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Analysis of the Romanian Healthcare System on the Basis of Relevant Indicators and the Perspectives for the Use of Artificial Intelligence

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Abstract. *Healthcare systems are integral to the well-being of societies, serving as the backbone for delivering health services and improving public health outcomes. The healthcare system in Romania is a critical component of the country's socio-economic framework, with its performance directly affecting the health and development of the population. While there have been improvements in certain areas, challenges such as underfinancing, human resource issues and inequitable access to care remain. Artificial intelligence (AI) in healthcare represents a significant shift towards more efficient, precise, and personalized medical care. It encompasses a range of applications from diagnostics to treatment recommendations, patient engagement, and administrative tasks, aiming to enhance the quality and accessibility of healthcare services.*

The purpose of this study is to analyze the healthcare system in Romania using data on healthcare infrastructure (medical units), medical staff, population, hospital beds and investments. Additionally, it aims to organize ideas regarding the use and perspectives for the development of artificial intelligence in the Romanian healthcare system. A spatial distribution of indicators is created, highlighting the most significant areas in the Romanian healthcare system.

Healthcare systems are essential for providing healthcare and promoting public health. Effective health systems promote economic growth, ensure equitable access to healthcare, and respond to public health emergencies.

Keywords: health system, public healthcare, Romania, big data, artificial intelligence

Introduction

Healthcare systems are organizational structures designed to meet the health needs of people. They include a wide range of activities with the primary purpose of promoting, restoring or maintaining health. The performance of healthcare systems is evaluated based on their capacity to enhance health outcomes, meet population expectations, and ensure equitable financial contributions. The organization of key functions is linked to variations in performance. Understanding and improving healthcare systems, particularly in low- and middle-income countries, requires systems thinking that recognizes their complexity and the interdependence of their components (Papanicolas et al., 2013; Fiandaca et al., 2013). Healthcare systems are considered complex adaptive systems, where traditional linear approaches are inadequate, and a shift towards dynamic, holistic perspectives is necessary. To build knowledge of healthcare as a system, it is essential to understand the interdependent elements and their relationships within the complex whole of healthcare (Wickramasinghe et al., 2007; Martínez-García and Hernández-Lemus, 2013).

Healthcare systems are crucial to the health and well-being of societies. They provide essential services that maintain and improve health. These systems include a range of components, from medical practices to policy frameworks, and are influenced by various factors, including cultural beliefs, economic conditions, and technological advancements. Effective healthcare

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systems are essential for ensuring patient care and high reliability. Therefore, it is necessary to develop new methods for importance analysis and system-wide reliability engineering. Innovation and systems thinking are key to the evolution of healthcare systems (Atun, 2012).

Technological modernization is considered a crucial direction for healthcare systems to meet patient needs more efficiently and equitably. Also, the financing of health systems is critical to achieving national and international policy objectives, with the choice of mechanisms informed by desired health system types. Systems healthcare is a new field that focuses on health and wellness through the use of smart devices and services based on sensory data (Normand and Thomas, 2008; Conejar and Kim, 2015; Zaitseva et al., 2015).

Artificial Intelligence (AI) is increasingly used in various fields, including medicine, to enhance patient care and healthcare delivery. AI's ability to process large amounts of data and provide insights is revolutionizing medical diagnosis, treatment, and research.

AI in medicine is employed in making diagnosis, treatment, and patient care faster by scrutinizing radiological images, pathology slides, and EMRs, thus bringing in more efficiency in the work of physicians (McDougall, 2018). Examples of AI applications in healthcare include medical image analysis, genetics, smart prosthetics, and personalized patient care which are meant to enhance clinical decision-making, advance drug development, reduce cost and improve precision. In the integration of AI in medicine, ethical concerns have to be taken seriously, as AI is supposed to continue the idea of shared decision-making, especially since the possibility of autonomous AI is on the way. Therefore, AI systems that are value-flexible have to be developed (McDougall, 2018; Buch et al., 2018; Fogel and Kvedar, 2018).

Advances in computing and ultra-fast computing speeds offer a broad benefit to AI application in modern society: weather forecasting, face recognition, fraud detection, and genomics (Miller and Brown, 2017). The future role of AI in medical field is not yet answered. Machines (computers) are able to detect signals which could not be understood without employing biostatistics by using algorithms to manipulate massive datasets (big data) through multilayer mathematical models (Miller and Brown, 2017). The machine plus doctor combination can always be more accurate than any other possible situation. Cognitive tools are reshaping the medical profession through artificial intelligence and its use of natural language processing to read the fast-evolving scientific literature and to collate years of disparate electronic medical records. This and other ways, AI could possibly choose the care path of chronic diseases, recommend precision therapies for complicated illnesses, decrease the occurrence of medical mistakes and facilitate the suspension of subjects in clinical trials (Miller and Brown, 2017).

This study aims to analyze the healthcare system in Romania highlighting the most significant areas in the Romanian healthcare system having, at the same time, a perspective on the use of AI in healthcare systems.

Literature review

Artificial intelligence (AI) is evolving rapidly and can transform healthcare by improving patient management and administrative operation. The development of AI technologies is to reproduce human cognitive abilities and is more and more applied to healthcare.

AI can boost diagnostic accuracy, design treatment plans, and predict patient outcomes apart from the new challenges like software failures, biased data, and opaque algorithms. Ethical and regulatory matters in the use of AI in healthcare include bias, transparency, privacy, security and liability which calls for a governance model to address these issues (Yu et al., 2019). AI has

a capacity to relieve human resources crisis in healthcare by providing services of diagnostics, decision making, and administration but it raises ethical problems and requires fitting in medical education (Jiang et al., 2017; Wahl et al., 2018).

AI in healthcare presents both challenges and opportunities. The opportunities include improved patient outcomes, better engagement, enhanced healthcare delivery, cost reduction, and support for research and education. AI has the potential to revolutionize healthcare by offering personalized and accurate solutions, enhancing diagnosis and treatment, and increasing efficiency (Rastogi, 2023). However, there are challenges that need to be addressed. These include clinical safety, bias and discrimination, transparency and interpretability, data privacy, integration with existing health systems, and impacts on the healthcare workforce (Eshwar, 2023). Ethical considerations, regulatory hurdles, and the need for careful implementation are also challenges to be addressed (Ajami and Karimi, 2023; Chan and Petrikat, 2023).

Europe is in the process of coping with AI, crafting strategies to use its potentials to the fullest, while tackling ethical, legal and societal challenges (Wahl et al., 2018; Cohen et al., 2020; Meszaros et al., 2022). Europe can boast of its excellent research base, advanced legal and regulatory frameworks and rich cultural diversity which makes it one of the leaders in AI healthcare (Wahl et al., 2018; Puaschunder, 2020). The European Union is addressing human-centered, ethical development of AI with coordinated national and European strategies which aim to make AI coherent with EU's core values (Wahl et al., 2018; Meszaros et al., 2022). Legal and ethical issues including data protection and patients' rights have been addressed by existing laws such as GDPR and the AI Act (Cohen et al., 2020). Investment in the computing infrastructure, data accessibility, and interdisciplinary knowledge exchange is a matter of importance for AI's healthcare success (Annoni et al., 2018; Puaschunder, 2020; Sarah et al., 2020; Wen and Huang, 2023; Horgan et al., 2019). Integration of AI in healthcare systems in Europe is a complex but advantageous process because it makes it possible to detect diseases even in early stages, to save effectively on resources and to decrease the costs for the patients and the society. As much as AI can be successfully implemented in the healthcare area, there is the need to have an appropriate risk management system and ethical considerations of the system in place as well as strategies that would make the innovation to be sustainable (Wen and Huang, 2023; Horgan et al., 2019).

In Romania, the AI healthcare applications are being evaluated with a view to providing quality care that can be accessed easily and the optimization of health services (Vladescu et al., 2016).

AI has the ability to make a huge impact on diagnosis, prognosis, and treatment procedures for the healthcare system in Romania, which will then result in better and higher quality patient care. But there are also ethical and logistical challenges to the application of AI technologies that must be overcome in order to guarantee that artificial intelligence will be used responsibly and successfully in healthcare system (Fitzek and Choi, 2023). Availability of hospitals in Romania is a decisive factor that is being now solved by AI and open data sources such as Google Maps that are being used to model and to possibly optimize the distribution of medical services. In terms of the access to quality health services, there are regional differences, which is evident as the infrastructure and specialist medical personnel are highly concentrated in large cities, but AI can be used to address this problem by optimizing the locations of these health services (Parker and Campbell, 1998).

