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SPATIAL ANALYSIS AND TENDENCIES OF THE INCIDENCE OF HEART DISEASES OF THE POPULATION OF UKRAINE

Since September 29, 2000 the International day of heart has been celebrated on the initiative of the World Federation of heart. Its main task is to attract the attention of the people of the planet to the problems of circulatory system diseases as the ones which have the highest incidence rates and mortality. *The aim* of the paper was to make a spatial analysis and to find out the morbidity tendencies of heart diseases among the population of Ukraine. The incidence structure of Ukraine's population was identified. The dynamics of circulatory system morbidity in the years of 2009–2017 in Ukraine was analyzed. It has been established that heart disease incidence has tended to decrease. The administration regions of Ukraine were grouped according to the incidence rate of heart diseases among the population. The attention is paid to hypertension and myocardial infarction as they are the most common among the diseases of circulatory system. The decrease in the incidence rate by 1.6 and 1.1 times was recorded, respectively. In Ukraine the mortality dynamics from the diseases of circulatory system was analyzed for the years of 2009–2020. Cardiovascular diseases are the leaders in mortality of the population. The analysis of the mortality dynamics from the diseases of circulatory system proved the tendency towards its increase. The analysis of the statistical and cartographical data made it possible to single out two groups of the factors which predetermine the morbidity of circulatory system diseases among the population of Ukraine: physical-geographical and social-economic. The physical-geographical factors of the diseases of circulatory system (abnormally high air temperatures in summer, a great number of days with heat stress, abrupt changes of atmospheric pressure) determine the highest incidence rates in southern (Odesa, Mykolayiv, Dnipropetrovsk, Kharkiv regions) and western (Zakarpattia, Ternopil, Ivano-Frankivsk, Khmelnytsk regions) areas of Ukraine. It has been stated that physical-geographical conditions of the territory, namely the location of the regions with high incidence rates near large mineral deposits, determine the next group of the factors of circulatory system diseases. The group includes a large number of industrial enterprises, situated in the vicinity of the mining area, sedentary work and the age of the population. A correlation analysis pointed out to the availability of a multi-leveled connection between people's morbidity and its age structure. An average level of the correlation between cardiovascular diseases

and the population over 65 (years old) was established. A cluster analysis was made by means of which the typification of the regions based on medical indicators was carried out.

Key words: medical geography, morbidity/incidence, circulatory system, mortality, physical-geographical factors of circulatory system diseases, social-economic factors of circulatory system diseases.

INTRODUCTION

Modern world is versatile, and at the same time it is complicated for the population. A significant amount of information and emotions does no good for people's health. The issue of health care of the population has always been urgent; nowadays the relevance of the problem is of much greater significance in Ukraine, when a medical reform is being implemented and the country's economy is in a critical state (Vlasenko, & Shovkun, 2019; Vlasenko et al., 2020).

During a long period of time cardiovascular diseases have taken leading places in the structure of people's morbidity in different regions and in the countries of the world, which is why they present a complicated problem in the system of health care of both a certain country and the region in general. Cardiovascular diseases (CVD) are the ones which are associated with heart or blood vessel pathology. They are classified into heart diseases, artery diseases and vein diseases (Kovalenko, 2016). According to the statistics of WHO, the diseases of circulatory system are the reason for half of the death cases.

The occurrence and treatment peculiarities of cardiovascular diseases are connected with the factors which cause the disease. So, it is important to identify and study the risk factors which are of two types: modified and non-modified. Modified risk factors are the ones which can be eliminated in one or another way; unfortunately non-modified risk factors cannot be removed. Age, gender and heredity belong to these factors. The group of modified factors is more numerous: smoking, unhealthy diet, a low level of physical activity, excessive alcohol consumption, overweight, a high blood pressure, a high cholesterol level, a high glucose level, psychological factors (stress, anxiety, depression) (Kornatskiy, Dorogoy, & Manoylenko, 2012). The interaction of the factors makes each of them stronger which in turn becomes more dangerous for people's health. But due to the correction of risk factors it is possible to prevent the diseases of cardiovascular system for a greater part of the population.

