built on the calculation of the rank health index, which includes the statistical data, complex indicators of mortality risk from certain diseases and the results of a questionnaire survey of residents. The monograph of N. Mezentseva et al. (2018) is devoted to the analysis of regional differences in the incidence of the diseases in the population of Ukraine and the typification of the regions of Ukraine in terms of the spread of diseases and the incidence in the population.

At the same time, the spatial aspect of the incidence of the diseases in the population of Lviv region is insufficiently covered.

Characteristics of the study area

Lviv region is one of the regions of Ukraine with the center in Lviv city. It belongs to the medium-sized regions of Ukraine as it occupies an area of 21.8 thousand km2. Lviv region is located in the west of the country. The southwestern and western borders of the region are part of the state border of Ukraine with Poland. The rest of the borders are domestic.

The population of the region as of January 1, 2019 is 2,522,000 people, the population density is more than 120 people per 1 km2, and therefore the region is one of the most densely populated in the country. Lviv region according to the administrative-territorial division has 20 districts.

An extremely acute demographic problem for Lviv region is a rather high mortality rate of 12.9 per 1000 people and a low birth rate of 9.8 per 1000 people in 2018. The analysis of the general incidence in the population of Ukraine in the context of administrative regions showed that the highest indicators of the general morbidity in the population of Ukraine were in the Dnipropetrovsk and Ivano-Frankivsk regions and in Kyiv town. It turned out to be quite high in Lviv, Rivne, Vinnytsa, Kyiv and Chernihiv regions. The indicator was more than

70,000 to 80,000 patients per 100,000 people. The incidence rate in the population was the lowest - less than 60,000 patients per 100,000 in the population in such regions as Kherson, Zaporizhzhia, Sumy and Poltava regions. The information regarding Autonomous Republic of Crimea, Luhansk and Donetsk regions was not considered due to its absence (associated with the operation of the joint forces) (Fig. 1). According to the classes of diseases in Ukraine, respiratory diseases have the largest share (over 44%). The highest incidence rates in the population with respiratory diseases are specific for the towns of Kyiv, Lviv, Ivano-Frankivsk and Kyiv regions. Diseases of the nervous system and sensory organs account for more than 11% of the morbidity. The greatest number of patients with this type of disease lives in Ivano-Frankivsk, Lviv, Rivne and Dnipropetrovsk regions (more than 10 thous. patients per 100 thous. in the population). Hence, an acute question of studying the incidence of the diseases in the population of Lviv region.

Methods

The use of statistical methods makes it possible to study the phenomena in their development, to estimate the intensity of dynamics and structural changes, and to identify patterns of the development. Statistics examines the phenomenon not in isolation, but in its versatile connections with other phenomena and the external environment, reveals the factors causing changes in these phenomena. The use of this method in the paper made it possible to study the dynamics of the incidence of the diseases in the population, the regularities of the influence of a complex of natural and socio-economic factors of the geographic environment on population health, the geography of human diseases, and to reveal the causal relationships between the possible pathogenic effects of environmental factors and population health.

The information base for the study was the following:

- statistical data of the State Statistics Service of Ukraine and the Main Department of Statistics in Lviv region;
- "Lviv Regional Center for Public Health" Lviv Regional Council;
- statistical yearbooks, collections and express editions on the website of the Main Department of Statistics in Lviv region (State Statistics Service of Ukraine, 2009-2018);
- scientific articles, abstracts, conference reports for the period of 2009-2018.
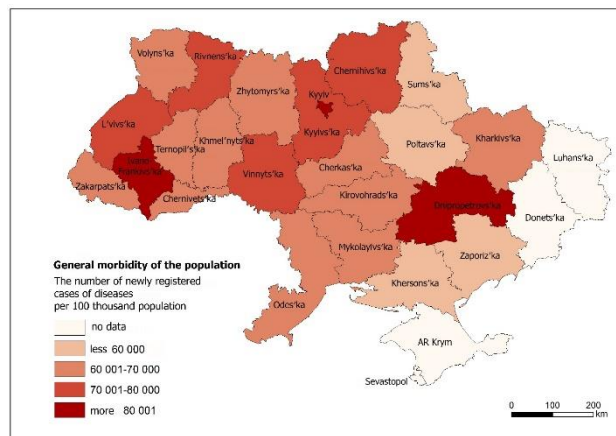

Fig. 1 General morbidity of Ukraine population

The following research methods were used for the analysis of statistical data: multivariate analysis, cluster analysis in particular, to identify the similarity of regions in terms of indicators (software package PAST) characterizing the level of morbidity in the population; the analysis of variance (LSD-test), which showed the presence of significant differences between the incidence in the population of Lviv region for respiratory diseases, as well as traditional methods of the comparative geographical analysis to identify regional differences in the distribution of various types of morbidity in the population, grouping and typing for distinguishing and combining regions by the spread of various types of morbidity, the influence of various factors, graphic and cartographic modeling for the study of spatial differences and dependencies of the incidence in the population.

The cartographic method was used to interpret the numerical data as one of the leading one in medical geography, since it shows the territorial features of the incidence in the population in the most accurate and effective manner. For this study, ArcMap software was used, which is included in the ArcGIS package that is a product of ESRI. PAST software was used for the statistical analysis of data.

