

Krzysztof Świtała¹, Sebastian Sikorski²

USE OF GIS IN HEALTHCARE

Abstract: The use of spatial data allows implementation improvement of the public entities tasks in the field of health care. Both government and territorial self-government administration, within the scope of their competence, can process such information resources. The aim of this article is to present the role of spatial data in healthcare management processes. Local self-government units, in order to ensure equal access to health care services, develop, implement and evaluate the effects of health policy programmes, as well as take other actions resulting from the identified health needs and health condition of the inhabitants. These tasks of the local government may be carried out more effectively through the use of spatial information systems, facilitating data analysis, which may be fully or partially automated. In the Polish legal system, regional maps of health needs are created by voivodes, while the Nationwide Map of Health Needs is developed, established and updated by the Minister of Health. Spatial information systems can be a useful tool to support the implementation of tasks by the above-mentioned competent bodies and verification of the achieved results, provided that appropriate quality of collected data and interoperability of used solutions is ensured at the organisational, semantic and technical level.

Keywords: spatial data, INSPIRE, Map of Health Needs, information system in healthcare, interoperability

Received: 7 December 2021; accepted: 9 December 2021

© 2021 Authors. This is an open access publication, which can be used, distributed and reproduced in any medium according to the Creative Commons CC-BY 4.0 License.

¹Cardinal Stefan Wyszyński University, Law and Administration Faculty, Department of Informatics Law, Warsaw, Poland, ORCID ID:<https://orcid.org/0000-0003-0426-5383>, email: k.switala@uksw.edu.pl

²Cardinal Stefan Wyszyński University, Law and Administration Faculty, Department of Administrative Law and Territorial Self-Government, Warsaw, Poland, ORCID ID: <https://orcid.org/0000-0002-7974-9537>, email: s.sikorski@uksw.edu.pl

Introduction

Spatial data processing concerns various areas of public administration and economy. The use of these information resources makes it possible to represent objects and phenomena by indicating their relationships and the extent to which they influence the environment and the shaping of space. Article 3 point 1 of the INSPIRE Directive 2007/2/EC defines spatial data as any data with a direct or indirect reference to a specific location or geographical area (OJ UE L 108/1). These resources consist of two basic elements:

- location in the field of a specific object according to geographical coordinates,
- object description indicating its properties, features and functions (Białousz, 2013).

Spatial data can be used to analyse and formulate conclusions about a specific area and its components. These observations also apply to the health sector, where spatial data can facilitate a comprehensive analysis of the actual state of existing processes or the planning of strategies and new policies. The use of spatial information systems allows for the improvement of resource management and implementation of statutory tasks in the public sector.

The first part of the article presents the position of spatial information systems in the national information infrastructure, which is an introduction to consider the role of spatial data in the processes of health management.

Spatial information systems and the national information infrastructure

Spatial information systems include methods and techniques related to the processing of data related to the location and characteristics of specific objects in space. The primary purposes of this technology are data collection, as well as support for decision-making, research, education, and the dissemination of information about land. The elements of spatial information systems include: data – together with its processing and collections, hardware, software, technologies or users (Fig. 1).

Sources of spatial resources for such solutions are: topographic and thematic maps, satellite images, aerial photographs, results of geodetic and specialist measurements, registers and databases and other information systems, signals of GPS and GLONASS satellites as well as Galileo (Baranowski, 2012). Spatial information systems are multi-module structures that allow for extensive data analysis. On their basis, it is possible to draw conclusions to support decision-making on selected issues.

At the national level in Poland there is a spatial information geoportal available at <https://www.geoportal.gov.pl/>. The legal basis for its operation and processing of certain categories of data is Art. 13 of the Act of 4 March 2010 on spatial information infrastructure (OJ DzU 214/2021). The Chief Geodesist of Poland (pol. Główny Geodeta Kraju) creates and maintains this geoportal as the central access point to spatial data services, making it possible to search (Catalog Service for the Web), view (Web Map Service), download (Web Feature Service for vector graphic, Web Coverage Service for raster graphic) and transform (Web Processing Service) spatial data.