In Ukraine, in the structure cardiovascular diseases the most widely spread ones are the following: hypertension, coronary heart disease, myocardial infarction and stroke, atherosclerosis and also rheumatic heart disease (Vernera, 2018; Dudnyk, & Koshelya, 2016). Cardiovascular diseases are the main ones in the structure of the mortality of the population. The mortality problem exists not only in Ukraine, it is characteristic of the whole world. By the year of 2030, twenty three million people are expected to die from these diseases.

The monograph of N. Mezentseva and co-authors (Mezentseva, Batychenko, & Mezentsev, 2018) is devoted to the analysis of the regional differences in the morbidity of the population in Ukraine and the typification of Ukraine's regions

based on the disease spread and the incidence rate of the population. The analysis of the morbidity structure within Chernihiv region was made in the research conducted by T. Shovkun (Shovkun, & Myron, 2020); it was based on the disease types and the peculiarities of spatial differentiation. A spatial analysis of medical-geographical indicators within Ternopil region was presented in the work of I. Demianchuk (Demianchuk, 2017).

The research on morbidity, characteristics and spread tendencies of cardiovascular diseases and disablement among the population of Ukraine was carried out by V. Gandzyuk (Gandzyuk, 2014).

And yet, a spatial aspect of the morbidity of cardiovascular diseases among the people of Ukraine within administrative regions is not covered enough, which is why the aim of the paper was to make a spatial analysis and to find out the tendencies of the cardiovascular incidence among the population of this country. To reach the goal, the following tasks were set: to identify the incidence structure and to analyze the morbidity dynamics of Ukraine's population (2009–2017); to analyze the mortality from circulatory diseases among the people of Ukraine (2009–2020); to single out the factors which predetermine the circulatory morbidity of Ukraine's population; to make a correlation analysis between people's morbidity and peculiarities of its age structure; to make a cluster analysis with the aim of performing the typification of the regions based on medical indicators.

DATA & METHODS

The materials of the statistics center of Ukraine's Ministry of Health (MH) were the information base (Shchorichna, 2015; Shchorichna, 2017); besides to analyze the age peculiarities of the population, the statistic data of demographic yearbooks was used (Demografichniy, 2019). A comparative-geographic analysis was made to identify regional differences and the spread of various kinds of diseases, to do the grouping and typification of the regions. A cartographic method was used to interpret the numerical material, as this method showed territorial peculiarities of people's morbidity in the most precise way. A multidimensional method was used to analyze statistical data, a cluster method helped identify some regional similarities according to the indicators (program package Past) which characterized the level of people's morbidity.

As the morbidity of the population changes over time, to study it in dynamics becomes an important component of the analysis. The indicators of the primary morbidity were analyzed in the period of 2009–2017, calculated per 100 thousand people. It made it possible to identify the tendencies of the peoples' morbidity. The graphs of the morbidity of the population were built with help of Microsoft Office Excel.

A correlation coefficient was calculated to find out the connections between the peoples' morbidity and the age structure.

It has to be stated that beginning from the year of 2014 we have no complete statistical data concerning the morbidity of Ukraine's population. This is connected with the occupation of the Crimea and the Operation of the joined forces in Luhansk and Donetsk regions. In addition, due to the fact that the form of statistical reporting about the morbidity and spread of circulatory system diseases (CSD) was canceled

and no total data at the national level for the years of 2018–2021 was available, the comparison of the materials as to the morbidity and spread of CSD in Ukraine was done including 2017. The dynamics of the mortality from circulatory system diseases in Ukraine was analyzed for the years of 2009–2020.

RESULTS

In Ukraine respiratory diseases – 45.2% and circulatory diseases – 6.7% are the most frequent ones in the structure of people's morbidity. In 2017 the number of these diseases per 100 thousand people was 3118.0 cases and 4198.0 cases, respectively.