Results and Discussions

Demographic situation in the region

The analysis of the main demographic indicators for the population of Lviv region for 2009-2018 indicates that the birth rate in the region is characterized by a steady downward trend, which corresponds to the all-Ukrainian trend. The mortality rate is characterized by a stable dynamic of changes, although compared to 2016 and 2017, there is a slight increase. There is a wave-like dynamics of changes in the mortality rate of children under 1 year of age, which is probably associated

with the changes within and an overall low level of the health care system.

Natural population growth decreased 2.8 times from 2009 to 2018, and 3.4 times from 2013 to 2014.

The growth of the average age in the population is traced. The young population lives in Turkovsky, Yavorovsky and Zhovkivsky districts, and the old one - in Zhydachevsky, Peremyshliansky and Truskavets. According to the situation in the towns of Lviv region, the leading position in terms of the average age in the population is occupied by the town of Truskavets, and the lowest indicator is characterized by the town of Novy Rozdil.

The average life expectancy at birth experienced an upward trend, and just as the national values, the average life expectancy at birth is higher in towns than in rural areas. There is a steady tendency to a slight increase in life expectancy over the years for both the urban and rural population of Lviv region by gender (Vlasenko & Shovkun, 2019).

The number of the deceased male and female population by age groups in urban and rural settlements has been analyzed. It was found that in urban and rural communities, the overwhelming majority of the deceased are in the age group of 70 years and older.

The dynamics of the current and permanent population is characterized by a steady downward trend in both the current and permanent population of Lviv region. The dynamics of the number of urban and rural permanent and current population is stable in terms of indicators, although in 2010-2011 there were abrupt changes in the number of permanent urban population, which grew rapidly, while the rural population decreased significantly.

General structure of the incidence of the diseases in the region

The morbidity structure in the population of Lviv region by classes of diseases is traditionally formed by diseases of the respiratory system, circulatory system, endocrine system, digestive disorders, metabolic disorders and neoplasms (Fig. 2). The leading position in the incidence in the population of the region is occupied by the respiratory diseases, accounting for 86% of the total incidence in the population as a whole. At the same time, among the diseases of the respiratory system, tuberculosis, flu, rhinitis, tonsillitis, tracheitis, bronchitis, bronchial asthma, pneumonia and others prevail.
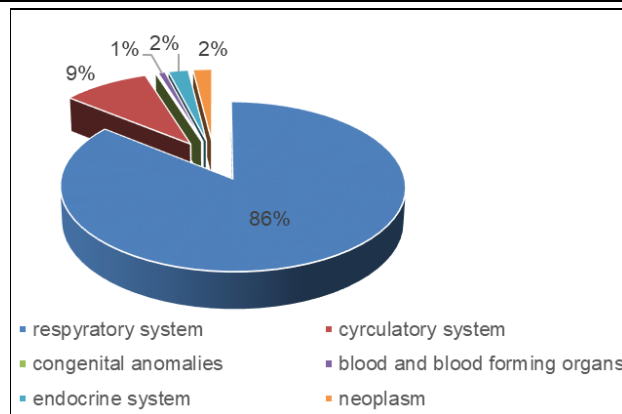

Fig. 2: Morbidity of the population within Lviv region by dominant classes of the diseases

The analysis of the data for 2018 indicates a downward trend in the incidence rate in comparison with previous years. Diseases of the respiratory system and diseases of the circulatory system dominate in all administrative districts of the region.

Long-term dynamics of the morbidity

During the period from 2009 to 2018 the incidence of respiratory diseases in the region changed in waves. At the same time, there is a clear downward trend in this indicator. During the study period, it decreased by 21.4% (Fig. 3).

Diseases of the circulatory system are one of the first causes of mortality in Ukraine (Mezentseva et.al., 2018). This indicator, like the previous one, shows a clear downward trend (by 28.6%) during the analysed period (Fig. 3).

A slightly different dynamics was observed regarding the endocrine system diseases, digestive disorders, and metabolic disorders. The maximum rate was recorded in 2010. But, during the study period, this indicator decreased by 5% (Fig. 3).

Lviv region belongs to the regions with a high level of neoplasms, which have a negative impact on the population health (Mezentseva et.al., 2018). Environmental pollution is one of the factors that cause the incidence of neoplasms. Over the 2009-2018 period, the incidence of neoplasms changed in waves, the highest value was recorded in 2013, and the lowest was in 2011. During this period, the incidence rate of neoplasms increased by 2%, although that is less than the national average.

Diseases of the blood and hematopoietic organs also take an important place in the structure of morbidity in the region's population.
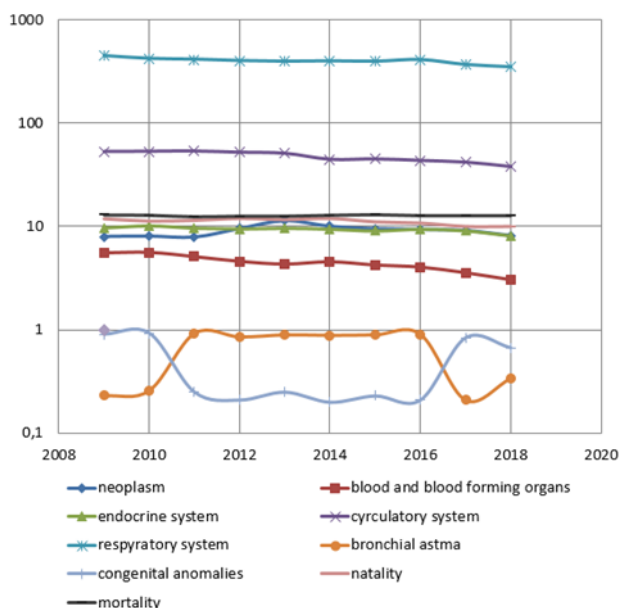
Fig. 3: Long-term dynamics of the morbidity structure in Lviv region

The demographic situation in Lviv region contributes to reducing the incidence and improving the health of the population. A characteristic feature of the age structure of the region's population is the predominance of people of the working age over the elder population, although the population aging is typical for Ukraine. During the 2009 – 2018 period, the incidence of the diseases of blood and hematopoietic organs has significantly decreased in the region (to 45 %).

