The Role of AI-Driven Technologies in Transforming Healthcare: Trends and Perspectives in Europe and Worldwide

Ana-MariaNedelcu Severin[1], Anamaria-Catalina Radu[1]*, Ivona Rapan[1], Luiza-Andreea Ulmet Poenaru[2]

[1]Institute of National Economy, Romanian Academy, Calea 13 Septembrie, no. 13, sector 5, postal code 050711, [2]Romanian Academy, School of Advanced Studies of the Romanian Academy, Doctoral School of Economic Studies, National Institute for Economic Research ''Costin C. Kirițescu'', Institute of National Economy
Email: ana_maria_ned@yahoo.com, stradivonas@gmail.com, luiza.ulmet@yahoo.com
*Corresponding Author Email: anamaria_radu15@yahoo.com

Abstract

Industry 4.0 has significantly transformed multiple sectors through the integration of disruptive technologies supported by data analytics, artificial intelligence (AI), and the Internet of Things (IoT). These tools enable the creation of interconnected digital enterprises capable of autonomous decision-making. In healthcare, AI plays a pivotal role, from advanced diagnostic systems and personalized treatment recommendations to virtual assistants that remotely monitor patients and generate early alerts for medical intervention. It supports physicians by providing accurate, data-driven insights, streamlining administrative tasks, and enhancing the efficiency of medical procedures, while also fostering innovation and creating new professional opportunities. AI applications in medicine include robotics, where intelligent systems perform tasks with human-like decision-making capabilities, assisting rather than replacing medical experts. Across Europe and globally, its use has expanded in fields such as orthopedics, radiology, cardiology, haematology, neurology, and urology. This study, Implications of AI-related Technologies in the Healthcare System Across Europe and Globally, employs statistical analysis of secondary sources to explore recent trends and future perspectives. Findings highlight the increasing adoption of AI in both public and private healthcare institutions, underscoring its transformative impact and potential to further advance medical research, diagnostics, and treatment delivery in the coming years. The motivation for the paper "The role of AI-driven technologies in transforming healthcare: trends and perspectives in Europe and Worldwide" is to create a framework to better understand the impact brought by artificial intelligence and disruptive technologies in the medical field. The medical practice evolved with the introduction of digital technologies, mostly in surgery and in diagnostics. Nowadays it is easier for medical specialists to establish a diagnostic based on previous data from other patients that is analyzed with the help of AI instruments. Also, with the aid of artificial intelligence, doctors can establish the proper

treatment that can be used in that case. Another significant change that took place within the medical field is the use of robotics in surgery which makes operations minimally invasive, thus much safer for the patients and with a quicker recovery rate post-surgery. Authors' contribution to the paper consists in bringing a touch of novelty and value to the research illustrating the evolution of artificial intelligence that took place in the healthcare system in the past years, as well as its expected evolution in the near future.

Keywords: Healthcare, Emerging Medical Technologies, Robots, Artificial Intelligence, Industry 4.0

Introduction

Artificial intelligence and connected technologies became increasingly common within the business environment and at the societal level. They play a crucial role in improving certain aspects of the medical field as: the monitorization and patient care, time reduction within the administrative processes and activity management in pharmacological organizations.

The medical practice suffered alterations as a result of the evolution of AI, mainly of machine learning (ML). It represents the main component technology of AI and of the computers' processing power. Nowadays these technological advancements led to an increased efficiency and accuracy in certain specializations of the medical field in what regards making diagnostics and establishing a scheme treatment for the various conditions of which the patients are suffering of. In surgery the robot-assisted medicine emerged and led to the increase of working capacity of the medical specialists in practicing several difficult interventions which imply a considerable level of precision and which would otherwise have an increased risk of developing postoperative complications. Artificial intelligence did not impact only the surgical specialization but others as cardiology, radiology and haematology.AI-based instruments play the role of supporting medical specialists in the decision-making process regarding patients' diagnosis and treatment by analyzing certain existent data.

This disruptive technology seeks for similarities between the provided data and the data of the patient waiting for a diagnostic. In this way the risk of making a wrong diagnostic is removed, thus AI has a considerable precision.

From Medical Imaging to Robotic Surgery: The Expanding Role of Artificial Intelligence in Modern Healthcare

In the past years artificial intelligence became an increasingly utilized word due to the consequences of the technological progress and its notable results in analysis and processing. Within the medical specialties which require imaging as radiology and oncology, the research and development focused on the AI potential transfer in the clinical applications and became a conventional tool in medical imagery, as diagnosis, segmentation and classification (Cui et al., 2020).