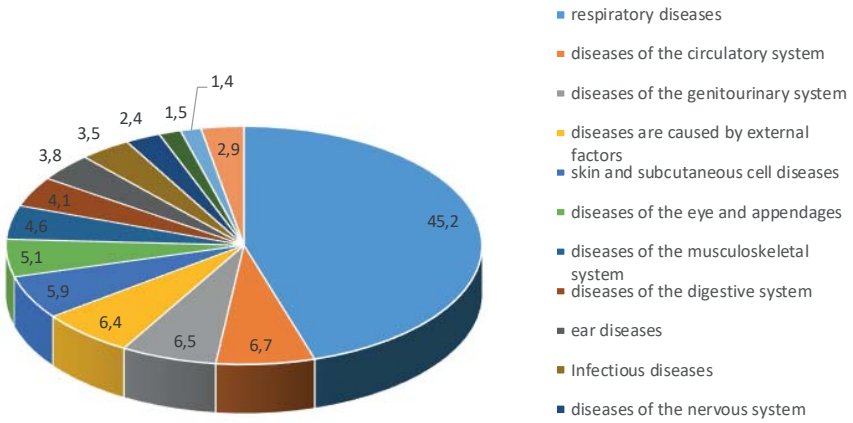

Fig. 1. Structure and specific weight of the morbidity of the population according to disease classes (2017)

The analysis of the circulatory incidence of the population during the period under study showed a sharp decrease of the incidence rate by 1.14 times.

Hypertension takes a leading place among cardiovascular diseases. The reasons which cause this kind of disease are heredity, intense mental work, smoking, excessive alcohol consumption and too much stress, in particular emotions (Kovalenko, 2016).

In Ukraine the analysis of people's morbidity of hypertension also showed the decrease in the incidence rate. In 2017 people's morbidity of hypertension in Ukraine was 1609.7 cases per 100 thousand of the population. This rate is 1.6 times lower as compared with that of 2009 (Fig. 2). In Ukraine the region which has the highest incidence rates of hypertension among people is Mykolayiv region. The incidence rate (3334.6 cases per 100 thousand people) exceeded the average indicator all over Ukraine by 2 times. Along with this, Kherson region which is adjacent to Mykolayiv region has the lowest incidence rate – 1127.7 cases per 10 thousand people (Shchorichna …, 2015; Shchorichna …, 2017).

The complication of hypertension leads to myocardial infarction.The analysis of the incidence rate of infarct among people points to its wavy change. Its highest rate was recorded in 2013 and it amounted to 135.7 cases per 100 thousand of the

population (Shchorichna …, 2015; Shchorichna …, 2017). Totally, the incidence rate was decreased by 1.1 times (Fig. 2).

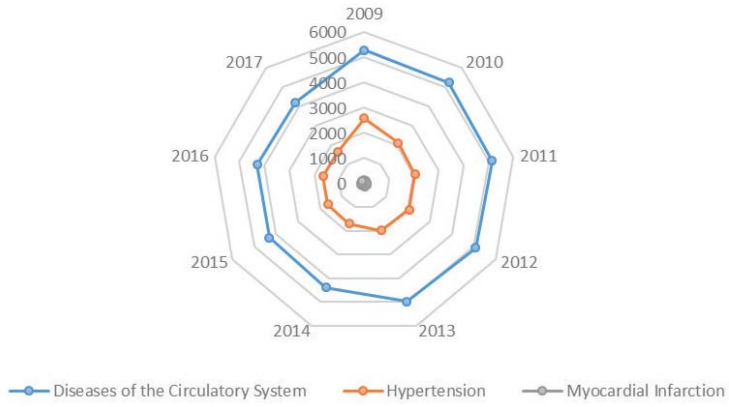

Fig. 2. Level of people's morbidity of circulatory diseases

Kirovohrad, Khmelnytsk, Cherkasy regions are among the administrative ones with the incidence rate which is higher than the average all over Ukraine by 1.2 times. The lowest rates were recorded in Zhytomyr, Rivne, Mykolayiv regions and in Kyiv city (from 103.2 to 109.6 cases per 100 thousand people) (Shchorichna …, 2015; Shchorichna …, 2017).