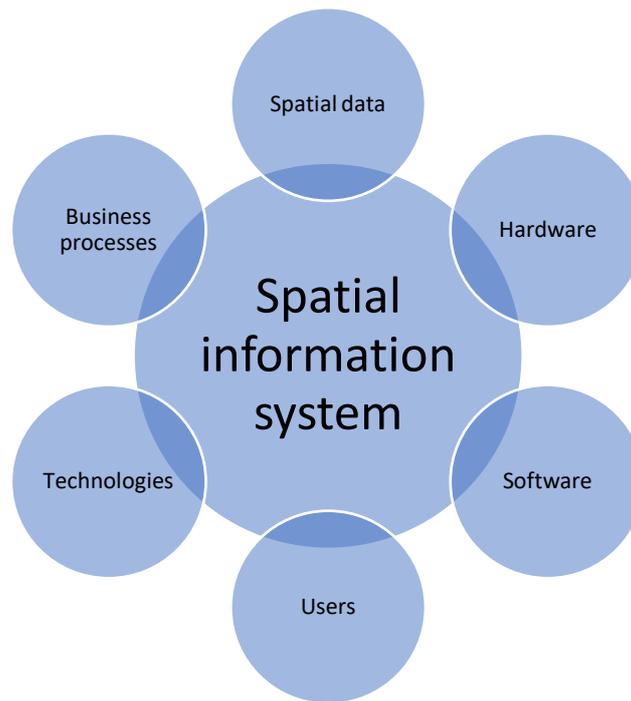


Fig. 1. Spatial information systems structure
Source: Own elaboration

At the regional level, there are also specialized provincial spatial information systems:

- Pomorski (<https://pomorskie.e-mapa.net/>),
- Kujawsko-Pomorski (<https://kujawskopomorskie.e-mapa.net/>),
- Warmińsko-Mazurski (<https://warmińskomazurskie.e-mapa.net/>),
- Lubuski (<https://lubuskie.e-mapa.net/>),
- Wielkopolski (<https://wielkopolskie.e-mapa.net/>),
- Mazowiecki (<https://geodezja.mazovia.pl/msip.html>),
- Podlaski (<https://podlaskie.e-mapa.net/>),
- Łódzki (<https://rsip.lodzkie.pl/>),
- Dolnośląski (<https://dolnoslaskie.e-mapa.net/>),
- Świętokrzyski (<http://sip.e-swietokrzyskie.pl/>),
- Lubelski (<https://lubelskie.e-mapa.net/>),
- Podkarpacki (<https://podkarpackie.e-mapa.net/>),
- Małopolski (<https://miip.geomalopolska.pl/imap/>),
- Śląski (<http://www.orsip.pl/geoportal>),
- Opolski (<https://mapy.opolskie.pl/>).

Considering the data processed in these systems, one can find among resources layers associating with various areas of competence of local government, including those relating to the shaping of processes in healthcare sector.

Both the national geoportal and regional geoportals are part of the national information infrastructure. This concept refers to the global, European and national scale. Information infrastructure is a complex of institutions, organizational units,

resources and information systems, as well as information and communication technologies, whose appropriate shape and mutually ordered relationships determine the proper functioning of certain social, economic and political systems (Oleński, 2006). In the general theory of systems, the notion of system is defined as a set of elements that remain in mutual relations (von Bertalanffy, 1984). The information system is considered as a set of elements that cooperate with each other in order to collect, process, store and provide information to support decision-making processes and processes of coordination, control, data analysis in organizations (Laudon, 2011). This concept also has legal definitions. Pursuant to Article 2 point 14 of the Act of 5 July 2018 on the National Cyber Security System, an information system includes an ICT system (the content of Article 3 point 3 of the Act of 17 February 2005 on Informatisation of the Activities of Entities Performing Public Tasks indicates that it is a set of cooperating IT devices and software ensuring processing, storage, as well as sending and receiving data via telecommunication networks by means of a telecommunication end device appropriate for a given type of network – OJ DzU 2070/2021), together with data processed in it in electronic form (OJ DzU 1369/2020). In art. 2 point 13 of the Act of 29 June 1995 on public statistics the scope of the legal concept of public administration information systems covers systems for collecting, storing and processing information by public administration bodies, the Social Insurance Institution, the National Health Fund, the Financial Supervision Authority, registration bodies, other national or local government legal persons and other entities keeping official registers (OJ DzU 955/2021). Public spatial information systems are part of the national's information infrastructure.

In EU law the term infrastructure for spatial information has its legal definition in Article 3 point 3 of the INSPIRE Directive 2007/2/EC. It consists of metadata, spatial data sets and spatial data services; network services and technologies (OJ UE L 108/1). Infrastructure for spatial information also includes agreements on sharing, access and use, as well as coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with this Act. The Polish implementation of this definition in Article 3 point 2 of the Act on Spatial Information Infrastructure supplements the elements mentioned above by additionally including administrative bodies and third parties contributing to the infrastructure (OJ DzU 214/2021).