In Romania there is a necessity of patients' satisfaction and improved medical services, which AI might tackle with by upgrading service quality perceptions. The quality of health care in Romania can be made more geographically accessible with AI as it can help in optimizing the

location of health services and addressing the regional disparities (Boncea, 2015; Vladescu et al., 2016). AI facilitates economic growth and raises the standards of living by making the practice of healthcare more efficient and curbing chronic disease financial burden.

Methodology

The purpose of this study is to analyse the spatial distribution of indicators that are relevant for the analysis of the healthcare system in Romania and at the same time have a perspective on the use of artificial intelligence in the Romanian healthcare system. The data used are at the level of county, respectively development region, and spatial analysis tools were applied to see what is the situation of the healthcare system in Romania and if the indicators have an optimal distribution in relation to the population of the country. Investments in the Romanian healthcare system are also analysed at development region level.

Study area

The study area in the paper is Romania, and the analyses are carried out in two directions: one, the main one, represents the data and their analysis at the county level (42 counties) (Figure 1), and the second one represents the analyses carried out at the development region level (8 development regions).

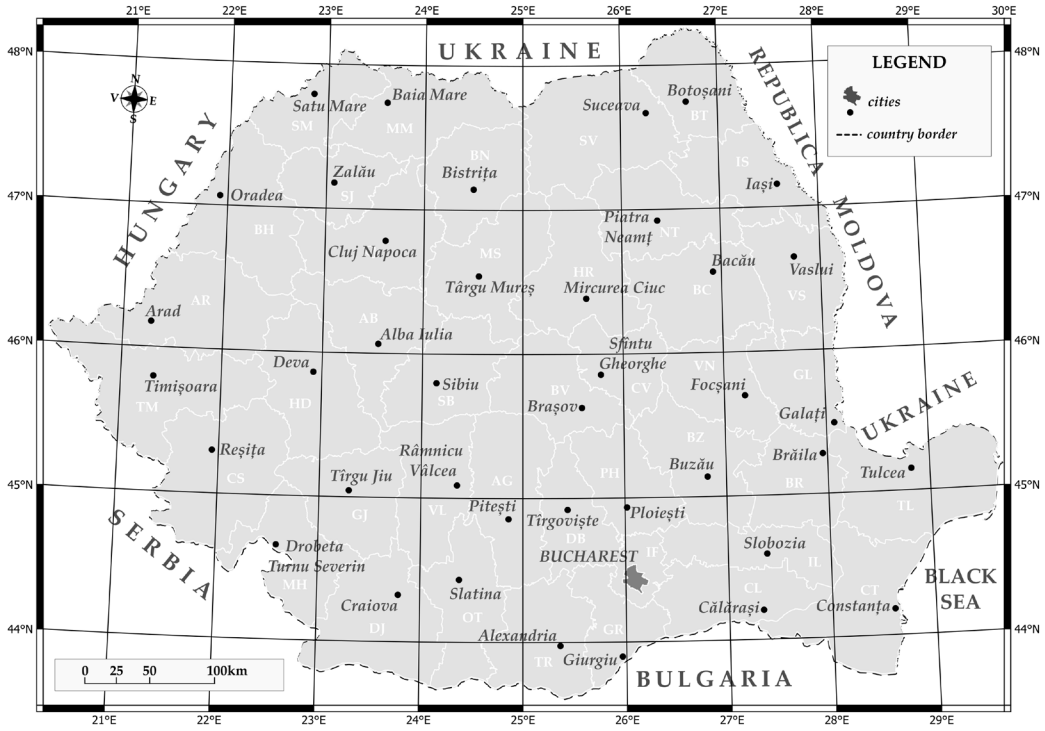


Figure 1. Study area localization map - Romania, indicating counties

Data source: https://geo-spatial.org/

Spatial analysis

The first part of the analysis is the spatialization of the distribution of data representing medical units and medical staff (only at the level of the public health system) at the level of the 42 counties.

The data for the health units show the sum of the data for the following categories: other types of medical practices, specialist outpatient clinics, hospital-integrated outpatient clinics,

family medical practices, general medical practices, specialist medical practices, school medical practices, student medical practices, dental practices, diagnostic and treatment centres, diagnostic and treatment centres with hospital beds, dialysis centres, health centres, mental health centres, multifunctional health centres, transfusion centres, specialist medical centres, specialist medical centres with hospital beds, nurseries, pharmaceutical warehouses, medical dispensaries, pharmacies, dental laboratories, medical laboratories, polyclinics, dispensaries, pharmaceutical outlets, spa sanatoriums, tbc sanatoriums, specialist medical civil society, civil medical society, civil medical dental society, hospitals, medical-social establishments and health establishments (including establishments assimilated to hospitals) with day hospitalisation only. The data for medical staff show the sum of data for the following categories: pharmacists, doctors, mid-level health workers, dentists and family doctors.

The Choropleth Bivariate representation method was used for the spatial analysis. Specific ranges were created for each type of data analyzed (number of medical units and medical staff). Then a set of 23 specific maps was created for each type of data. The equations for the determination of the analysis intervals, the coloring of the maps and the aggregation of the data for the 2 variables were carried out. The first variable is represented by medical staff, which is vertically aligned in the legend (Figure 2) with values from low to high, and the second variable is represented by health units, which is horizontally aligned in the legend with values from low to high. The aggregation of the two variables can be seen in the data showing the correlation between health units and medical staff.

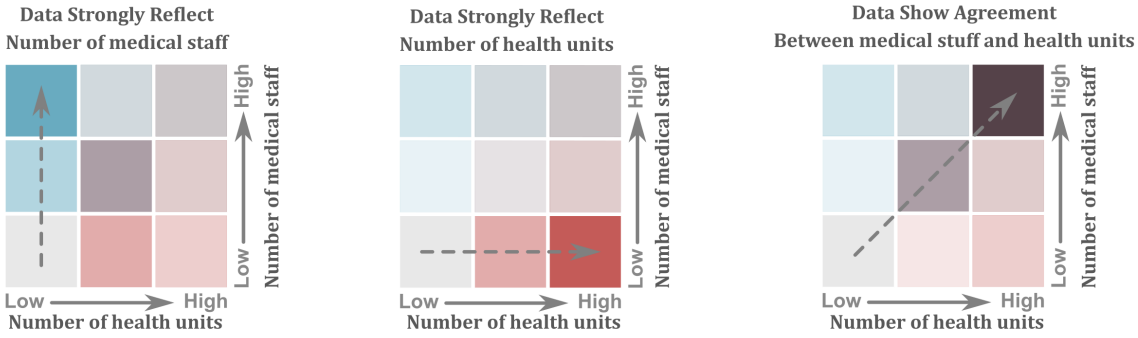


Figure 2. Bivariate Choropleth Maps Legend

In the second part of the analysis, Choropleth maps were created of the data distributed across the 42 counties representing the number of hospital beds per 10,000 population, and ranges specific to the type of data analyzed were created.

In the third part, a classical spatial analysis was performed on the data distributed among the 42 counties analyzed. Using the county-level database, which includes the number of medical staff, hospital beds and health units for the years 2000 and 2022, the spatial analysis was performed by creating areas specific to the type of data being analyzed, and the size of the symbol (circle) used to represent the data is directly proportional to the values in the areas created.

For all spatial analyses, the analysis period was 2000 to 2022, a database was created with the number of medical units, the number of medical staff, the number of population, and the number of hospital beds. The software QGis for spatial analysis and Inkscape for vector graphics were used for spatial analysis.

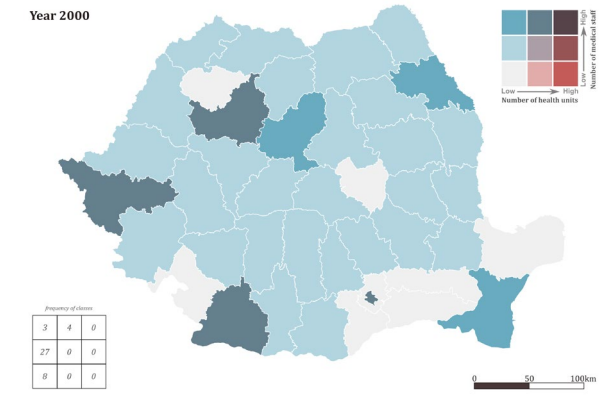
In the fourth part, a classical analysis of the data showing the investments in the Romanian healthcare system distributed among the 8 development regions of Romania (1. North-East

Development Region, 2. South-East Development Region, 3. South-West Oltenia Development Region, 5. West Development Region, 6. North-West Development Region, 7. Center Development Region and 8. North-West Development Region. Bucharest-Ilfov Development Region). Graphical representation methods were used. For the analysis period from 2014 to 2021, a database of investments at the level of development regions was created.