AI is a vast domain which implies the utilization of a computer in order to create an intelligent behaviour. It implies a minimal intervention of a human operator. The term was introduced within a conference which had the debate subject science and development of intelligent machines. The American computer scientist John McCarthy was the one who

established in 1956 the denomination of this technology which was about to have significant effects in the economic, societal and environment levels decades later (Ahuja, 2019).

From the historical perspective, AI was approached from two perspectives: the computationalism (tries to replicate thinking and logic in a direct way with the biological implementation) and connectionism (begins from biologic brain cells that are interconnected in a large number by synapses and which implies that intelligence is based on learning from previous experiences in a given situation) (Miller, 1994).

In the 1980s expert systems (Holman & Cookson, 1987) gained popularity. These are a traditional example of the above-mentioned category. Among the applications of these systems in the medical field is MYCIN (has the role of diagnose blood infections) (Buchanan et al., 1984) and INTERNIST-1 (utilized in making diagnostics within the internal medicine specialization) (Miller et al., 1982). A decade later the interest for this approach specific algorithms began to significantly reduce in the favour of the connectionist approach (Su, 1994). It implies that AI-based learning to take of the human experts' responsibilities in accurately and detailed data analysis.

Their increasing volume, including medical imagines incline the balance in the favour of this approach which consists of learning techniques that are divided in machine and deep learning. The first computerized learning approach implies that data that are provided to machines (computers) and consists of their ability to learned without being clearly programmed (Arthur Samuel, 1959). Machine learning relies on training and interference which allow the comparison of the models resulted from previously collected data with new models and subsequently making a forecast or proposing a decision.

Deep learning refers to a subgroup of ML algorithms that have the characteristic of being hierarchically organized on different levels in order to automatically extract relevant characteristics from data. The existent ML models have proven themselves to be useful in various tasks such as the detection of skin (Esteva et al., 2017) or breast cancer (Lotter et al., 2021).

Deep learning is capable of segmenting images from different organs from the head and neck regions within the CT type imagery with a comparable performance with the one of radiology specialists (Nikolov et al., 2018).

Artificial intelligence comprises computational technologies that replicate human intelligence mechanisms such as thinking, learning and understanding (Secinaro, 2021). Some of the intelligent devices can play different roles which usually would inquire human interpretation (Panch, 2018). These techniques have an interdisciplinary approach applicable to various domains such as healthcare. Artificial intelligence was introduced in medicine from 1950s when doctors made the first attempts of making a diagnostic based on computerized programs (Burton, 2019).

The "narrow artificial intelligence" concept or "narrow AI" represents the current level of AI materialization in what regards the execution of tasks that are specific to human reasoning (Copeland, 2016). Within this type of AI vocal and facial recognitions are comprised

which present different aspects that are characteristic to human beings. This form of intelligence comes from AI techniques that are known as machine learning and deep learning which reached a high performance in a variety of applications such as natural language processing (NLP), autonomous vehicles, but also in fields such as the medicine.

Artificial intelligence is often associated with either physical or software type robots. The term "robot" refers to biosynthetic machines which are able to conduct hard labor (Horgan et al., 2019).Contrasted with human intelligence, this technology can lead to faster results and better analyzed decisions (Horgan et al., 2019). It has the capability of solving the lack of medical personnel in developed and in countries that are under development by increasing the efficiency at the organizational level and maximizing the diagnosis precision. Moreover, it has the role of improving the quality of the medical act, and also it can lead to the mitigation of costs, late diagnostics and inefficiency (Khanijahani et al., 2022).

Its intricacy and progress prove that it will become increasingly applied within the medical field (Bush, 2018). Several manifestations of AI are already utilized by medical services' suppliers with the purpose of diagnosis, treatment, patient involvement and certain administrative tasks. There are various situations in which this technology could execute tasks as well or even better than a human, although the factors on which the implementation relies will prevent large-scale automatization of medical workplaces for a long period of time (Rysavy, 2013).

AI innovation is usually related to generating ideas, instruments and new knowledge by simulating human intelligence with the aid of programmed machines with replicate human specific behaviour, especially thinking (Zhang & Lu, 2021). Artificial intelligence-based innovations play a considerable role within the medical field by creating new facilities and managing medical related problems (Wahl et al., 2018).

Current algorithms are capable of overcoming radiology specialists in identifying malignant tumours and guiding researchers in implementing clinical studies. However, many years even decades will pass until an extensive implementation within the vast medical sectors will be possible (Shimabukuro et al., 2017).