Thus, the analysis shows a general downward trend regarding the incidence rate of the blood and hematopoietic organs in the population of Lviv region during the study period. This is unlikely to indicate an improvement in public health and medical care. According to available data, in Ukraine during the last decade, the number of medical personnel and the number of hospitals has dramatically decreased. At the same time, the quality of medical care in healthcare institutions remains unsatisfactory (Chorna et al., 2020). Among the main reasons for the deterioration of the health status in the population of Ukraine, there is poor financing of health care, poor-quality medical services, inopportune access to doctors, and lack of preventive measures and presence of bad habits (Sherstiuk & Sokolov, 2016). It should also be taken into account that medical statistics operates with fairly approximate data on the population in Ukraine and its regions. Labor migration is especially high in Lviv region, which borders the European Union. In this regard, a significant part of the working-age population is periodically or permanently outside

Ukraine. Therefore, the real population in the region may be significantly lower.

Despite this, several main trends in the dynamics of morbidity rates can be identified. Thus, the incidence rate of respiratory diseases, diseases of the circulatory system, blood and hematopoietic organs are gradually decreasing, characterized by minor fluctuations relative to the central trend. Obviously, these indicators are quite stable and over long periods of time.

Separately, it is necessary to highlight the nature of the dynamics of the incidence of neoplasms and the diseases of the endocrine system. These indicators are characterized by growth in 2010 - 2013. It should be noted that there was a significant redistribution of the rural and urban population of this region in 2010-2011. In particular, the urban population has sharply increased and the rural population has decreased. Obviously, a significant part of the rural population migrated to cities, where the level of medical care and diagnosis of neoplasms is higher, which ultimately could cause an increase in the incidence of neoplasms.

Another type of dynamics is characteristic of two indicators, characterized by low values. These are congenital anomalies and the incidence of bronchial asthma. It seems there is a clear inverse relationship between these indicators: the decline in the first indicator since 2010 coincides with the growth of the other. Moreover, the opposite trend is observed after 2016. It is unlikely that these two indicators directly affect each other. Most likely, other factors are at work, causing consistent changes in these parameters. Thus, the influence of migration processes on the dynamics of these indicators cannot be excluded.

Spatial analysis of the morbidity in 2018

The spatial distribution of areas with a high incidence of respiratory diseases (Fig. 4) appears to be influenced by international transport corridors crossing these areas. On the one hand, active transportation leads to an increase in emissions of pollutants into the atmosphere from non-stationary sources, contributes to the development of non-infectious respiratory diseases. On the other hand, the concentration in the population in trade and services along such transport corridors contributes to the active spread of infectious respiratory diseases. The exception here is Pustomytivsky district and the town of Lviv, where the incidence of respiratory infections is one of the lowest in the region despite the high population density. This may be due to better developed medical services in the regional center and its immediate periphery and better developed preventive measures of such diseases.

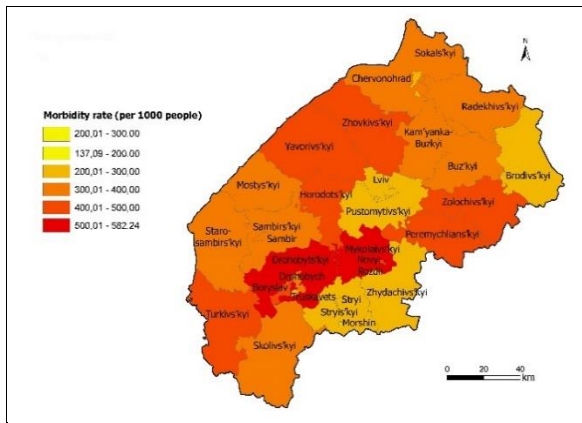In the case of diseases of the circulatory system, the opposite pattern is observed.