Results and discussions

Analysis of the healthcare system in Romania

The analysis of the correlation between the number of health units and the number of medical staff in Romania (Figure 3) reveals three tendencies during the period analyzed. A first scenario in which a low number of both indicators analyzed is observed at the beginning of the period analyzed (between 2000-2002), followed by a period in which both the number of health units and the number of medical staff increase (observed in the period 2003-2014), followed by a constant decrease of both indicators from 2015. The most important area is Bucharest, followed by Cluj, Mureș, Timiș and Iași.



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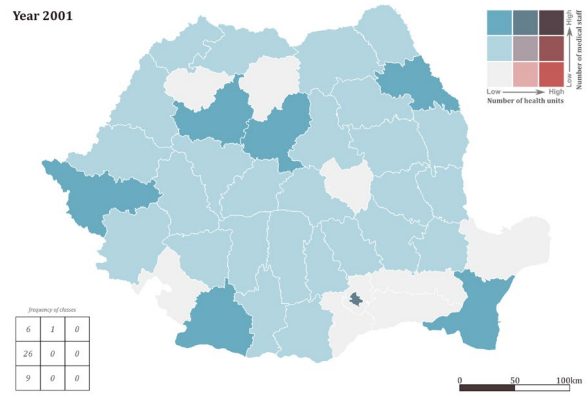

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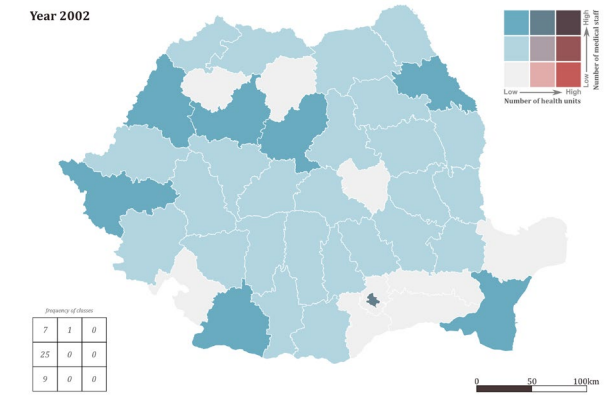

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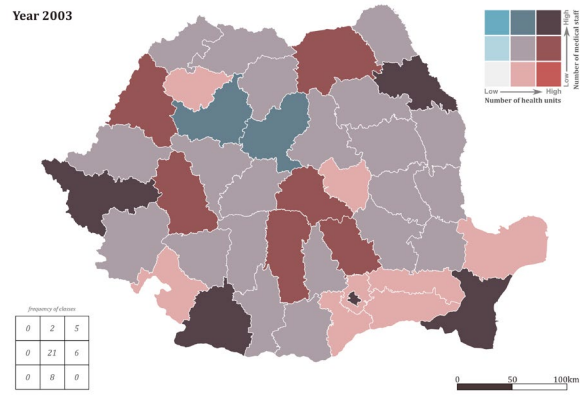

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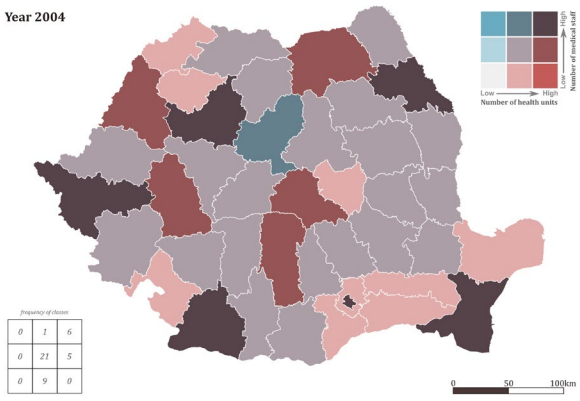

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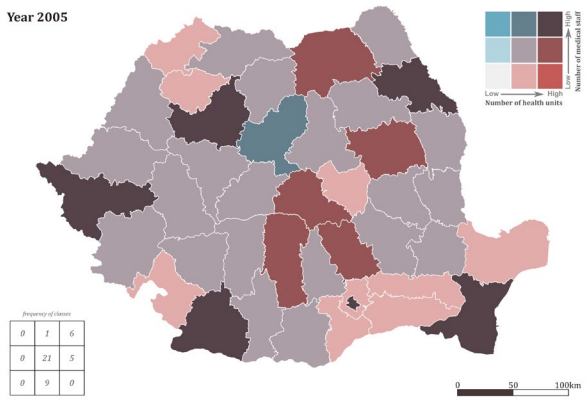

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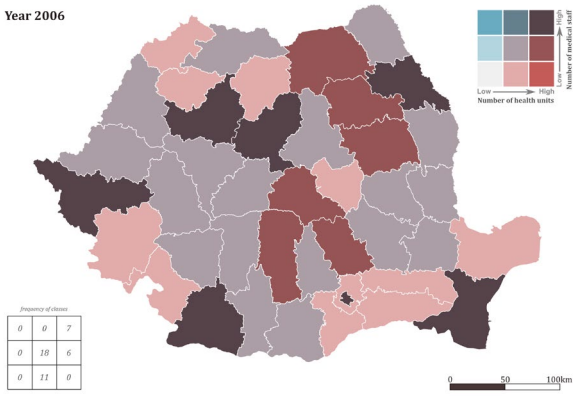

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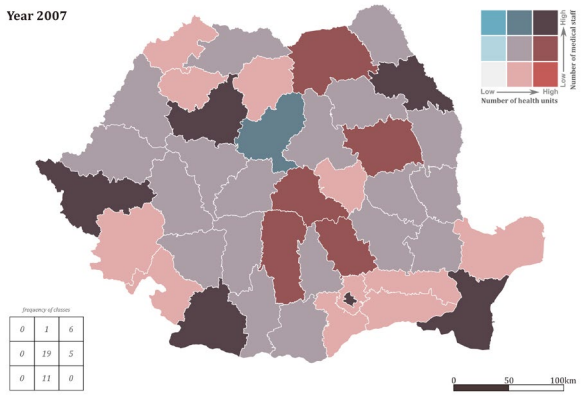

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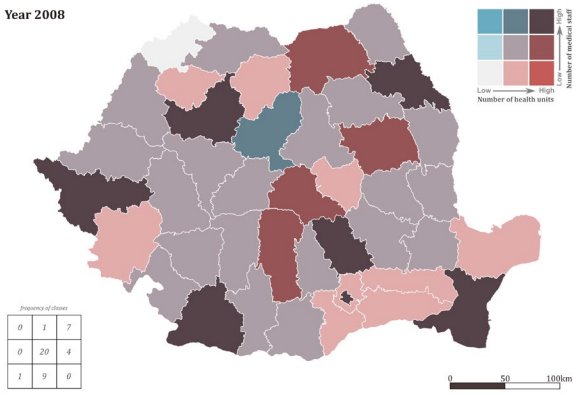

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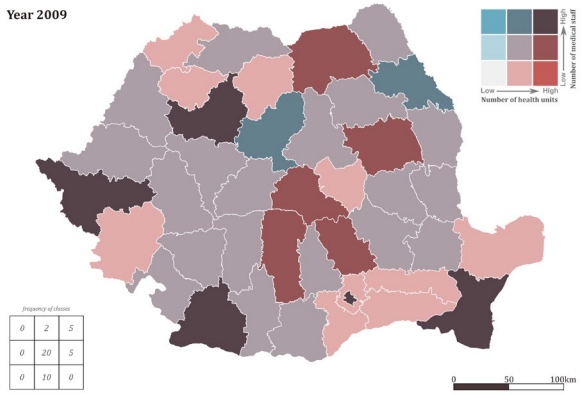

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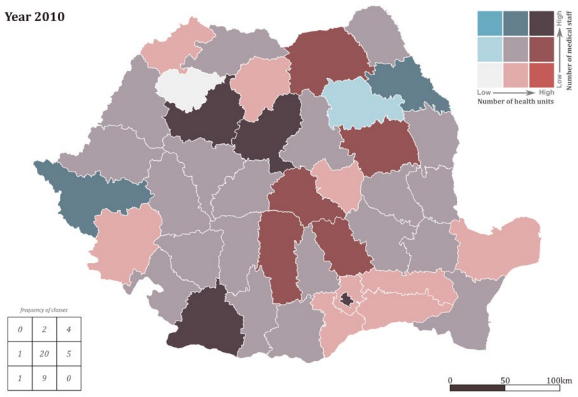