Information infrastructure is therefore a complex of institutions, systems and resources reducing uncertainty, in which public resources and entities implementing public tasks are important (Szpor, 1998). Such solutions make it possible to organise the information sphere of the functioning of the state and its institutions. In relation to health care, safe, effective and comprehensive exchange of data and the possibility of their extensive analysis makes it possible to actually realise the postulate of realisation of knowledge-based medicine and management of this sector based on complete and up-to-date information. Transformation of the information model through the introduction of comprehensive legal solutions and implementation of modern IT tools in the health care sector should ensure its uniform, integrated and flexible structure, which will be

beneficial both for patients – their health and information security, as well as from the point of view of optimization of processes operating in the health care system (Wdowiak et al., 2009). An effectively functioning national information infrastructure is an important component of modern information societies and knowledge-based economies.

Spatial data in healthcare

Among the themes of spatial data specified in the INSPIRE Directive 2007/2/EC and its Annex No. 3, the following data is of particular importance in the context of the subject of this presentation:

- human health and safety – these resources are referred to geographical distribution of dominance of pathologies, information indicating the effect on health or well-being of humans;
- utility and governmental services – includes utility facilities such as administrative and social governmental services such as civil protection sites and hospitals.

In an analogous way, these thematic areas are provided for in the Annex to the Act on Spatial Information Infrastructure. In section 5 of chapter 3 issues related to health and safety of the population can be found. Moreover, section 6 refers to public services including social services and hospitals (OJ UE L 108/1). Spatial data analyses results allow the observation on a time line of the relationship of health events with the space and the objects located in it, e.g. hospitals, emergency stations (Khashoggi et al., 2020). This allows dependencies and variability between such elements to be identified (Fig. 2).

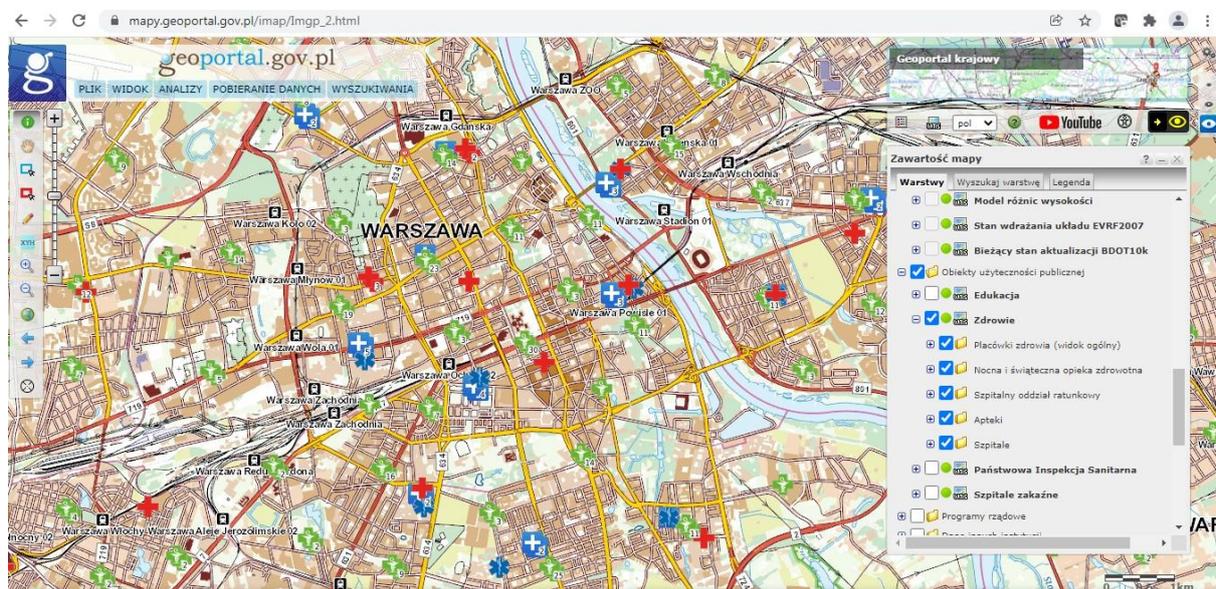


Fig. 2. Spatial objects in the geoportal related to healthcare infrastructure

Source: Own elaboration

Detailed competences related directly or indirectly to the processing of spatial data for the needs of health care management can be found in the regulations related to the functioning of local government and government administration. Content of Art. 7, 8 and 9 of the Act of 27 August 2004 on health care services financed from public funds outlining the tasks of local government (of municipalities, districts and voivodeships) in ensuring equal access to health care services refer to the following areas:

- development, implementation and evaluation of health policy programmes and
- monitoring actions of the local self-government community in the area of health, as well as
- undertaking other activities resulting from identified health needs (OJ DzU 1285/2021).