Deep learning models from labs and start-ups are trained to recognize specific images like haemorrhages in nuclear magnetic resonance (MRI) investigations. Nevertheless, more tasks are required in order to identify all the potential results in medical imaging and only a part of them can be accomplished by the existent AI capabilities (Vial et al., 2018).The medical community has benefited from the significant evolution of this disruptive technology which allows a vast utilization within the field, mainly its applications as the automation of different stages of the clinical practice or providing support in clinical decisions, image segmentation and result forecast (Singh et al., 2020).

Global healthcare systems are facing difficulties due to a large number of patients and the increased spreading of chronical diseases and cancer which has led to a raise in medical assistance costs, as well as a lack of medical staff (Förster et al., 2023).At the same time, the United Nations want to promote a healthy lifestyle and wellbeing and inequality reductions in order to foster the sustainability of global societies. These factors led to an answer from

the medical industry and government stakeholders, as well as medical institutions which are interested in increasing innovation and improve the existent practices (Hayyolalam et al., 2021).

Experts forecast a significant impact of artificial intelligence in various medical specialties as chronical disease management and making clinical decisions given to the progress it has manifested in the past years in learning algorithms, computational power and availability of Big Data from medical files and health monitoring systems like smartwatches.

This technology can be applied to a large sphere which comprises robotics, diagnosis, medical statistics and anatomy. Also, it implies two divisions, which are the virtual and the physical one. The first comprises computing approaches from data management with the help of deep learning and supporting medical specialists in making diagnostic and treatment related decisions. The second one, the physical is outlined with the aid of robots that have the purpose of assisting patients and in surgery of assisting the medical specialist (Hamet & Tremblay, 2017).

The study conducted by Guo et al. (2020) focused on tangible AI medical applications and provided researchers a conceptual frame through which they could understand the way in which algorithms can support medical specialists in making diagnostics and in surgical interventions. They also play a role in establishing a treatment plan that is suitable for individual patients.

Researchers forecast the future of artificial intelligence having three possibilities: the first one which implies that medical specialists are no longer required – AI will make diagnostics given to cost reductions and comparable results. A second possibility implies a large number of patients that would be treated by AI, in this way reducing the number that have to be checked by a doctor and at the same time reducing the costs. The third possibility consists of the help of AI that is provided to medical specialists which will help them of making more efficient clinical decisions (Rong et al., 2020).

Connelly and colab. (2020) analyzed the rapid increase of the robot assisted operations in the past years and their approval in various specialties of the medical field as urologic, orthopaedic, cardio-thoracic and maxillo-facial surgery.

An example of robot that assists surgical interventions is Da Vinci, a robot with American origins that was created in 2000 and received its name in the honour of the one who's sketches helped both developing the medical field, as well as robotic surgery. This minimal invasive operative system can be controlled by a surgeon with the help of a dedicated console and can execute interventions that require a high level of precision. It has been mostly utilized in the urologic, gynaecologic spheres and in repairing heart valves (Probst, 2023).

The Use of Artificial Intelligence in Healthcare at the Global Level
Artificial intelligence significantly contributes to the improvement of conducting activity within the medical system, because it transforms the way in which medical specialists approach patients' conditions and make decisions regarding their treatment. The massive investments that took place in the past years in promoting the field led to a notable evolution

within the artificial intelligence technology. In 2021, AI utilization within the medical services market at the global level reached the threshold of 11 billion dollars (Stewart, 2023).According to a previous conducted study (Stewart, 2023), the global market is expected to reach 187.95 billion dollars by 2030. Until 2026, experts estimate that it will be of 52.97 billion dollars. Some experts expect that the CAGR between 2022-2030 to reach the threshold of 37%. The implementation of this disruptive technology in medicine has led to reducing the time which medical specialists pay for conducting administrative tasks (Dhaval, 2024).
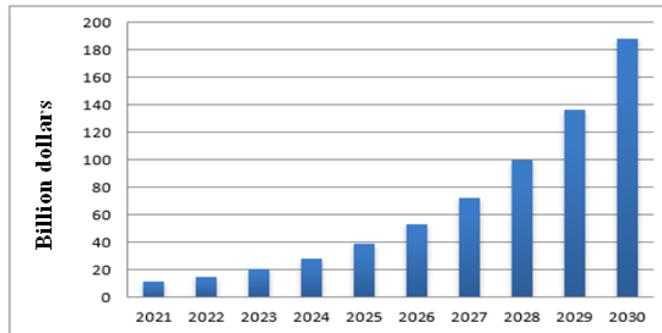

Figure 1. Forecasts regarding the artificial intelligence global market evolution in the medical field in 2021-2030