Taking into consideration the territorial differences in the structure of people's morbidity of the diseases of circulatory system in Ukraine, the administrative regions were grouped according to the incidence rate. As a result, the following levels of the groups of the regions were singled out: 1) very low – Zaporizhia and Kherson regions; 2) low – Luhansk and Volyn regions; 3) decreased – Cherkasy, Chernivtsi, Chernihiv regions; 4) average – Vinnytsia, Zhytomyr, Kyiv, Kirovohrad, Lviv, Poltava, Rivne, Sumy regions; 5) increased – Zakarpattia, Ternopil regions and Kyiv city; 6) high – Donetsk, Odesa, Kharkiv, Khmelnytsk regions; 7) very high – Dnipropetrovsk, Ivano-Frankivsk, Mykolayiv regions (Fig. 3).

The analysis of the statistical and cartographical data makes it possible to classify two groups of the factors which predetermine the morbidity of the diseases of circulatory system among the population of Ukraine.

Physical-geographical factors of CSD. As one can see from Figure 3, most of the regions with the highest incidence rate of CSD (Odesa, Mykolayiv, Dnipropetrovsk, Kharkiv and Donetsk regions) are situated in the natural zone of the Steppe of Ukraine. In the previous years, abnormally high air temperatures in summer were recorded on a greater part of the mentioned territory. Thus, according to the data of the Ukrhydrometeocenter, during the last 30 years the average annual air temperature increased by 1 °C in Ukraine. The number of the days with heat stress (air temperature is higher than +30 … +35 °C) increased all over the country. There used to be 30–40 such days during a vegetative period in the southern regions,

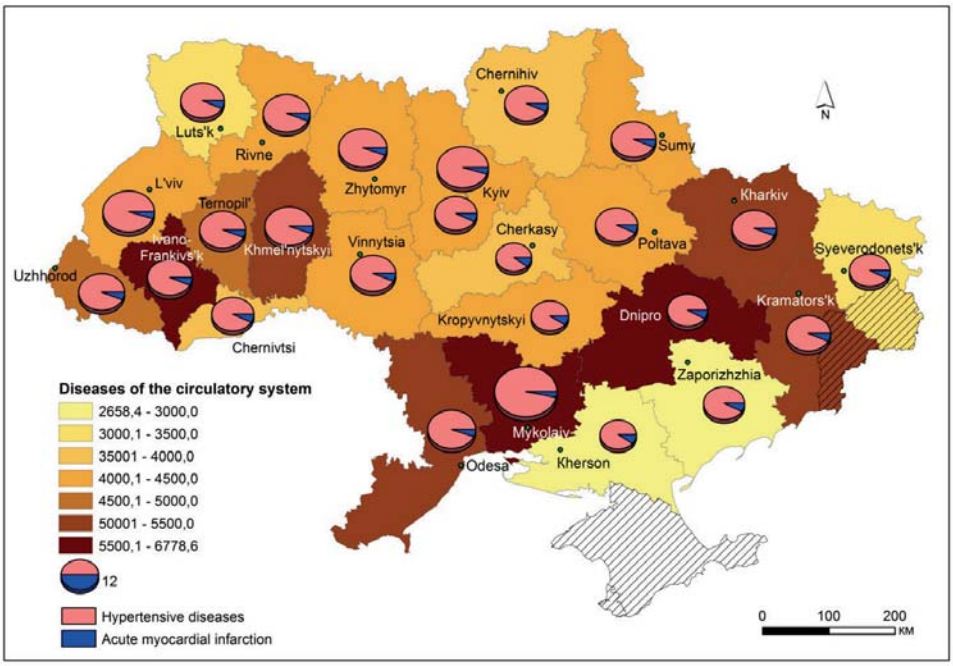

Fig. 3. Morbidity of the diseases of circulatory system among the population of Ukraine (per 100 thousand people) (made by the authors according to the data of the Center for Medical Statistics of the Ministry of Health of Ukraine (Shchorichna …, 2015; Shchorichna …, 2017).