Fig. 4: The incidence of respiratory diseases in the population of Lviv region (2018)

The highest incidence rate is observed in the peripheral areas of the region (mainly rural areas), while in the central areas the value of this indicator is quite low. Risk factors in the case of diseases of the circulatory system include the quality of nutrition, the presence of bad habits (smoking, alcohol consumption etc.), working and resting conditions, environmental conditions and a tendency to being overweight (Kornatsky, 2006). It is in rural areas that these factors are more pronounced. In addition, the rural population accounts for a large proportion of older people, among whom diseases of the circulatory system are more common. It should be noted that diseases of the circulatory system are the predominant cause of death in all districts of Lviv region.
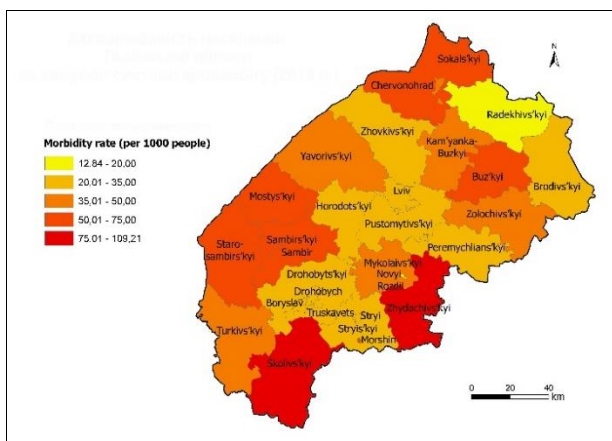

Fig. 5: The incidence of the diseases of the circulatory system in the population in 2018

The spatial distribution of the districts of Lviv region by the incidence rate of the diseases of the endocrine system, digestive disorders and metabolic disorders is somewhat similar to the previous case with diseases of the circulatory system. High and

maximum incidence rates of the endocrine system are concentrated mainly in rural areas, excluding the Pustomytivsky district (Fig. 6).
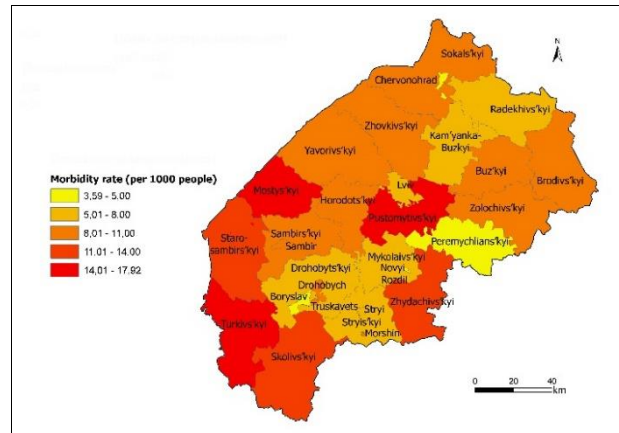

Fig. 6: The of the diseases of the endocrine system, digestive disorders, metabolic disorders incidence in the population of Lviv region (2018)

The reasons for endocrine disorders are very diverse; still, they can be divided into two groups: hereditary and acquired. Hereditary causes are gene and chromosomal mutations. Their active participation in the formation of the spatial pattern of morbidity in Lviv region is unlikely. Acquired - numerous external influences, directly damage the gland or realize its hereditary predisposition to damage. The main risks of developing endocrine disorders are obesity, unhealthy diet, physical inactivity, and high blood pressure. In addition, the risk increases with age. That is, the risk factors for the occurrence of diseases of the circulatory and endocrine systems are largely similar, which determines the similarity of the distribution of incidence rates.

The incidence rates of malignant neoplasms are growing every year, and especially in industrially developed countries, namely in Western Europe, the USA, and in Ukraine - in industrial areas (Serdiuk & Kartashova, 2019). The main reasons for the growth in the incidence of neoplasms is the environmental chemical pollution, untimely seeking medical advice and bad habits. Among the urban population, the incidence of malignant neoplasms is significantly higher than among the rural population. The indicator of newly registered cases of neoplasm diseases in 2018 was in Lviv region - 6.2% per 100 thousand in the population, which is almost 7 times less than in the leading Dnipropetrovsk region. Among the causes of mortality, neoplasms occupy one of the leading positions in Lviv region. There is a steady upward trend for this indicator in all regions.

There is a fairly clear tendency towards an increase in the incidence of neoplasms in large cities and in areas where the mining and processing

industry (Sokalsky district) is actively functioning, in Kamenka-Buzky district (Dobrotvirska Thermal Power Plant), Mykolayivsky district (SE "Sirka"), Samborsky district (metalworking enterprises), (Fig. 7).
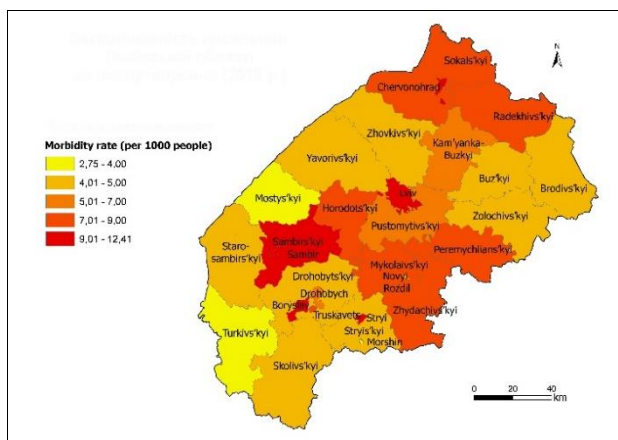

