GIS for optimizing location of primary health care facilities in rural areas: a case study in Barskyi and Sokalskyi rayons, Ukraine

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SUMMARY

The article examines possibilities of using GIS technology in decision-making in health care. The software ArcGIS for Desktop (ESRI), application ArcMap, was used to complete the task. The capabilities of geospatial analysis to assess health care at local level have been considered. The GIS analysis effectively identifies problem areas with limited access of the population to primary health care (case study: Barskyi Rayon, Vinnytsya Oblast and Sokalskyi Rayon in Lviv Oblast). It is proved that geospatial analysis is a useful tool for problem solving on forming an optimal network of primary health care through restructuring and conversion of existing facilities in ambulatory of general practice / family medicine.

Key-words*: health care, decision-making, GIS, geospatial analysis, access to health care, primary health care.*

REZUMAT

Articolul examinează posibilităţile de utilizare a tehnologiei GIS a factorilor decizionali în asistenţa medicală. Software ArcGIS pentru Desktop (ESRI) şi aplicarea ArcMap au fost utilizate pentru a finaliza sarcina. Pentru a evalua asistenţa medicală la nivel local au fost luate în considerare capacităţile de analiză geospaţială. Analiza GIS identifică în mod eficient zonele cu probleme, cu accesul limitat al populaţiei la asistenţa medicală primară (studiu de caz: raionul Barskyi, regiunea Viniţa, şi raionul Sokalskyi, regiunea Lvov). Este dovedit faptul că analiza geospaţială este un instrument util pentru rezolvarea problemelor, formând o reţea optimă de asistenţă medicală primară prin restructurarea şi reconversia instalaţiilor existente în ambulatoriul de medicină generală practică şi de familie.

Cuvinte-cheie: *asistenţă medicală, factori decizionali, GIS, analiza geospaţială, accesul la asistenţă medicală, asistenţă medicală primară.*

All over the world, organizations that work in health care rely increasingly on decision made using geographic information systems (GIS). GIS facilitate the improvement in efficiency of activities in health, its modernization and upgrade to the up-to-date level of attendance to population, corresponding to country's and society's needs. Healthcare is characterized as one of the most important fields that need geolocation support for decision-making (other being the fields of economy, ecology, defense, and science). One of the reasons for widespread use of GIS in health care is the spatial dependence between health-related factors.

The assessment of Ukrainian healthcare system efficiency is topical considering current reforms, which aim to improve health of the population and to provide equal access to medical services of proper quality.

Some questions regarding the use of modern information and communication technology to create new mechanisms of health administration were researched by: O. Baluieva, A. Vladzymyrskyi, R. Larina, V. Lobas. Methods to incorporate computer science in health care were analysed by O. Mintser, V. Ponomakenko, O. Kovalenko, O. Maiorov. Issues regarding the efficiency of the system responsible for security and monitoring the quality of health care services were presented by N. Hoida, N. Kryzyna, L. Liekhan, and others. Withal, monitoring of factors contributing to health care services accessibility – in particular, geographical accessibility to health care institution in rural areas – has not been sufficiently researched.

Objective of the study is to examine possibilities of GIS use in decision making process in health care system; to evaluate the expediency of GIS-analysis techniques use in analysis of population's access to primary health care in Sokalskyi Raion, Lvivska Oblast and Barskyi Rayon Vinnytsya Oblast.

Software ArcGIS for Desktop (ESRI), application ArcMap, was used to carry out defined tasks.

A geographic information system (GIS) is an integrated complex of hardware, software, and informational means that ensure input, storage, treatment, manipulation, analysis, and presentation of spatial data (geo-data).

Today, GIS technology presents a powerful tool to integrate different data, perform their spatial analysis, modelling, and visualization. This helps to widen the area of research, as well as to present the results in a convenient for further work, cartographic way. Since geospatial data is becoming increasingly common and GIS software – user friendly, the interest to GIS-analysis as a way to find spatial patterns in certain data distributions as well as interconnections between different objects. The advantage of GIS methodology relies on the fact that GIS enables the identification, support, management of spatial connections between topological objects, which represent objects from the physical world, creation of new objects and links, connection of new attributes, and completion of GIS analysis.