now there are 50–65 of those (Adamenko, & Ogarenko, 2019). The formation of Black Sea cyclones and the west transfer of air masses from the Atlantic Ocean through the Carpathian Mountains result in frequent sharp changes of atmospheric pressure in the western and southern regions of Ukraine. Serious differences of the mentioned climatic indicators all together lead to the development of a hypertensive crisis among weather-dependent people which eventually results in lethal cases. The physical-geographical conditions of the territory, namely the location of the regions with high incidence rates within the area of mineral deposits, determine the next group of the factors.

Social-economic factors of CSD. A great number of industrial enterprises which are adjacent to the mining area are situated in the regions with a very high incidence rate of CSD (Dniprovsko-Donetska and Karpatska oil and gas regions, Dniprovskyi brown coal (lignite) basin, Donetskyi coal basin, Kryvorizkyi iron-ore basin, Nikopolskyi manganese-ore basin and others). The mining and enrichment of ore, manganese, titanium, iron and uranium ores are done within the territory of Dnipropetrovsk region only. The largest pollutant enterprises of the environment are PSC “Kryvorizkyi iron-ore integrated plant”, PSC “Pivdennyi mining-processing integrated plant”, PSC “Pokrovskyi mining-processing integrated plant”, PSC “Yevraz Suha balka”, PSC “Inhuletskyi mining-processing integrated plant”, PSC

"Central mining-processing integrated plant", PSC "Pivnichnyi mining-processing integrated plant", PSC "Dniprovskyi metallurgical plant" (the plant named after Petrovskyio), JSC "Nikopolskyi ferroalloys plant", JSC "Marhanetskyi mining-processing integrated plant", PSC "Dniptovskyi metallurgical integrated plant". Within the area of Ivano-Frankivsk region the most difficult ecological situation is recorded near such industrial enterprises as Burshtynska NPP, OSC "Oriana", CSC "Lukor", OSC "Naftochimic of Prykarpattia", Ltd. JV "Interplyt", OSC "Ivano-Frankivsk cement", OSC "Hutrofirma "Tysmenytsia", Ltd. "Uniplyt", OSC "Shkirianyk", etc. As to the number of discharges, the largest pollutant enterprises of the atmospheric air in Mykolayiv region are Mykolayiv alumina plant, Yugcement, SC "Mykolayivgas", branch of "Ukrtransgas" in Mykolayiv region. In addition to the unfavorable ecological situation, computerization of the production has a significant impact on the health of the population of the region. Sedentary work at the enterprise often causes the disease of "white collars" which results in psychological overwork and myocardial infarction.

The age of the population is another important social-economic factor which predetermines diseases of circulatory system. It is a typical situation for Ukraine when there are more people of an older age than those of a younger age. In 2017, from the total population, the number of people at the age 0–15 was 16.2%, those at the age of 60 and older – 22.5%, people at the age of 16–59–61.3%. (Population of Ukraine 2018 Demographic Yearbook).

A correlation analysis between the age structure of the population and the morbidity of the people showed an average connection between the morbidity and the population at the age of 65 and older, and a very weak correlation between the morbidity and the category of people at the age of 15–64 (Table 1).

Table 1

Correlation between the morbidity of the population and its age structure

Age structure	Correlation coefficient		
	Diseases of circulatory system	Hypertensive disease	Myocardial infarction
15–64	0.13	0.17	0.18
65 and older	0.57	0.54	0.4

The analysis of the incidence rates and the age structure of the population in the administrative regions shows that Mykolayiv region which has the highest incidence rate of the diseases of circulatory system, takes only the 18th place in the age structure of the population "65 and older". Kherson and Volyn regions, which have the lowest incidence rates, are characterized by a smaller number of the population of an older age group. These peculiarities emphasize a complex effect of the factors on the incidence rate of the population.