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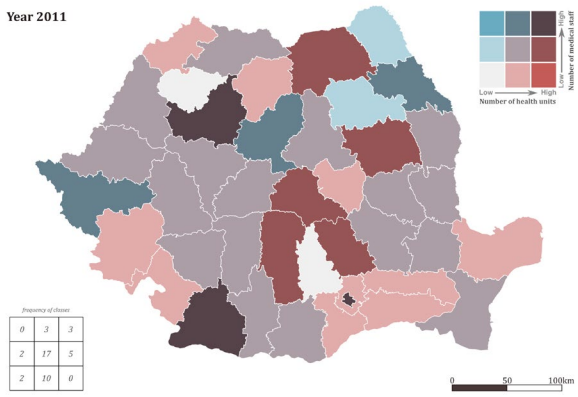

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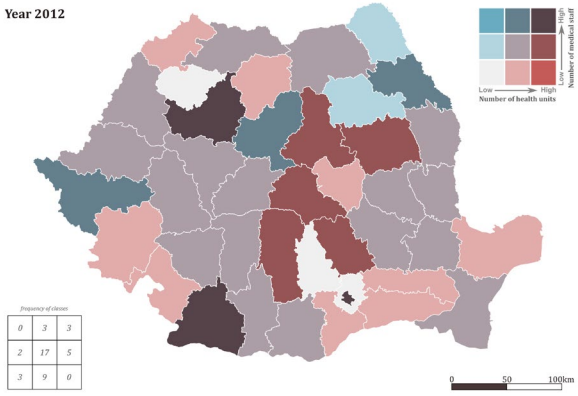

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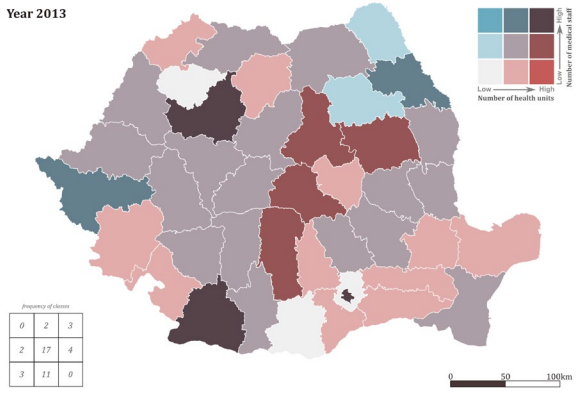

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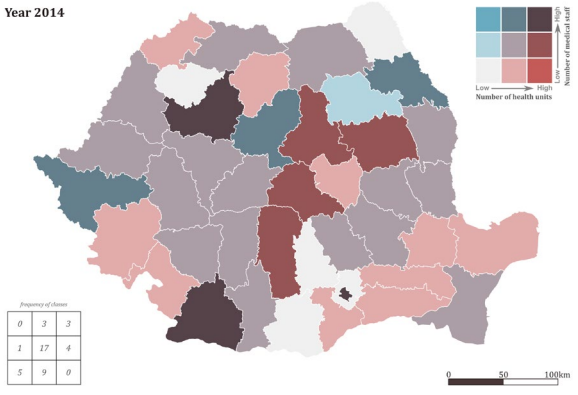

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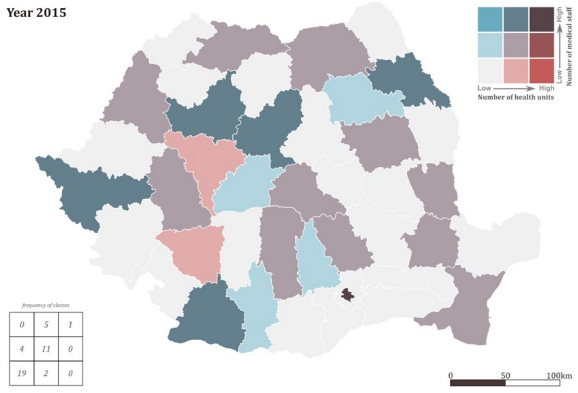

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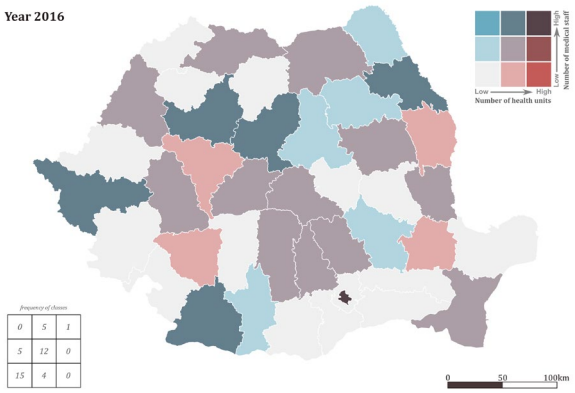

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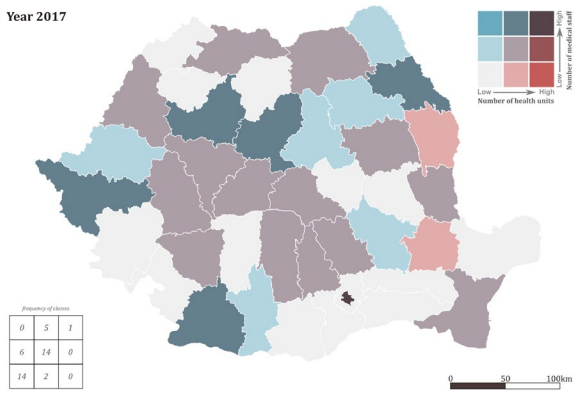

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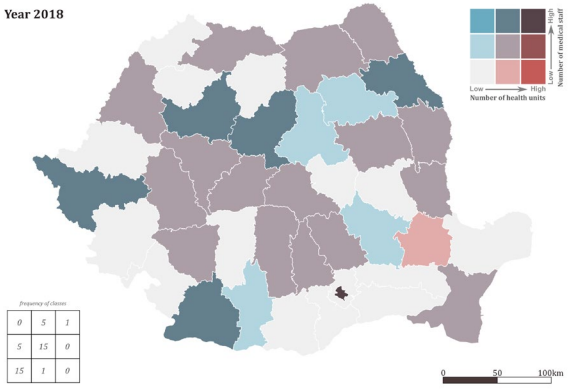

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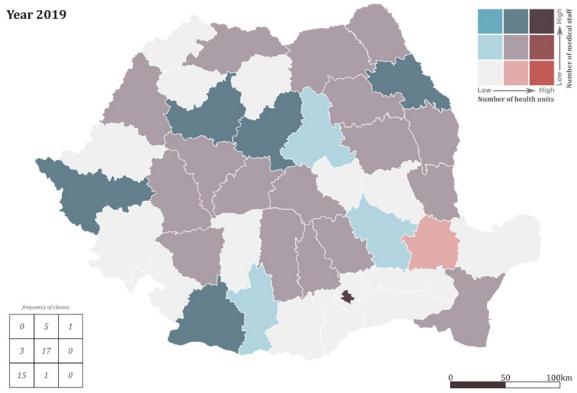

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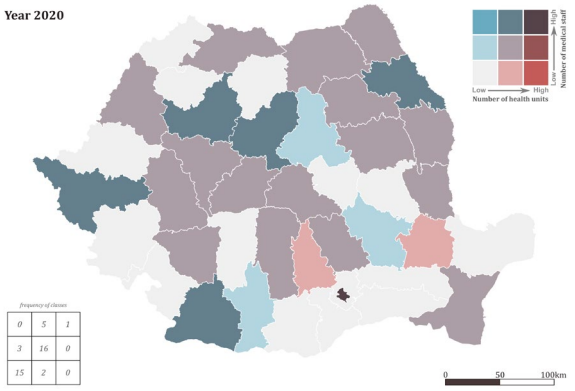

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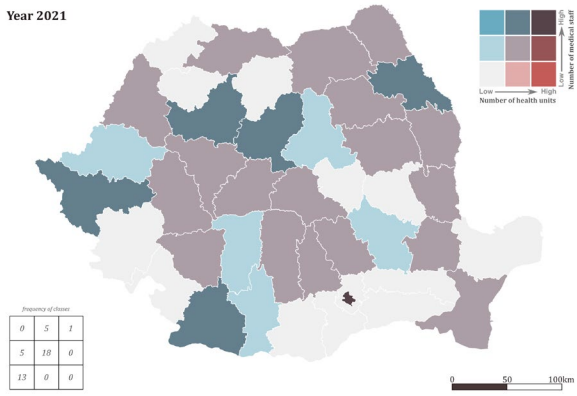