Source: Adapted fromStewart, 2023

From the structural point of view, the AI global market in the medical field is divided into three parts: software, hardware and services. In the following period of time, it is expected that software services would record the fastest growth. This category comprises: machine learning platforms, text analysis tools, learning platforms and vocal recognition systems (Precedence Research, 2023).
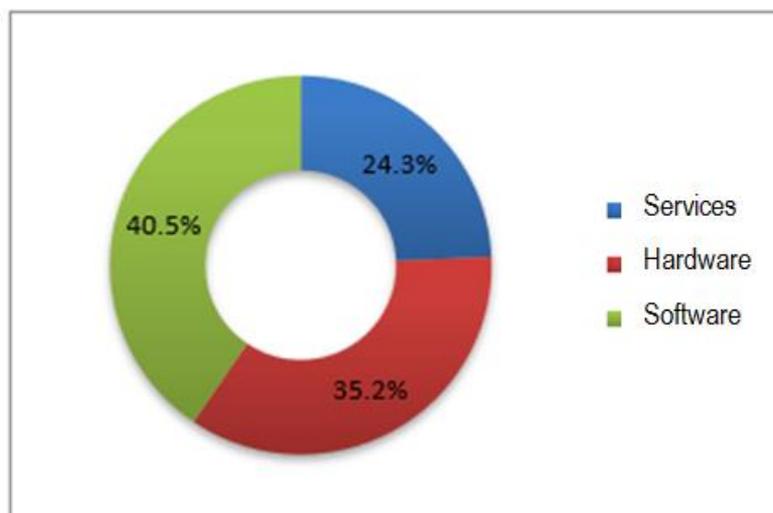

Figure 2. The artificial intelligence market in the medical field divided by components at the global level in 2022
Source: Adapted from Precedence Research, 2023

Analyzing from the point of view in which artificial intelligence has been utilized in creating various applications at the medical system level, it has to be mentioned that it has

been mainly used in the robot assisted surgery at the level of the interventions with an increased difficulty or which require an increased level of precision.

In addition, in this field it has been reached to AI for ensuring cyber security, reducing errors in what regards dosages, but also for a faster diagnosis of certain conditions. The utilization of this disruptive technology at the robots' level, but also at the operating level has brought a series of benefits in cardiovascular surgery but also in neurology where doctors require an absolute precision. According to previous conducted studies, this technology allowed medical specialists to faster analyze certain data and make decisions in a short period of time regarding the diagnosis and treatment of patients (Chornyy, 2024).

Studying from the perspective of the way in which the artificial intelligence market is divided at the global regions' level, it has to be mentioned that 59% of it belongs to North America, 19% Europe, 13% Asia Pacific and 7% Latin America. Thus, it can be noticed that North America remains the leader on this market, having the most advanced technology of this domain. Governmental policies as well as the infrastructure existent at its level permanently encourage the AI development in the medical field at this region's level.
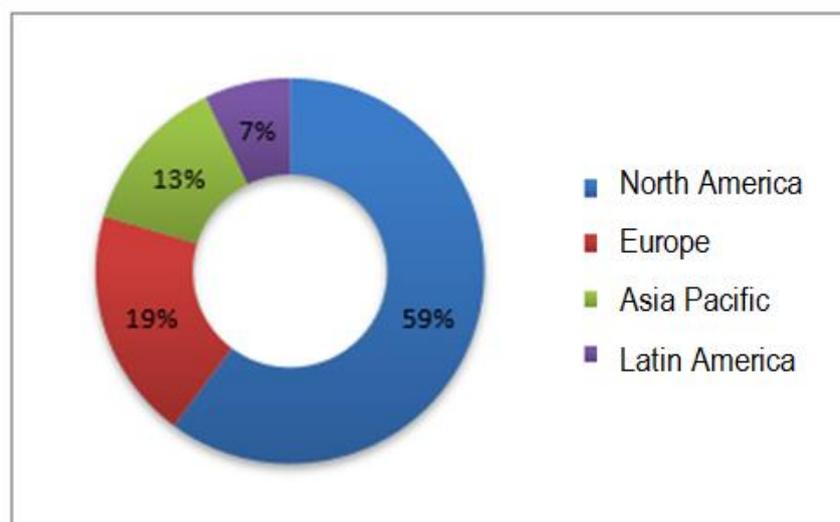

Figure 3 – Artificial intelligence market in the medical field at the global regions' level
Source: Adapted from Precedence Research, 2023

The Utilization of Artificial Intelligence in the Medical Field at the European Level
At the European Union level, the AI market from the medical field has considerably evolved in the past years, given to the investments of crucial resources made by member states in generating new applications based on this technology in order to improve the activity conduced at the level of this sector. In 2020 it has been valued at a total of 2.04 billion dollars and it is estimated that until 2028 it will reach the threshold of 50.42 billion dollars. The annual compound growth rate (CAGR) at the European level is expected to reach 49.2% during 2020-2028. The increase of lifespan at the European Union level determined an accelerated increase of medical assistance systems at the EU level in the past years. This aspect also determined an increase in the number of start-ups that conduct their activity in this sector (Prudent Markets, 2022).