The dynamics of the mortality of the circulatory system diseases points to a clear tendency to the increase of the mortality rate in the years of 2012–2015 and from 2019 (Fig. 4).

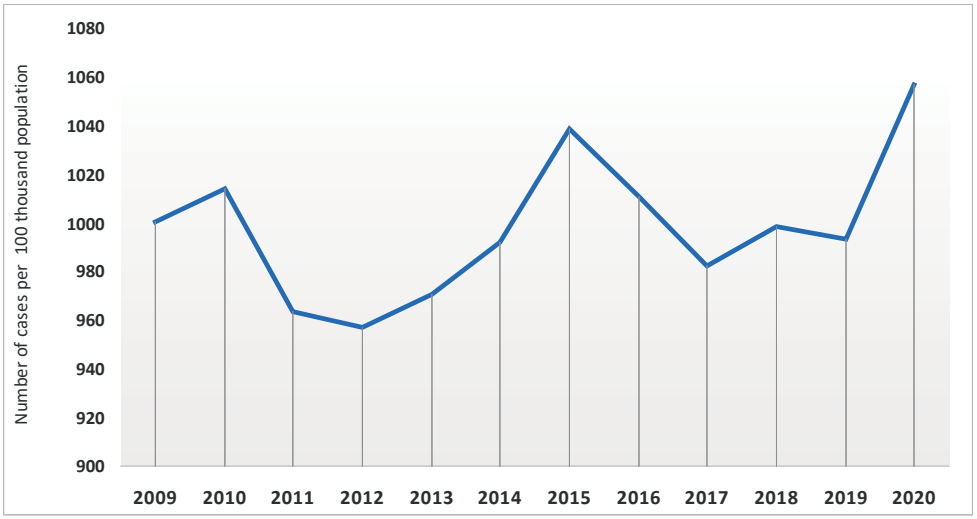

Fig. 4. Dynamics of the mortality of the circulatory system diseases among the population of Ukraine (per 100 thousand people)

In 2020, among the administrative regions, the highest mortality rates were recorded in Chernihiv, Poltava and Zhytomyr regions (Fig. 5).

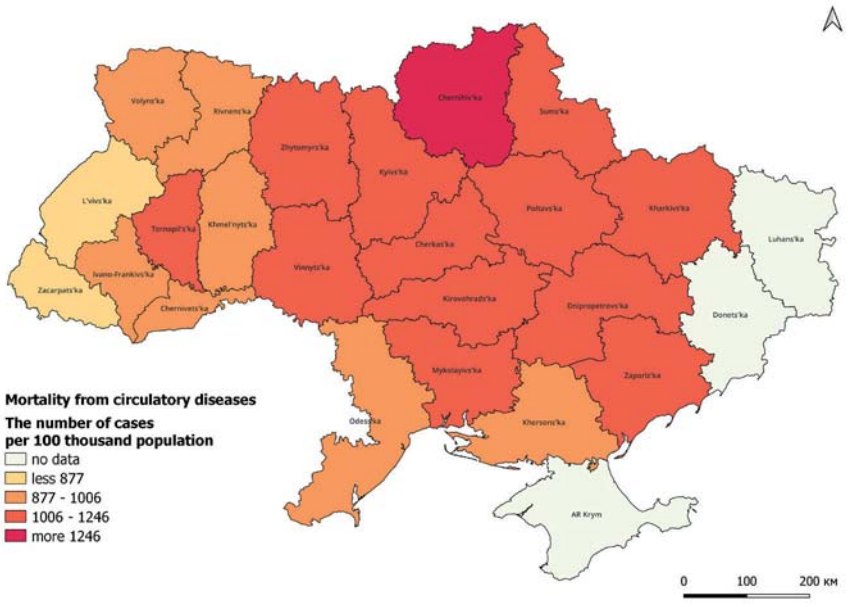

Fig. 5. Mortality of the circulatory system diseases among the population of Ukraine in the administrative regions (per 100 thousand people)

They exceeded the average mortality rate in Ukraine by 1.2–1.3 times. Along with this, the mortality rates, recorded in Lviv and Zakarpattia regions, were lower by 1.3 times as compared with the average indicator taken all across the country (Shchorichna …, 2015; Shchorichna …, 2017).