Fig. 7: Morbidity from neoplasms in the population of Lviv region

As for the incidence rate of the diseases of blood and hematopoietic organs (Fig. 8), most of the region is characterized by rather high values, peaking in Brodivsky, Mostyssky, Starosamborsky and Skolivsky districts. According to available data, at least some common pathology from this group may be the result of drinking water with an increased iron content, which is quite common in the waters of the Western region of Ukraine (Lototska et.al., 2019).
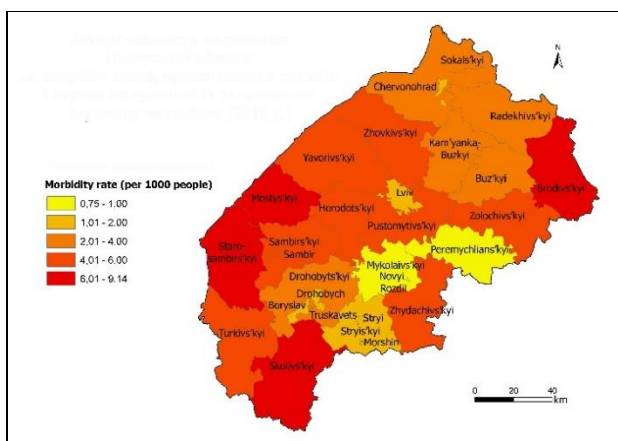

Fig. 8: Incidence of the diseases of the blood, hematopoietic organs and certain disorders involving the immune mechanisms in the population

A cluster analysis was also carried out, with the help of which typification of districts was achieved, according to medical and demographic indicators (Fig 9). To estimate the probability of cluster formation, the bootstrap index was used, which estimates the percentage of iterations in which a cluster is formed. The results obtained prove the presence of two groups in the analyzed data, formed from 100% probability. The likelihood of the formation of other clusters is too low (<60%), therefore, in the further discussion, they are not considered.

As it can be seen from the received dendrogram, one cluster includes eight districts (Horodotskyi, Drohobytskyi, Zhovkivskyi, Zolochivskyi, Mykolaivskyi, Peremyshlianskyi, Turkivskyi and Yavorivskyi) and two towns (Boryslav and Noviy Rozdil) (cluster 1). The second cluster includes all other district (Brodivskyi, Buskyi, Zhydachivskyi, Kamianka-Buzkyi, Mostyskyi, Pustomytivskyi, Radekhivskyi, Sambirskyi, Skolivskyi, Sokalskyi, Starosambirskyi and Stryiskyi) and towns (Drohobytch, Lviv, Morshyn, Stryi, Truskavets and Chervonohrad).

The distribution of clusters by districts and cities, as well as the dominant diseases of the region, is presented on schematic maps of Lviv region (Fig 10-11). It has been determined that the leading diseases are diseases of the respiratory system as a whole, without exception, districts of the region (Fig 10), the second place is taken by the diseases of the circulatory system (Fig 11).
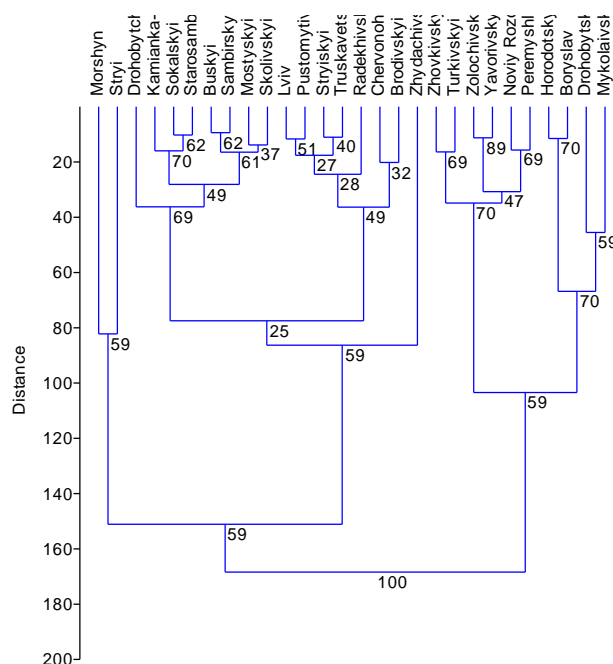

Fig. 9: Cluster analysis (dendrogram) according to the incidence rate in the population of Lviv region and demographic indicators

The analysis of variance (LSD-test) showed the presence of significant differences between the incidences of the respiratory diseases in the population of Lviv region (Table 1). Thus, cluster 1 significantly differs from cluster 2 with a high degree