Efficient completion of GIS analysis requires knowledge of the analytical process structure as well as that of possibilities for using its techniques to solve specific issues. General objectives of the spatial analysis [1]:

- Analysis of object location – used to localize regions or places, which require immediate action, by certain criteria. The location can be described using, for example, the name of a settlement, postal address, or geographic coordinates. Visualization (representation of information) being a medium of information presentation, enables the identification of spatial interactions between different objects. It helps to develop better understanding of the inspected object, to identify different phenomena and tendencies, which remain hidden during the usual data analysis;

- Analysis of the numerical indicators distribution;

- Building the density map. Density characterizes the concentration of objects on a given location. Density maps are quite effective as a tool, on one hand, for evaluation of distribution patterns of separate objects, and on the other hand, for mapping the regions of different size;

- Searching for objects located in the region;

- Analyzing space surrounding the object. GIS enables us to asses space (Neighborhood) around a specific location as well as to conduct a proximity analysis (Proximity). For instance, buffer zone generator is used to estimate the number of people located in the area, covered by an outpatient clinic;

- Analysis of spatial and temporal changes. For instance, what was the tendency for a disease spreading in a local administrative unit; or which health care institutions have been created during the last year?

Presenting information in a clear and convenient for the user way is one of essential functions of every data processing systems. Content, structure, and quality of input information play the key role in ensuring the efficiency of the analysis and, consequently, of accepted on its bases weighted decisions. It is worth noting that in order to conduct a complex analysis of any phenomenon or any process; one needs information of various kinds and purposes (in a form of statistical report, strategic or organizational information). Without a doubt, in the absence of versatile information the analysis will be incomplete and thus the decisions will be partial. Meanwhile, the excess of information complicates the process of searching and synthesizing information, as well as implementing decisions. Therefore, there is always a need to remove unnecessary data in order to improve the flow of information.

Thus, we believe that an important advantage of GIS lies in the fact that in this system input information is kept and treated in the form of separate sets of data files. Because of this, any researcher or decision maker can single out ("select") data from each layer according to his/her needs, to solve each separate issue.

Based on open data regarding Sokalskyi Raion, Lvivska Oblast, and Barskyi Rayon, Vinnytsya Oblast the geographic aspect of population's access to primary health care was examined.

According to data from the official web portal of the Verkhovna Rada of Ukraine, Sokalskyi raion is composed of 106 settlements (cities and villages) with a total population of 98,123 people, and 63,578 of which live in rural areas. Barskyi raion is composed of 94 settlements with a total population of 62,239 people, and 43,684 of which live in rural areas. [2] Data regarding population numbers and territory of each settlement was obtained from the corresponding accounting file.

In order to assess access to health care, a network of current health care facilities, and service areas covered by each facility, were analyzed.

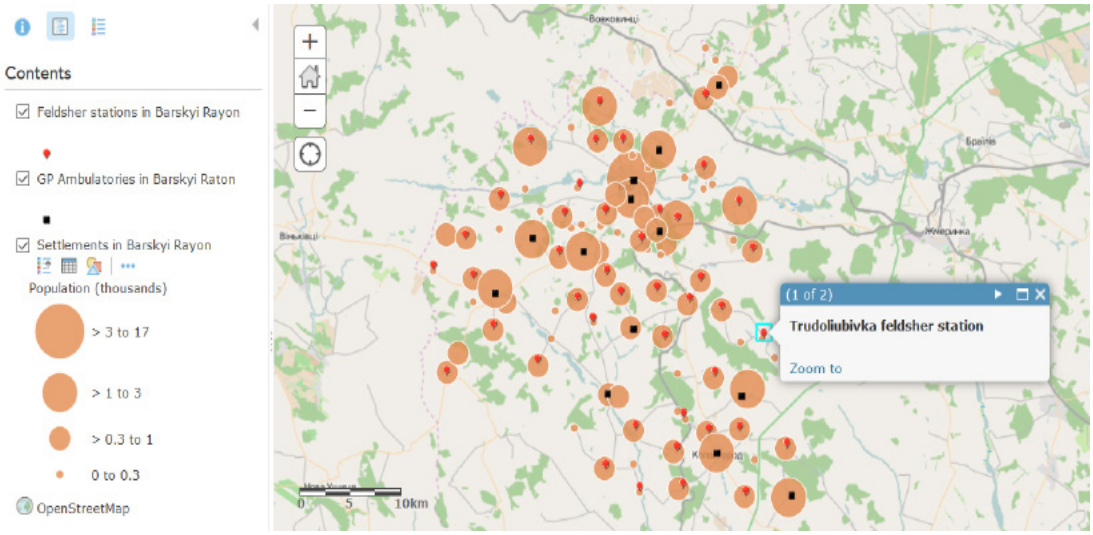
In Sokalskyi Rayon primary health care (PHC) is provided by the district service, which incorporates 3 large outpatient polyclinics, 10 ambulatories of general practice–family medicine (GP ambulatories), 2 centers of family medicine, 1 rural outpatient clinic and 51 feldsher-midwifes stations. [3]

In Barskyi Rayon PHC includes (Fig. 1): 14 GP ambulatories and 43 feldsher-midwifes stations. [4]

Through the results of GIS-analysis, spatial interconnections between objects of the inspected oblast were identified. Information, represented on the map, allows us to include additional data, which after an appropriate analysis could influence the decision making process.