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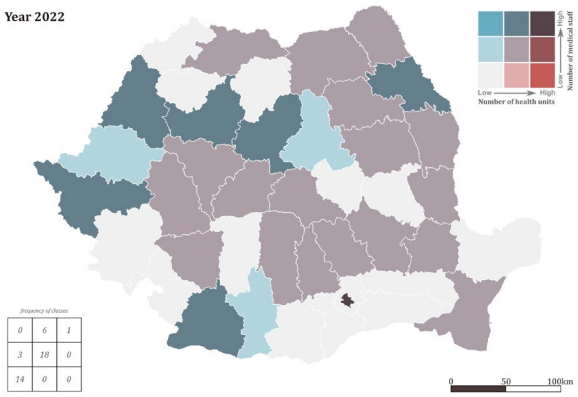
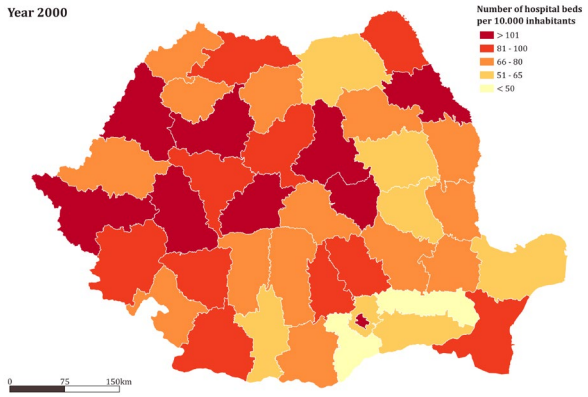


Year 2022

Figure 3. The evolution of the number of health units in relation with the number of medical staff for the period 2000-2022

Data source: Tempo online database of the National Institute of Statistics.

The analysis of the spatial distribution of the number of beds per 10,000 inhabitants (Figure 4) shows a downward trend in the values, which indicates that the number of hospital beds is continuously decreasing during the period under study, while the number of inhabitants is decreasing, stagnating in some counties or increasing in others.



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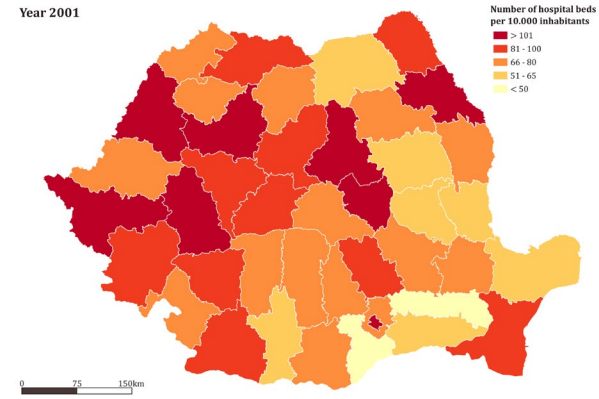

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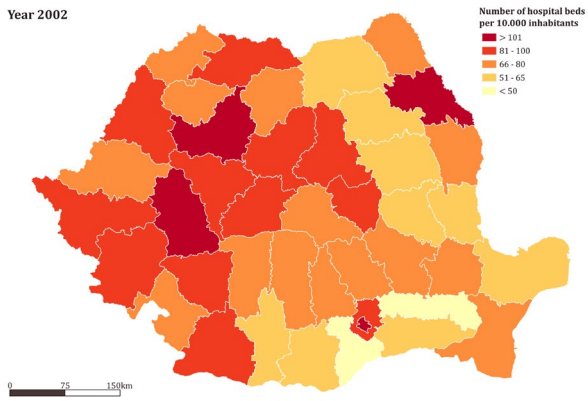

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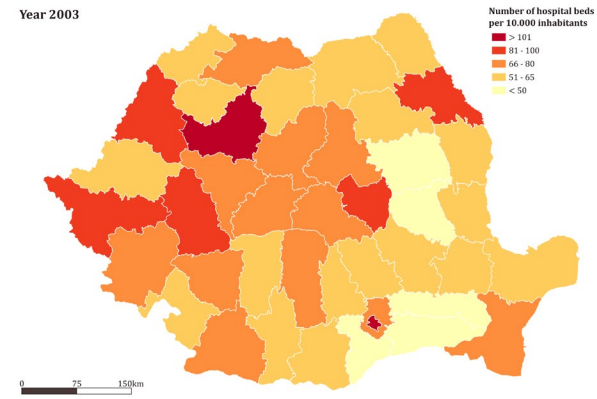

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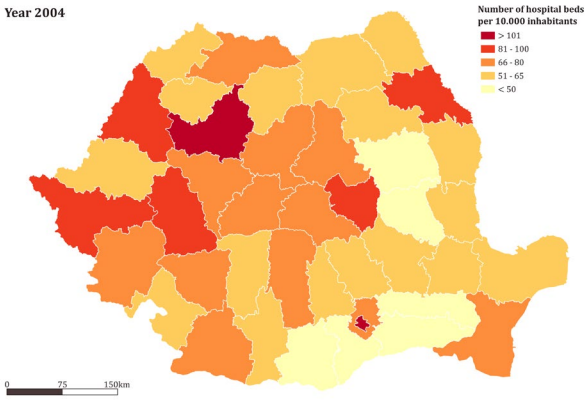

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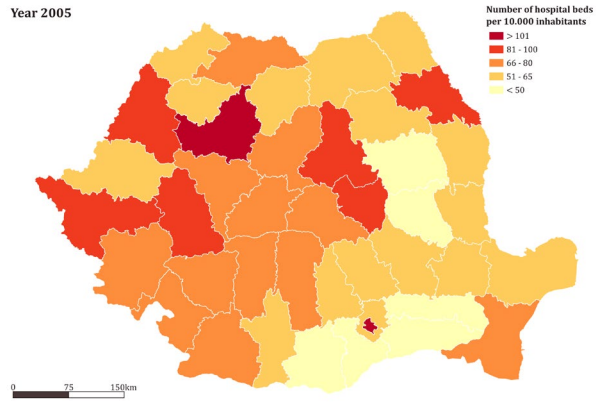

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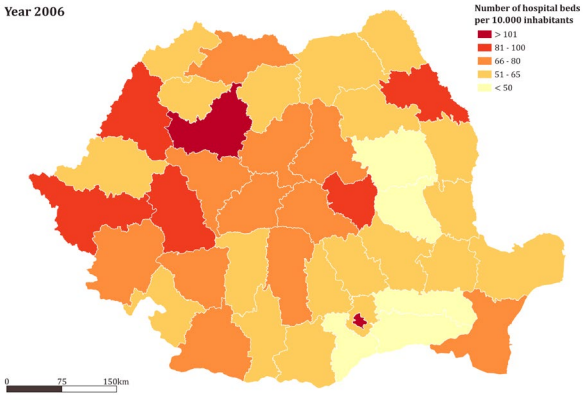

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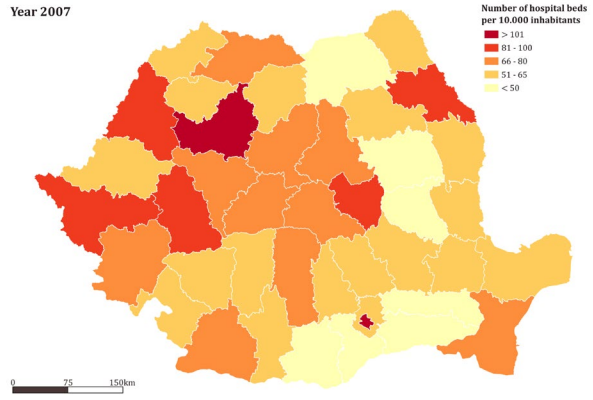

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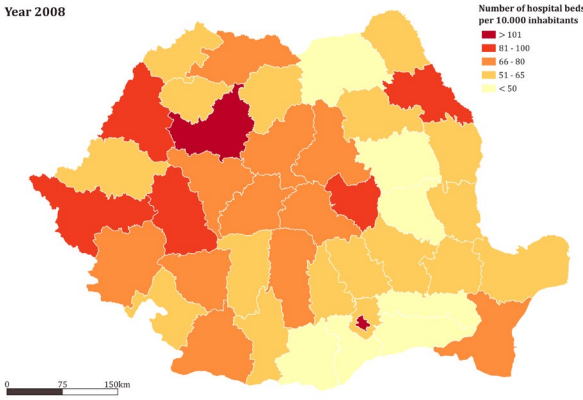