of reliability (p <0.001). In terms of incidence rates, the resulting clusters do not differ significantly from other groups of diseases (p > 0.05)
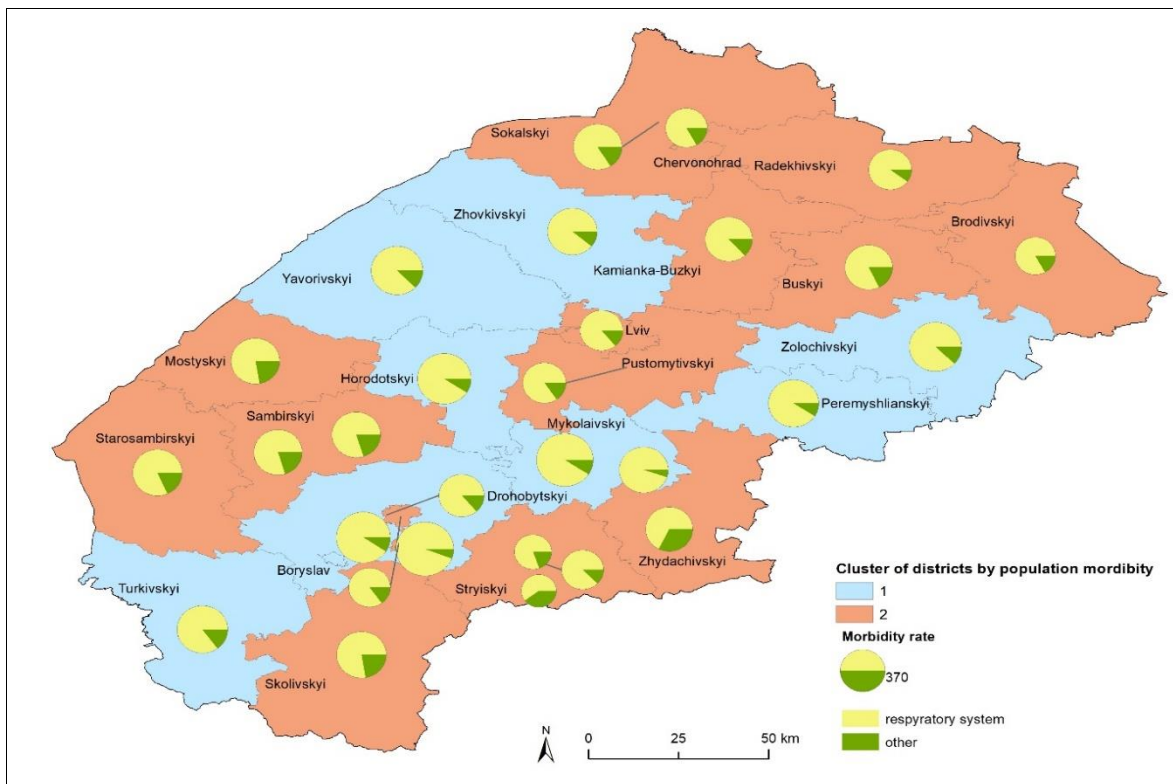

Fig. 10: Spatial distribution of the clusters and the share of the respiratory diseases in the total morbidity structure in the region
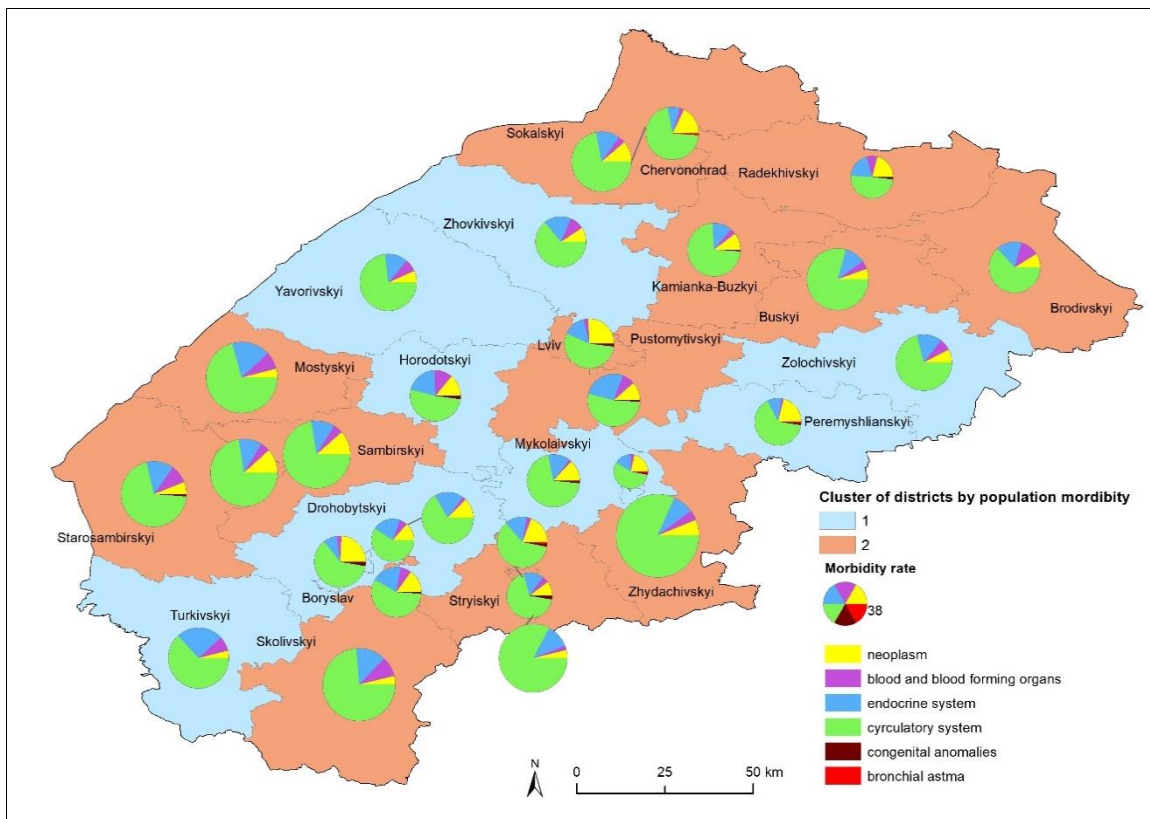

Fig. 11: Spatial distribution of the clusters and the morbidity structure in the region according to the classes of the diseases excluding respiratory diseases

Significant differences between the clusters were also found in the overall incidence rate. The first cluster is characterized by significantly higher values of this indicator, while the analysis of incidence without taking into account respiratory diseases does not show significant differences between the clusters (Table 1).