The proximity of the PHC facilities to the patients – that is the radius of the service area for this facility (unit) – has been selected as a basic parameter for this analysis. This enables a prompt assessment of the PHC facility on the level of doctor/unit and on the level of oblast/country. To analyze the accessibility of PHC on the level of doctor/unit the following assessment coefficients, which depend on distance measurement, are recommended for use: 3 – the best indicator – distance from the PHC facility to the patient is less than 2 km; 2 – good – 2-5 km; 1 – satisfactory – over 5 km; 0 – unsatisfactory – over 7 km. On the Rayon/ Oblast/ national level, in order to generalize indicators obtained to determine the number of facilities, further analyze them and use in the decision making, one should be using an assessment coefficient "part of PHC faci-

***Fig. 1.* Primary health care in Barskyi Rayon.**



lities located not more than 2 km away from patients." [5]

By Buffer tool we located settlements, which are over 2 km away from the PHC and 7 km away from the closest outpatient clinic (Figure 2).

It was discovered that 5% of rural population of Sokalskyi Rayon did not have appropriate access to PHC. Overall, because of the inappropriate planning, 3273 people were left without proper access to health care.

It is revealed that 65% of feldsher-midwifes stations are located on distance of 7 km from the GP ambulatories. Therefore, in the present situation the GPs not able to provide adequate quality of PHC. The situation affects staffing of health facilities district: indicator of physicians (per 10,000) in Sokal district is 22.95 – twice lower than the regional rate (45.9), while a third physician retirement age (33.6%). [6]

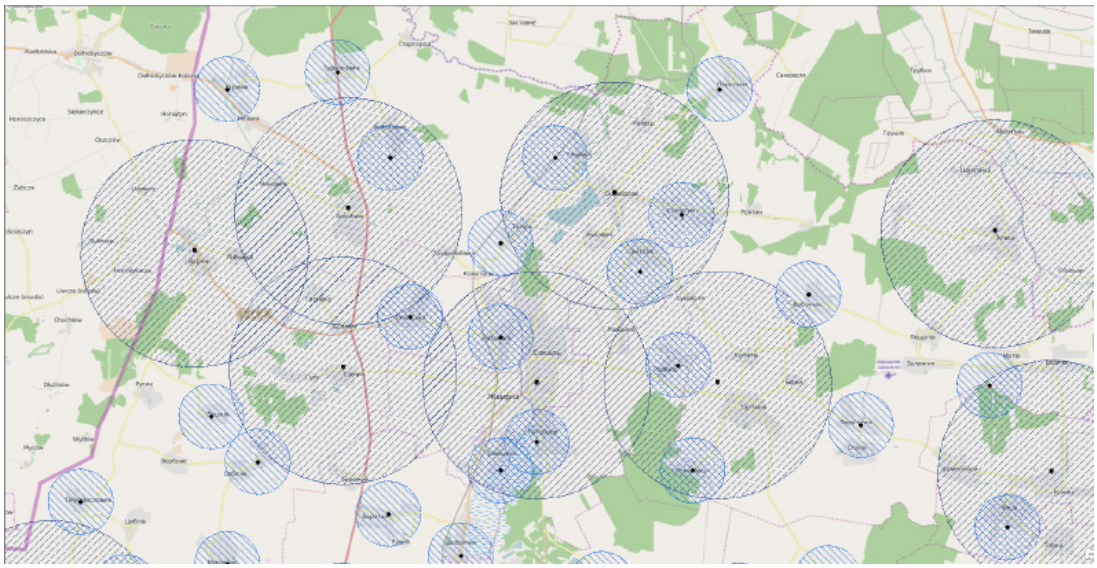
It is known that the location of the health facility within 5 km from the settlement reduces the frequency of patients appeals by 40%, and the location of the health facility at a distance of 10 km - three times. [7] Study found, how many people seek timely to the doctor.

In Barskyi Rayon (Figure 3) 49 villages (53.3%) are 5 km away from GP ambulatories. There is a total 17,550 people (40% of rural population), which are 40% less likely to seek health service. According to the second criterion more than 16.7 % of rural population seeks health care in three times less.