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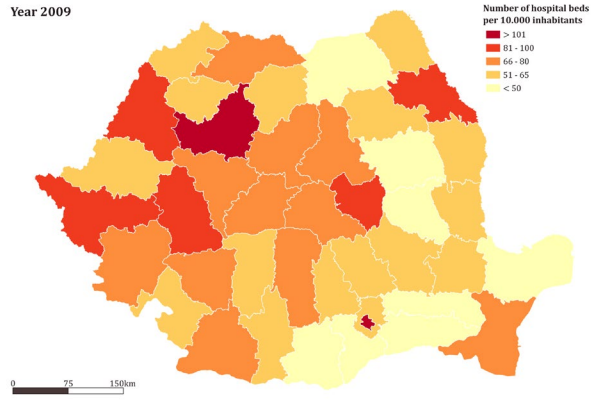

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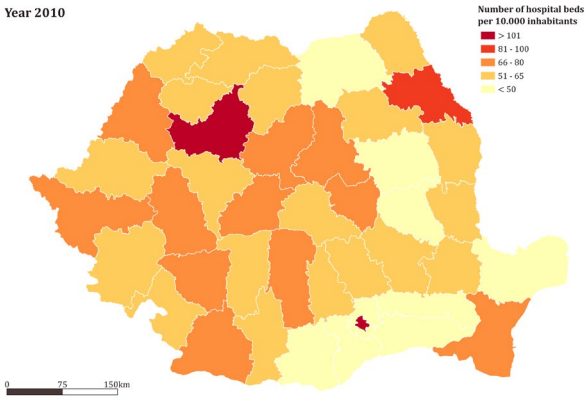

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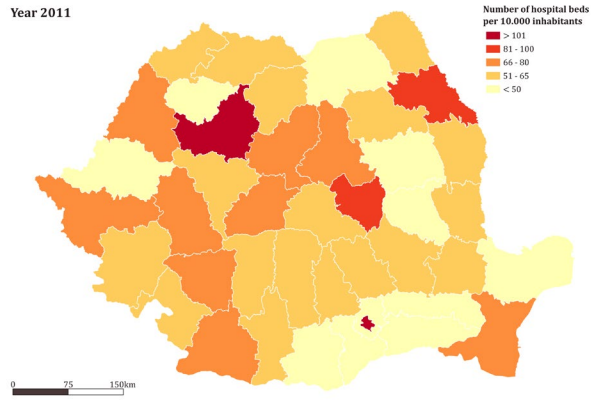

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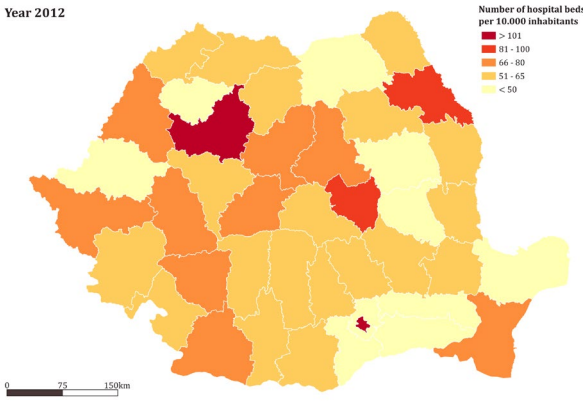

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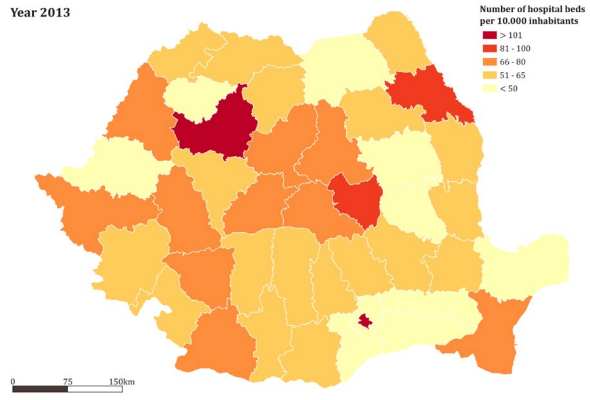

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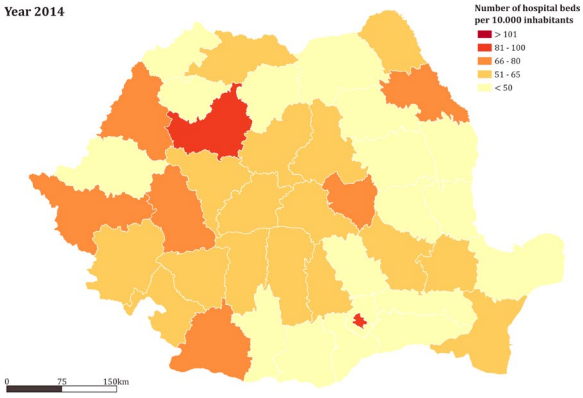

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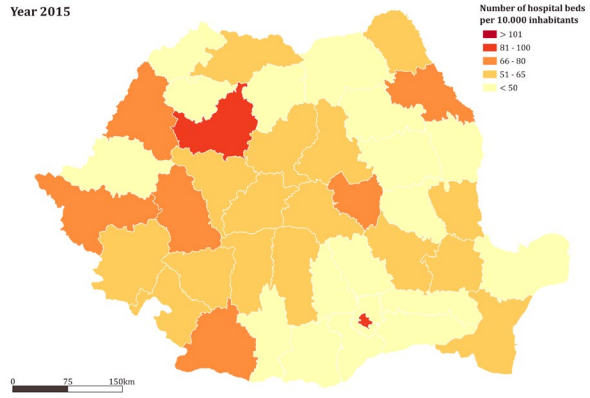

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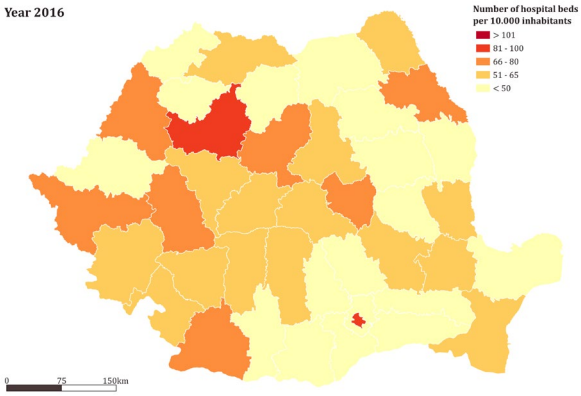

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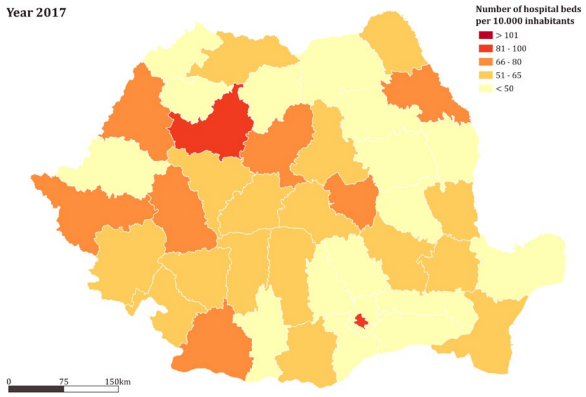

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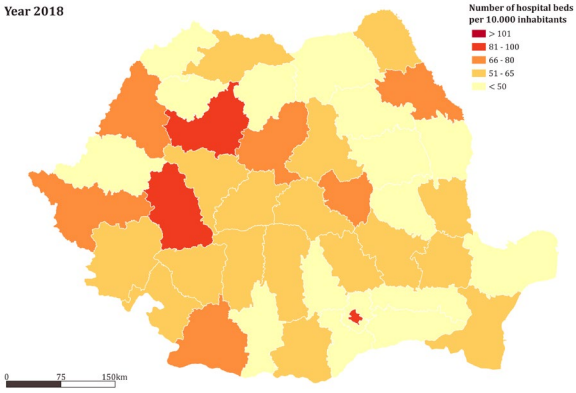

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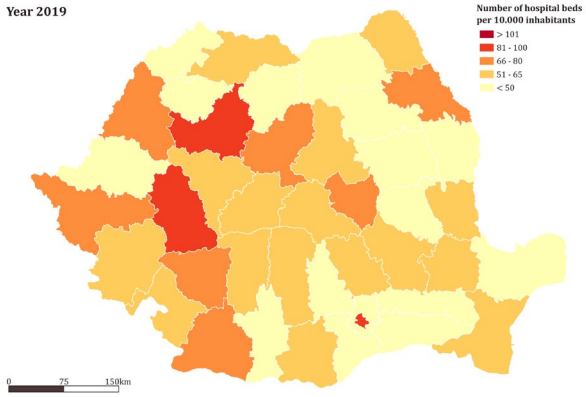