These tasks of the local government can be carried out more effectively through the use of spatial information systems, by facilitating data analysis, which can be fully or partially automated.

An important problem of the Polish health care system is the uneven distribution of resources – including medical staff –which results in the needs of local communities not being adequately met. This causes the migration of patients to satisfy health needs, which translates into the increase of indebtedness of medical entities, and in the further consequence, the limitation of quality and accessibility of services in connection with decapitalisation of system resources. The objective of rationalisation of the functioning health care system in Poland was the introduction of maps of health needs, which is – in its assumption – one of the tools stimulating the development of regional and national infrastructure, in accordance with the health needs of the society.

At the government level according to art. 95a Act on health care services financed from public funds The Minister of Health as the competent authority shall develop, establish and update the Nationwide Map of Health Needs (OJ DzU 1285/2021). The basis for the creation of the Nationwide Map of Health Needs are regional (voivodeship) maps. The authority competent to draw up the regional map of health needs is the voivode (pol. wojewoda), who passes this act to the marshal of the voivodeship (pol. marszałek województwa), the convention of districts (pol. powiaty) of the given voivodeship, the voivodeship consultants in health care, the President of the National Health Fund and the voivodeship council for social dialogue for an opinion. Regional map of health needs and the Nationwide Map of Health Needs consist of the following parts:

- health needs and challenges of health system organisation requiring action,
- actions that need to be coordinated,
- planned period for implementing the actions,
- entities responsible for implementing the actions,
- estimated costs of actions,
- expected outcomes of actions,
- performance indicators for the various actions mentioned above.

The maps were supposed to be the basis for determining the level of future health care needs and to indicate the key actions that should be implemented first by the

voivodeship branches of the National Health Fund, which would result in optimal provision of health care services. In the process of creating this document, the role of the Fund's representatives and voivodeship consultants is crucial (Sikorski, 2021).

The source of information for developing the Maps of Health Needs may be the Medical Information System, domain information systems (pol. dziedzinowe systemy teleinformatyczne) or medical registers regulated in the Act of 28 April 2011 on the information system in health care (OJ DzU 666/2021). These collections have significant potential from the point of view of their use in the processes of planning and evaluation of public policies implemented in Poland in the area of health care.

It should be noted that the effective use of data for the up-to-date management of health care still faces significant problems that require finding effective methods to solve them at technical, organisational and legal levels. In the course of the audit carried out in 2018 by the Supreme Chamber of Control, it was established that the previously published maps of health needs contained a lot of unreliable data, including in particular epidemiological phenomena and health system resources. The reason was the outdatedness and incompleteness of data contained in some registers. In addition, analyses were developed on the basis of information, often even historical, from 2012 and 2013 (Information on the results of the audit Creating Maps of Health Needs, Najwyższa Izba Kontroli, No. 191/2017/P/17/059/KZD).

The second significant – related to the first problem – is the interoperability of IT systems operating in the healthcare system. Article 3 point 18 of the Act of 17 February 2005 on Informatisation of the Activities of Entities Performing Public Tasks defines the concept of interoperability as the ability of different entities and the ICT systems and public registers used by them to work together to achieve mutually beneficial and agreed objectives, taking into account the sharing of information and knowledge by the business processes supported by them, implemented by means of data exchange through the ICT systems used by these entities (OJ DzU 2070/2021). A similar understanding of the concept of interoperability can be found in the EU legal system, in particular in the area of soft law relating to the management of electronic public services (European Interoperability Framework – Implementation Strategy (COM (2017) 134).

Interoperability is considered at three basic levels:

- organisational – it implies the unification of management standards, organisational structures, policies and business processes related to information processing,
- semantic – establishing agreed, consistent and unambiguous data structures at all stages of information processing,
- technical – ensuring compatibility of technical solutions (e.g. communication protocols) and software used for information processing (e.g. by formulating minimum requirements for such solutions in legal regulations or indicating the relevant technical standards that should be followed to ensure effective data exchange).

In addition, the processing of data in European public services should comply with the following set of principles:

- subsidiarity and proportionality,
- openness,
- transparency,
- reusability,
- technological neutrality and data portability,
- user-centricity,
- inclusion and accessibility,
- security and privacy,
- multilingualism,
- administrative simplification,
- preservation of information,
- assessment of effectiveness and efficiency.