A cluster analysis was made within the framework of the research which helped get the typification of the regions based on the following indicators: general morbidity, circulatory system incidence, hypertensive disease, myocardial infarction, mortality. To estimate the feasibility of the creation of a cluster, the index of a primary load was applied which helped evaluate the percentage of the iterations where a cluster was formed. In the dendrogram (Fig. 6) one can see the formation of two groups created with 100% probability. The probability of the formation is low (<60%) for other clusters, which is why they are not analyzed.

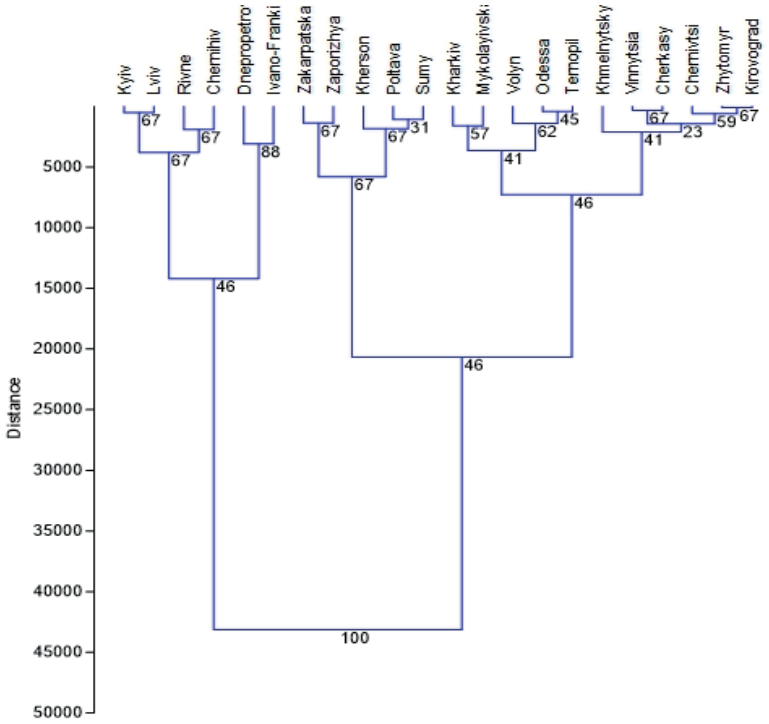

Fig. 6. Cluster analysis (dendrogram) according to the incidence rate in the population of Ukraine

The analysis of the dendrogram (Fig. 6) shows that the first cluster includes six regions which are characterized by high rates of general morbidity and that of circulatory system, average mortality rates, low morbidity of hypertension and average rates of infarctions. The second cluster comprises 16 regions with the predomination of high incidence rates of infarctions and mortality, average morbidity rates of circulatory system and hypertensive disease.

CONCLUSIONS

The diseases of circulatory system are the ones which are the most commonly spread both in the world and in the European region. The incidence rate of the diseases of circulatory system has a tendency towards the decrease. Although the morbidity of myocardial infarction among the population tends to decrease, its changing process is of a wavy nature.

Mortality is the indicator of the state of a health system in the countries. The mortality of heart diseases is considered to be dominating in Ukraine; its tendency towards the increase has been established as well.

According to the results of the spatial analysis of the circulatory system morbidity it has been found out that a high incidence rate is recorded in Donetsk, Odesa, Kharkiv, Khmelnytsk regions, and a very high rate – in Dnipropetrovsk, Ivano-Frankivsk, Mykolayiv regions which has been predetermined by such climatic features of these areas as the changes of temperatures and pressure in these regions as well as the availability of a great number f industrial enterprises.