Table 1 Parameters of clusters

Diseases	Cluster I (n=10)		Cluster II (n=18)	
	M ± m	Lim	M ± m	Lim
Respiratory	467,17± 18,74*	406,73- 582,24	302,16± 14,43*	137,09- 369,74
Circulatory system	32,30 ± 3,44	12,84- 45,71	47,89 ± 5,63	17,17- 109,2
Endocrine system	8,13 ± 1,30	3,59- 17,92	9,41 ± 0,77	4,10- 17,26
Neoplasm	6,15± 0,90	2,75- 12,41	6,67± 0,61	3,48- 12,29
Blood and blood-forming organs	3,04 ± 0,64	0,75- 5,73	3,75 ± 0,57	1,17-9,14
Congenital anomalies	0,59 ± 0,12	0,25- 1,35	0,53 ± 0,07	0,21-1,18
Bronchial asthma	0,31± 0,04	0,04- 0,46	0,32,± 0,04	0,1-0,64
Incidence rate	517,69± 18,21*	450,22- 617,94	370,74,± 16,33*	228,25- 458,24
Incidence rate (without respiratory diseases)	44,38± 4,71	17,95- 68,87	61,91± 6,37	27,71- 126,59

* - the differences are significant (ANOVA, LSD-test, p < 0,001)

Source: statistical data of the State Statistics Service of Ukraine and the Main Department of Statistics in Lviv region;

Since the spatial configuration of clusters is predominantly by differences in the level of morbidity of the respiratory system, in this case, similar patterns of the formation of such a spatial structure appear. That is, in the case of general morbidity, the influence of the location of transport corridors and differences in population density in certain areas will appear.

In general, the state of health of the population within Lviv region is determined by a complex of various factors: medical, environmental, socio-economic. Therefore, it is necessary to form a model of behavior in society that is focused on a healthy lifestyle. Also, in order to reduce the level of morbidity among the population, the improvement of living and working conditions, improving the quality and efficiency of health care should be of high priority.

Conclusions

The following conclusions can be made: i) the incidence rate in the population of Lviv region for the period 2009 - 2018 tends to decrease and it is below the average for Ukraine in 2018. Thus, the state of health in the population remains one of the main tasks of modern socio-economic reforms. ii) Regarding the disease prevalence, the leading place is taken by the diseases of the respiratory system, the circulatory system, and the endocrine system. The incidence of cardiovascular diseases, neoplasms, the diseases of blood and hematopoietic organs are widespread as well.

The results of the analysis show that the spatial distribution of areas with a high incidence of respiratory diseases was influenced by the factor of international transport corridors, leads to an increase in emissions of pollutants into the atmosphere from non-stationary sources and contributes to the development of non-infectious respiratory diseases, and the concentration in the population in trade and services contributes to active spread of infectious respiratory diseases.

In the case of diseases of the circulatory system, the opposite pattern is observed. The highest incidence rate is observed in the peripheral regions of the region, while in the central regions the value of this indicator is quite low. High and maximum incidence rates of the diseases of the endocrine system are also concentrated mainly in rural areas.

A trend to an increase in the incidence of neoplasms in large cities and in areas where the mining and processing industry is actively functioning has been revealed.

The state of health in the population of Lviv region is determined by a complex of various factors, such as medical, environmental, and socio-economic. Therefore, it is necessary to create a model of behavior in the society that is focused on a healthy lifestyle. Besides, the improvement of living and working conditions, quality and efficiency of health care should be of high priority in order to reduce the level of morbidity in the population.

The results of this research can be used by healthcare institutions of Lviv region in planning and implementing preventive measures for certain types of the diseases, improving monitoring of the health condition in the population, etc.

Acknowledgements

Author contribution

Vlasenko R. - data collection, preparation of the "General structure of the incidence of the diseases in the region", "Long-term dynamics of the morbidity structure in the region" and conclusions; Harbar O. - cartographic data presentation and statistical analysis, preparation of the "Spatial analysis of the morbidity in 2018" section; Kostiuk V. - preparation of "Theoretical background"; Andrijchuk T. - preparation of the section "Characteristics of the study region" and "Methods"; Demchuk N. - preparation of the database, preparation of the section "Introduction" and "Demographic situation in the region".

References

Chorna, V.V., Khliestova, S.S., Gumeniuk, N.I., Makhniuk, V.M., & Sydorchuk, T.M. (2020). Morbidity indicators and dissemination and modern attitudes on disease prevention. Visnyk Vinnyts'koho natsional'noho medychnoho universytetu, 24(1), 158-164.

Gandzyuk, V.A. (2014). Analiz zakhvoriuvanosti na ishemichnu khvorobu sertsia v Ukraini [Analysis of ischemic heart disease morbidity in Ukraine]. *Ukrayins'kyy kardiolohichnyy zhurnal – Ukrainian Cardiology Journal*, 3, 45-52 (in Ukrainian).

Gutsuliak, V.M. (2008). *Medychna heohrafiia: Ekolohichnyi aspekt: navchalnyi posibnyk. [Medical Geography: An Environmental Aspect: tutorial].* Chernivtsi: Ruta (in Ukrainian).