As a result of visualization, in Sokalskyi Rayon 57 villages (53.8%) are remoted from the GP ambulatories for over 5 km. There is a total 30,611 people (48% of rural population), which are also 40% less likely to seek health service. According to the second criterion 14 settlements with 10,406 hubitans have been identified. So more than 16% of rural population seeks health care in three times less.

The analysis showed that in Sokalskyi Rayon the existing network of GP ambulatories can not cover the entire population of the district. According with current legislation, to ensure adequate availability of primary care to residents, the feldsher-midwifes station should be created in the village/ city, where there are more than 300 habitants and where there is no other providers of free primary health care. Ambulatory created to provide primary health care for more than 1,500 people in urban areas and more than 1,000 people in rural areas.

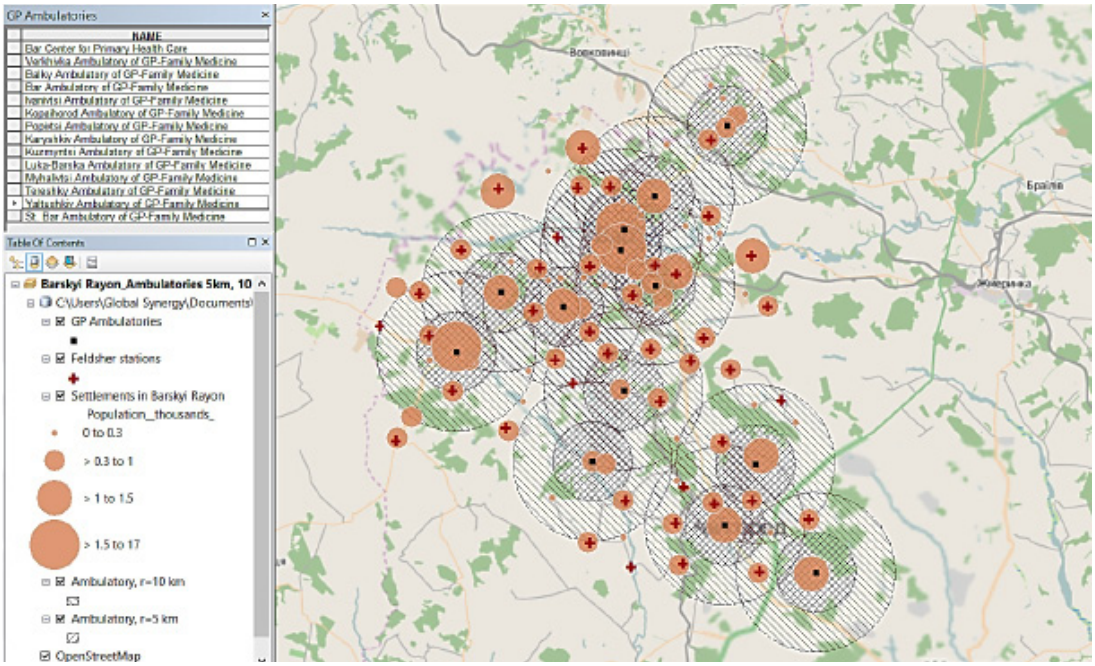
***Fig. 2.* PHC facilities in Sokalskyi Rayon**
(distance to feldsher-midwifes station 2 km; distance to ambulatory 7 km)



Thus, first of all the local authorities should to decide on the establishment of feldsher-midwife stations (villages of Sokalskyi Rayon: Zalizhnya, Zarika, Suhovolya, Tsebliv; in Barskyi Rayon: Sloboda-Khodatska) and GP ambulatories (in Sokalskyi Rayon: Volsvyn, Murovane, Reklynets; in Barskyi Rayon: Harmaky, Komarivtsi, Mankivtsi) and to develop incentives for GP who conducts economic activity in medical practice as individuals - entrepreneurs.

Geospatial analysis is a useful tool to address the task of forming an optimal network of primary care through restructuring

Fig. 3.* GP Ambulatories in Barskyi Rayon *(distance 5 i 10 km).



existing facilities in ambulatory general practice/ family medicine. Since the accessibility of health care is a prerequisite for the creation of a network of state and municipal health care facilities "tailored the needs of the population in health care, the need to ensure the quality of the service, timeliness, accessibility to citizens, effective use of material, labor and financial resources." [8]

Summarizing the results of the study, concludes that GIS analysis tools should be used in the process of development, implementation and assessment of decisions in health, identify potential problems and ways of improving the quality and health care accessibility.

In terms of decentralization and health reforms proposed approach should be widely implemented in the activities of public administrations in health care.

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