One of the highest mortality rates was recorded in Chernihiv region, the most depressed area in Ukraine. The peculiarities of the age structure predetermined the significant mortality rates within the areas of other regions.

The calculated correlation coefficients give all grounds to think that there is a connection between people's morbidity and their age structure. All this stresses the necessity to constantly monitor a morbidity rate of the population and to take those measures which will allow preventing the incidence of heart diseases, which in turn will result in the decrease of mortality, the increase of life expectancy and well as the improvement of life quality of the population.

Two clusters in the administrative regions of Ukraine were singled out with help of a cluster analysis according to the morbidity of heart diseases among the population, the mortality of these diseases and the general incidence rate. These clusters differ by morbidity and mortality rates among the population. The first cluster includes the regions which are situated in the area of Ukrainian Polissia, except for Dnipropetrovsk and Ivano-Frankivsk regions, and they differ by different morbidity and mortality rates. The second cluster comprises mostly the regions of the Forest steppe and Steppe zones where high and average incidence rates dominate.

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ПРОСТОРОВИЙ АНАЛІЗ І ТЕНДЕНЦІЇ ЗАХВОРЮВАНОСТІ НАСЕЛЕННЯ УКРАЇНИ НА СЕРЦЕВО-СУДИННІ ХВОРОБИ

За ініціативою Світової Федерації серця з 2000 року 29 вересня відзначається Всесвітній день серця. Його основним завданням є залучення населення планети до проблем захворювань серцево-судинної системи, як таких, що мають одні із найвищих показників захворюваності та смертності. *Метою* цієї статті було провести просторовий аналіз та з'ясувати тенденції захворюваності населення України на серцево-судинні захворювання. З'ясовано структуру захворюваності населення України. Проаналізовано динаміку захворюваності населення на хвороби системи кровообігу протягом 2009–2017 років в Україні. Встановлено, що захворюваність населення на серцево-судинні хвороби має тенденцію до зменшення. Здійснене групування адміністративних областей України за показником захворюваності населення на хвороби системи кровообігу. Увага приділена гіпертонічній хворобі та інфаркту міокарда, як таким, що є одними із найпоширеніших серед хвороб системи кровообігу. Зафіксовано зниження показника захворюваності у 1,6 та 1,1 рази відповідно. Динаміка смертності в Україні від хвороб системи кровообігу проаналізована за 2009–2020 роки. Серцево-судинні захворювання є провідними у смертності населення. Проведений аналіз динаміки смертності від хвороб системи кровообігу вказує на її

збільшення. Аналіз статистичних і картографічних даних дав змогу виокремити дві групи чинників, які зумовлюють захворюваність населення України на хвороби системи кровообігу: фізико-географічні та соціально-економічні. Фізико-географічні фактори хвороб систем кровообігу (аномально високі показники температури повітря влітку, тривала кількість днів із тепловим стресом, різкі зміни атмосферного тиску) визначають найвищі показники захворюваності у південних (Одеська обл., Миколаївська обл., Дніпропетровська обл., Харківська обл., Донецька обл.) та західних (Закарпатська обл., Тернопільська обл., Івано-Франківська обл., Хмельницька обл.) регіонах України. Зазначено, що фізико-географічні умови території, а саме розташування областей з високими показниками захворюваності у межах родовищ значних покладів корисних копалин, визначають наступну групу факторів хвороб систем кровообігу. До них відносяться значна кількість підприємств промисловості, які приурочені до місць видобування корисних копалин, сидяча робота на підприємствах та вік населення. Проведений кореляційний аналіз вказав на наявність різного рівня зв'язку між захворюваністю населення та особливостями його вікової структури. Встановлений середній рівень залежності між хворобами серцево-судинної системи та населенням віком старше 65 років. Здійснений кластерний аналіз за допомогою якого була проведена типізація областей за медичними показниками.

Ключові слова: медична географія, захворюваність, система кровообігу, смертність, фізико-географічні фактори хвороб системи кровообігу, соціально-економічні фактори хвороб системи кровообігу.