Kornatsky, V.M. (2006). Arterialna hipertoniia – svitova medyko-sotsialna problema porushennia zdorovia naselennia v XXI v. [Arterial hypertension is a global medical and social problem of population health disorders in the 21st century]. *Bukov. med. visnyk – Bukov. Med. Bulletin,* 3, 7-10 (in Ukrainian).

Kornus, O.G., Kornus, A.O., & Shishchuk, V.D. (2015). *Terytorialno-nozolohichna struktura zakhvoriuvanosti naselennia Sumskoi oblasti [Territorial and nosological structure of morbidity in the population of Sumy region: monograph].* Sumy: Sums'kyy derzhavnyy pedahohichnyy universytet imeni A.S. Makarenko (in Ukrainian).

Kundiev, Y.I., Nahorna, A.M., & Dobrovolsky, L.O. (2009). Porivnialna kharakterystyka stanu profesiinoi zakhvoriuvanosti v Ukraini i sviti [Comparative of the state of occupational morbidity in Ukraine and in the world]. *Ukrayins'kyy zhurnal z problem medytsyny pratsi – Ukrainian Journal of Occupational Health,* 2(18), 3-11 (in Ukrainian).

Lototska, O. V., Kondratjuk, V. A., & Kucher, S. V. (2019). Yakist pytnoi vody yak odna z determinant hromadskoho zdorovia v zakhidnomu rehioni Ukrainy [Guality of drinking water as one of the determinants of public health in the western region of Ukraine]. *Visnyk sotsial'noyi hihiyeny ta orhanizatsiyi okhorony zdorov'ya Ukrayiny – Bulletin of Social Hygiene and Health Organization of Ukraine*, 1(79), 12-18 (in Ukrainian).

Mezentseva, N.I., Batychenko, S.P., & Mezentsev, K.V. (2018). *Zakhvoriuvanist i zdorovia naselennia v Ukraini: suspilno-heohrafichnyi vymir: monohrafiia. [Morbidity and health in the population in Ukraine: social and geographical dimension: monograph].* K.: DP «Print Servis» (in Ukrainian).

Molikevych, R.S. (2016). Stan zdorovia naselennia Khersonskoi oblasti (medyko-heohrafichne doslidzhennia) [The state of health of the population of Kherson region (medical-geographical research)]. *Extended abstract of candidate's thesis.* Kyiv: NAN Ukrainy, In-t heohrafii (in Ukrainian).

Raviglione, M.C., Rieder, H.L., Styblo, K., Khomenko, A.G., Esteves, K., & Kochi, A. (1994). Tuberculosis trends in eastern Europe and the former USSR. *Tubercle and lung disease*, 75(6), 400-416.

Romaniv O.Ya. (2003). Medical and geographical bases of children's health (on the materials of Khmelnytsky region). Extended abstract of Doctor's thesis (Economic and social geography). Lviv. [in Ukrainian].

Serdiuk, A.M., & Kartashova, S.S. (2019). Vtracheni roky potentsiinoho zhyttia sered naselennia Ukrainy yak indykator vyznachennia priorytetnykh zavdan okhorony zdorovia [Lost years of potential life among the population of Ukraine as an indicator of determining health care priorities]. *Dovkillya ta zdorov'ya – Environment and health*, 3, 4-10 (in Ukrainian). https://doi.org/ 10.32402/dovkil2019.03.004

Sherstiuk, N.S., & Sokolov, A.V. (2016). Zdorovia naselennia Ukrainy ta yoho vplyv na demohrafichnu sytuatsiiu [Health in the population of Ukraine and its impact on the demographic situation]. Ekonomika i suspilstvo. Mukachivskyi derzhavnyi universytet – Economy and society. Mukachevo State University, 5, 316-319 (in Ukrainian).

Shovkun, T. (2012) Medyko-heohrafichnyi analiz zakhvoriuvanosti naselennia (na prykladi Chernihivskoi oblasti) [Medical and geographical

analysis of morbidity (based on the study of Chernihiv region)]. *Extended abstract of candidate's thesis.* Kyiv: Nats. un-t im. T.Shevchenka (in Ukrainian).

Shovkun T., & Myron I. (2020). Prostorovo-chasovyi analiz zakhvoriuvanosti naselennia Chernihivskoi oblasti [Spatial-temporal-analysis of morbidity of Chernihiv region (Oblast) population]. *Naukovyy visnyk Khersons'koho derzhavnoho universytetu – Scientific Bulletin of Kherson State University*, 43-51 (in Ukrainian).

Shyian, D.V. (2012). Terytorialni osoblyvosti zakhvoriuvanosti naselennia m. Kryvyi Rih yak tsentru staropromyslovoho rehionu [Territorial features of morbidity in the population of Kryvyi Rih city as the center of the old industrial region]. *Extended abstract of candidate's thesis.*

Kharkiv: Nats. un-t im. V.N. Karazina (in Ukrainian).

Terenda, N., Petrashyk, Y., Slobodian, N., & Lishtaba, L. (2018). Morbidity and prevalence of cardiovascular diseases in ukraine: trends and forecasts untill 2025. Georgian medical news, 282, 79-82.

Vlasenko, R., & Shovkun, T. (2019). Rehionalni osoblyvosti zakhvoriuvanosti naselennia (na prykladi Lvivskoi oblasti) [Regional features of the incidence in the population (on the example of Lviv region)]. *Natural sciences: history, the present time, the future, EU experience*. Wloclawek, 161-164 (in Ukrainian).