A study conducted in 2021 at the European Union level has illustrated that approx. 35% of the AI based start-ups that conduct their activity in the medical field focused their activity on creating more solutions with the role of patient monitoring. In addition, other organizations became interested in the rapid diagnosis of certain conditions (Dhaval, 2024).

In the following period of time an increase in the utilization of AI in this domain is expected from several reasons, which are: the increased number of chronic diseases in these countries, the progress that is forecasted in this field, the growth of the medical assistance infrastructure and also the governmental initiative regarding the enforcement of this disruptive technology in medicine. In the past years at the level of the European Union a series of IA-based applications that increased the efficiency of medical diagnostics, telemedicine, epidemiologic studies and patient clinical management were developed (Business Market Insights, 2021).

Another research conducted at the level of the EU member states during 2017 − 2020 showed that the countries that received the highest number of patents regarding the artificial intelligence use in the medical field were: Germany (62% of the total patents given in this domain), the Netherlands (22%), Sweden (2,8%), Ireland (2.2%), Belgium and France (1,9%), Italy (1,47%) and Finland (1%). States like Greece, Denmark or Spain recorded a total of 6 patents which counted as a 0.88% share of their total number. In Romania and Portugal 4 patents were recorded, their percentage being 0.58% of total, while Austria and Lithuania had 3 (0.44%), two (0.30%) and one (0.15%) patent each (European Commission, 2021).

In the next period of time in Europe it is estimated that given to the implementation of artificial intelligence at the healthcare system level the time doctors allocated to patients will raise (+20% of the current allocated time) because, the utilization of this technology will automatically determine the decrease of the period dedicated to administrative tasks and utilize it to consult patients (Stewart, 2023).

Another survey conducted at the level of companies that conduct their activity in the medical field illustrated that currently at the market level there are several enterprises that utilize AI technologies, while others plan to use them in the following three years. 11% of the organizations that reach to artificial intelligence mentioned that they utilize it in robot assisted surgery, to diagnose the patients' conditions, to monitor them or for the genomic analyze. According to the obtained results those who plan to utilize AI in the following period of time want to reach it in order to monitor patients (72%), to help them in easier determining certain conditions (61%) but also for the medical robotic part (53%) (European Commission, 2021).

Conclusions
Presently, artificial intelligence is considered as the engineering branch that implements new concepts and solutions in problem solving. The greatest challenge of artificial intelligence in the medical specialties is not whether it will be capable enough to prove its utility, but ensuring its adoption in the daily medical practice. However, for an abundant adoption of the AI systems regulatory approvals are required. Obtaining the necessary approvals is possible to take longer than the time these technologies need to mature, and as

a result the use of AI in healthcare will be limited for the foreseeable future with prospects for extensive use in the next decade (Davenport, 2018).

It is also increasingly apparent that AI-based systems will not replace medical professionals on a large scale, but rather support their patient care efforts. Over time, clinicians will likely shift to tasks and jobs that draw on specifically human skills such as empathy, persuasion, and big picture creation.

Artificial intelligence can be applied in the health field to a wide range of activities such as: clinical documentation, claims processing, revenue management, but also medical records. The increasing complexity and availability of health data will in the next period further stimulate the use of this technology both globally and at the European level. In the coming years, an expansion of the AI market in the medical field is expected, mostly due to the implementation of artificial intelligence tools in the prediction, evaluation, diagnosis and treatment of difficult conditions such as cancer or neural or cardiovascular diseases.

The application of this disruptive technology at the level of several fields in medicine will automatically lead to the growth of applications that will later develop within this field of activity. Previous studies have illustrated that artificial intelligence has the ability to detect and diagnose a number of conditions. Moreover, it helps to identify malignant tumors, but also to carry out difficult interventions. This paper aimed to study the evolution of the healthcare artificial intelligence market in the coming years. After analyzing the data from secondary sources, it was observed that this market has grown a lot in recent years, expecting to reach the threshold of 187.95 billion dollars by the year 2030.

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