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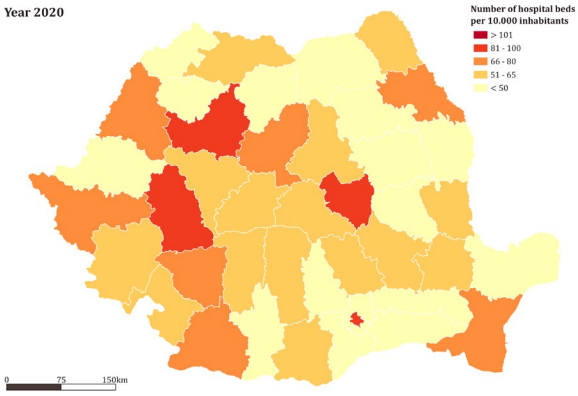

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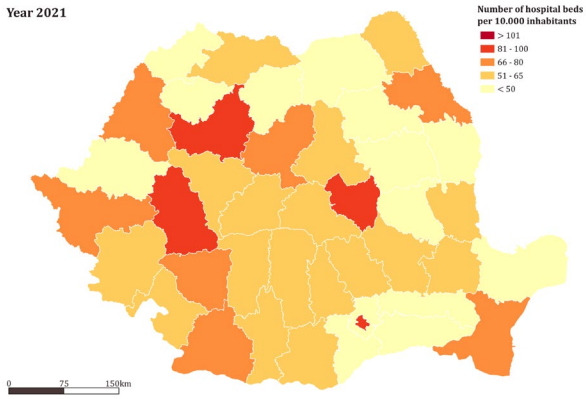

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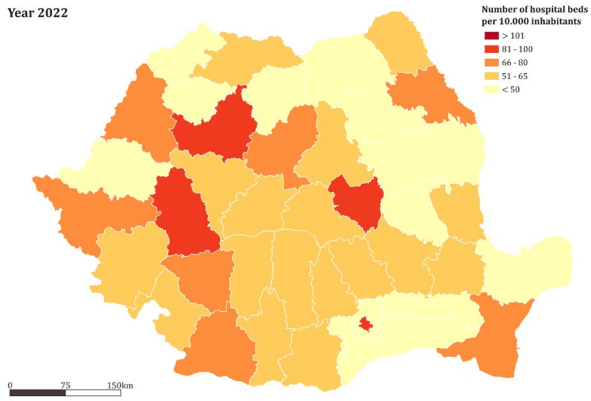
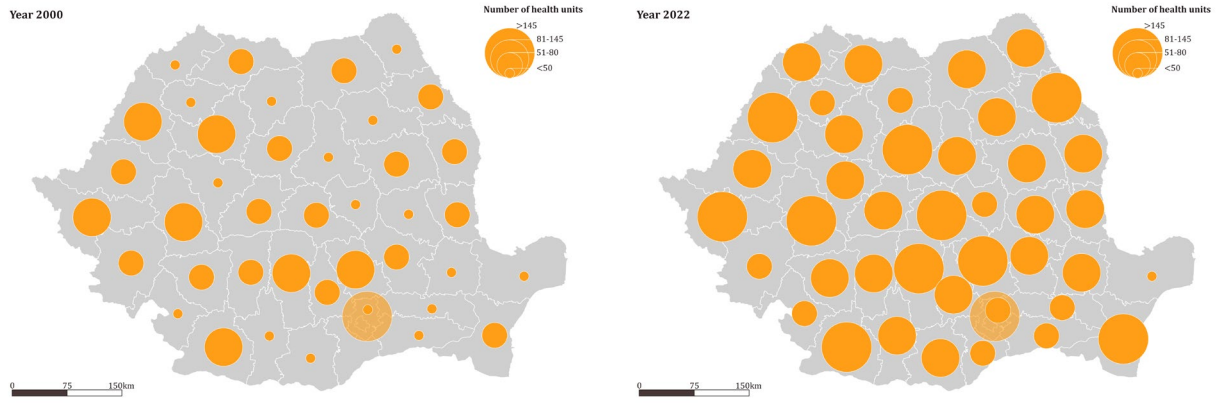


Year 2022

Figure 4. The evolution of the number of medical beds per 10,000 inhabitants for the period 2000-2022

Data source: Tempo online database of the National Institute of Statistics.

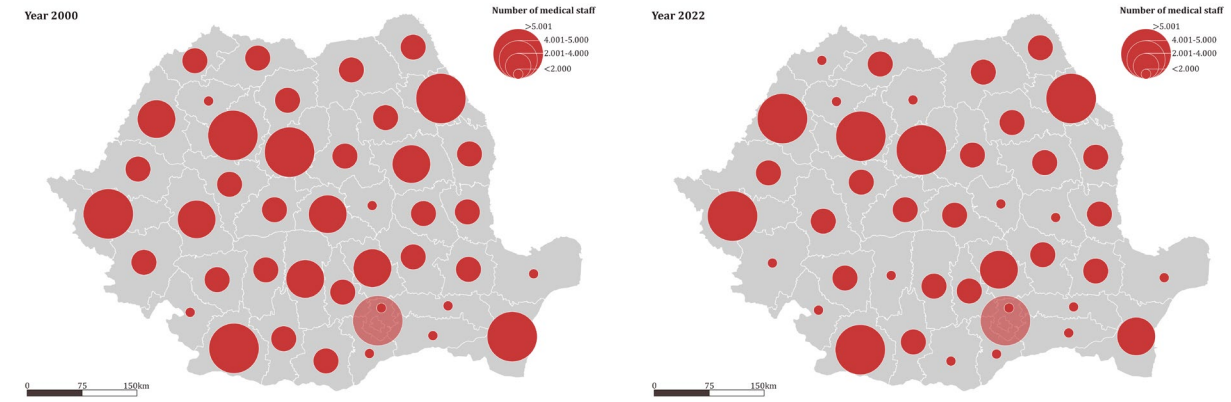
Regarding the spatial evolution of medical units, their number is increasing, as can be seen by comparing the spatial distribution from the year 2000 to the year 2022 (Figures 5, 6, 7), which shows that investments in the health system are substantial. There is a strong correlation between health and development, suggesting that investments in health can create a positive spiral of development and health. The spatial distribution of the number of medical staff and the number of hospital beds shows a decreasing trend of the values, comparing the year 2000 with the year 2022, it can be observed, in some counties, significant decreases of the indicators, attributed to insufficient investments and migration of medical staff. The main poles of development of the health system are the cities of Bucharest, Timișoara, Cluj-Napoca, Târgu-Mureș and Iași, which are also the main centers of economic development and health universities.



Year 2000 *Year 2022*

Figure 5. The evolution of the number of health units for the years 2000 and 2022

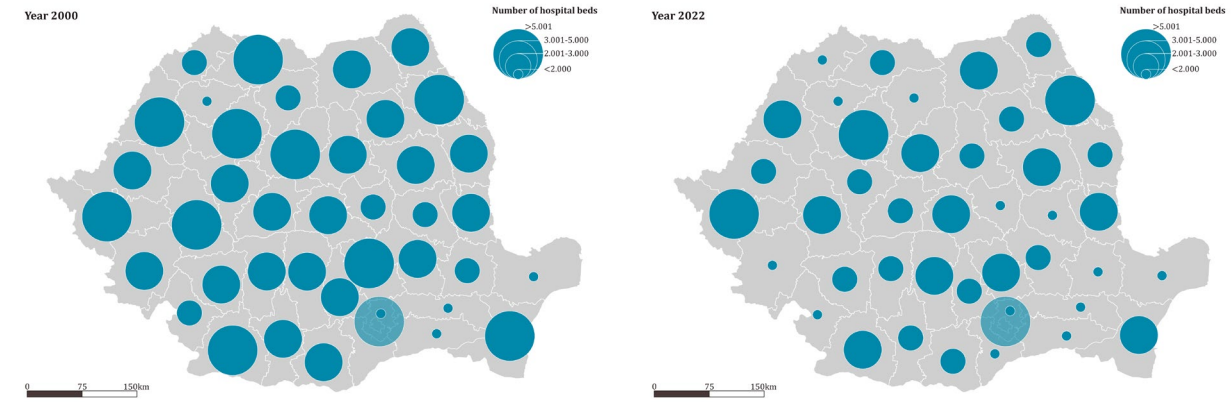
Data source: Tempo online database of the National Institute of Statistics



Year 2000 *Year 2022*

Figure 6. The evolution of the number of medical staff for the years 2000 and 2022

Data source: Tempo online database of the National Institute of Statistics



Year 2000 *Year 2022*

Figure 7. The evolution of the number of hospital beds for the years 2000 and 2022

Data source: Tempo online database of the National Institute of Statistics.