Compliance with them are relevant to the process of establishing interoperable european public services infrastructure. With regard to cooperation between the Member States and the EU institutions, there is also a legal level of gradual harmonisation of the regulations relating to data exchange within the European single market.

The components of the infrastructure for spatial information should maintain interoperability as defined in Art. 3 point 7 of the INSPIRE Directive 2007/2/EC as the possibility for spatial data sets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the data sets and services is enhanced (OJ UE L 108/1). In doctrine, interoperability is considered as the ability of components or systems to distribute information to each other, to understand it in a uniform way, and to use it effectively to achieve the intended results of their actions. It draws attention to such important related issues as precisely the compatibility and cooperation of distributed autonomous IT solutions (Światała, 2018). Achieving interoperability between individual information systems and their coherence with the organisational and legal layer allows improving the management of processes occurring in health care through efficient access to complete and reliable data on the functioning of this sector.

Conclusion

Spatial data related to the functioning of health care allow for a graphical representation of past, present and projected objects and phenomena concerning this sector. This facilitates conducting analyses aimed at formulating conclusions supporting decision-making processes related to the constant management of processes of ensuring medical safety of the population. Thanks to the processing of such resources, it is possible to evaluate the implemented health policies more effectively by verifying their effects. Spatial information systems also facilitate the forecasting of new phenomena related to public health and the selection of impact methods relating to them.

References

- Baranowski M. (2012). Zarys problematyki systemów informacji przestrzennej w kontekście infrastruktur geoinformacyjnych (*Outline of the issues of spatial information systems in the context of geoinformation infrastructures*). In: S. Białousz, E. Bielecka (ed.), INSPIRE i krajowa infrastruktura informacji przestrzennej, Warszawa 2012, pp. 39–40.
- Białousz S. (2013). Rozważania metodyczne o informacji przestrzennej (*Methodological considerations about spatial information*). In: S. Białousz (ed.), Informacja przestrzenna dla samorządów terytorialnych, Warszawa, p. 3.
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, European Interoperability Framework – Implementation Strategy (COM(2017) 134).
- Directive 2007/2/EC of The European Parliament and of The Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (OJ UE L 108/1).
- Information on the results of the audit Creating Maps of Health Needs, Najwyższa Izba Kontroli, No. 191/2017/P/17/059/KZD.
- Khashoggi B., Abdulkader Murad A. (2020). Issues of Healthcare Planning and GIS: A Review. *International Journal of Geo-Information*, no. 9, pp. 19–20.
- Laudon K.C, Laudon J.P. (2011). *Essentials of Management Information Systems*. New Jersey, p. 13.
- Oleński J. (2006). Infrastruktura informacyjna państwa w globalnej gospodarce (*State information infrastructure in the global economy*), Warszawa, pp. 270–271.
- Sikorski S. (2021), Administracja ochrony zdrowia w Polsce – między świadczeniem a reglamentacją (*Healthcare administration in Poland – between service and regulation*), Warsaw, pp. 444-459.
- Szpor G. (1998). Informacja w zagospodarowaniu przestrzennym. Zagadnienia administracyjnoprawne (*Information in spatial development. Administrative and legal issues*), Katowice, p. 25.
- Świtła K. (2018). System informacji w ochronie zdrowia a problematyka planowania i ewaluacji polityk zdrowotnych w Polsce (*The information system in health care and the issues of planning and evaluation of health policy in Poland*). *Roczniki, Kolegium Analiz Ekonomicznych SGH*, vol 52, pp.112–113.
- The Act of 17 February 2005 on Informatisation of the Activities of Entities Performing Public Tasks (OJ DzU 2070/2021).
- The Act of 27 August 2004 on health care services financed from public funds (OJ DzU 1285/2021).
- The Act of 28 April 2011 on the information system in health care (OJ DzU 666/2021).
- The Act of 29 June 1995 on public statistics (OJ DzU 955/2021).
- The Act of 4 March 2010 on spatial information infrastructure (OJ DzU 214/2021).
- The Act of 5 July 2018 on the National Cyber Security System (OJ DzU 1369/2020).

von Bertalanffy L. (1984). *General Systems Theory*, Warsaw, p. 85.

Wdowiak L., Kamiński Z., Horoch A., Bojar I. (2009). Systemy informatyczne w ochronie zdrowia. Część 2 – doświadczenia krajowe (*Systemy informatyczne w ochronie zdrowia. Część 2 – doświadczenia krajowe*). *Zdrowie Publiczne –Public Health*, no. 119(1), p. 80.