Investment in health systems is a multifaceted issue that affects labor productivity, economic growth, and the overall well-being of populations. Investment in the Romanian health system is characterized by a low share of GDP compared to other EU countries, with a need for increased funding. The public health system still requires significant reforms to improve efficiency and quality (Figure 8). In general, the health system in Romania is in a state of transition, with various efforts underway to address its challenges and improve health outcomes.

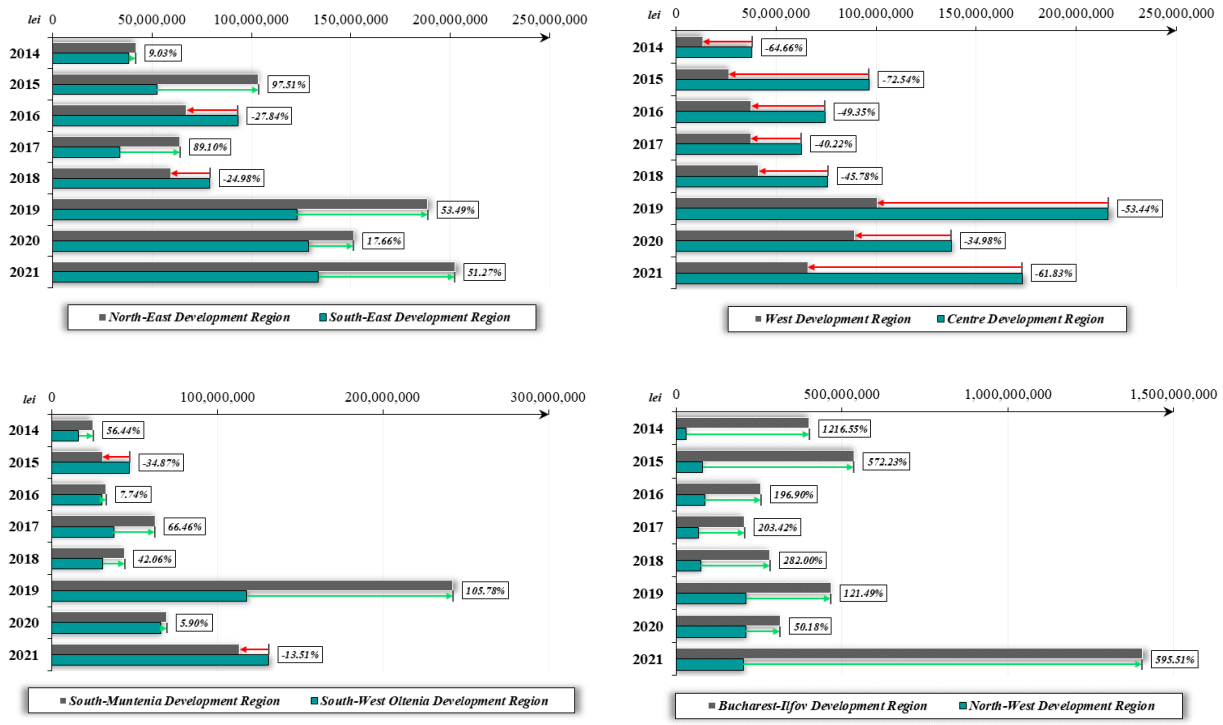


Figure 8. The evolution of the investments in the health system for the period 2014-2021 at the level of the regions of development

Data source: Tempo online database of the National Institute of Statistics.

Perspectives for the use of Artificial Intelligence in Romanian healthcare

Healthcare is increasingly integrating artificial intelligence (AI) to improve the quality and effectiveness of patient care. On the other hand, this integration is accompanied by certain issues that need to be addressed to ensure the safe and appropriate application of AI in this critical area (Wang and Preininger, 2019).

The use of AI in healthcare is promising, as it can be applied in various areas such as diagnostics, patient treatment, and patient care management. AI can be a great resource in healthcare delivery, especially in a resource-constrained environment; however, it also raises a number of ethical, regulatory, and safety concerns that need to be carefully addressed. The use of AI in healthcare is expected to improve the quality of care and even help change the way healthcare is delivered in the future (Lee and Yoon, 2021).

AI in healthcare is a set of benefits in the Romanian healthcare system that is expected to be revolutionary. It is expected to increase the quality and accessibility of healthcare services, improve patient outcomes, and increase the efficiency of healthcare delivery. By addressing issues related to patient satisfaction, regional disparities in medical care, and the need for personalized medicine, AI can be an important tool in the process of healthcare evolution in Romania. On the other hand, the effective use of AI in healthcare will require continuous monitoring and management of threats and challenges, such as those related to patient safety and data governance.

The implementation of AI in the Romanian healthcare system is complex and multidimensional. Although AI has the ability to drastically improve health outcomes, a significant number of challenges need to be addressed. These range from ethical and practical issues, to the

requirements of robust clinical trials and regulation, to societal, socio-economic and structural issues within the healthcare system. Overcoming these challenges is fundamental to ensure the effective and responsible integration of AI into the Romanian healthcare system.

The actions to be taken for the implementation of AI in the Romanian healthcare system are related to the regulation of the legal framework, legislation; adoption of the strategy in the field of AI with reference to the medical field; adoption of legislation with reference to ethical risks and those related to consent, establishment of disciplinary and criminal liability for violations; interconnection of data collection platforms in the healthcare system. It should also establish collaboration between management, doctors, engineers and IT specialists; relaunch the electronic patient record initiative; develop data synthesis and integrated algorithms. Areas where AI can be applied include genetics, operating rooms (where intelligent glasses are used), operating room software, MRI imaging, X-rays, screening, artificial intelligence algorithms, monitoring of cancer patients, patients with post-operative complications, voice output of medical records (reducing time and paperwork), production of vaccines and drugs, extraction of information from large databases, medical digitization in the cloud.

The results obtained can be complemented in future researches by integrating algorithms developed in researches that followed the spatial distribution patterns of pathologies (Peptenatu et al., 2023; 2024) or the arrangement of a phenomenon in a space analyzed with fractal algorithms (Braghină et al., 2011; Peptenatu et al., 2012). These types of analyses require the aggregation of large amounts of data, which requires complex approaches to their processing (Baloi et al., 2023; Pelău et al., 2022; 2023).

Conclusion

Artificial Intelligence (AI) is exponentially changing the healthcare environment by mimicking human cognitive processes and applying sophisticated analytics to healthcare data. This transition is characterized by the consolidation of AI in diverse areas such as diagnostics, treatment planning, and outcome prediction, which can greatly facilitate patient care and address global health issues.

The possibilities of AI in European medicine are successful with various applications that will improve medical services. The European strategy for AI in healthcare is mainly based on ethical standards, strong legal foundations and strategic funding for research and infrastructure development. Nevertheless, coordinated efforts at national and European level aim to ensure that the development of AI is in line with European values. That it will contribute positively to healthcare outcomes. Digitization, which was already taking place before the COVID-19 pandemic, has only become more apparent and development has led to the opportunity for AI to address healthcare challenges and provide better care for patients across Europe.

The Romanian health system is considered a key element of the national development process, whose efficiency is measured by indicators such as the quality of medical services and the health status of the population.

The Romanian health care system is underfunded, centralized, and understaffed, leading to inefficiencies and inequities in the delivery of health services. While there has been progress in life expectancy and infant survival, the system continues to face problems of resource allocation and retention of health workers. The hierarchical organizational culture in hospitals and the significant role of public institutions in the health system are also noteworthy. Efforts to improve the system are still underway, with a focus on increasing funding, decentralizing operations, and improving the quality of care.

The DIGITAL Europe program will create a European data space, facilitating access to and secure storage of large data sets and cloud infrastructure. Also, the directions of the development of artificial intelligence in the Romanian healthcare system tend to increase efficiency and productivity, automating and streamlining clinical processes, so that the doctor can take better care of the patient, much faster diagnosis, virtual duplicate medical records and digital pill implementation. (sensor inserted in the patient's body for prevention).

It will be a long, complex and multidimensional process to implement artificial intelligence in the Romanian healthcare system. While AI has the potential to dramatically improve healthcare outcomes, there are a significant number of challenges that need to be addressed in the Romanian healthcare system. These challenges range from ethical and practical issues, to the requirements of robust clinical trials and regulation, to societal, socioeconomic and structural issues within the healthcare system. In order to ensure an effective and responsible integration of AI into the Romanian healthcare system, it will be essential to address these challenges.

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