APPLICATION OF ARTIFICIAL INTELLIGENCE IN HEALTH CARE

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Abstract: *One of the important tasks of artificial intelligence (AI) is to support people in making decisions in the treatment process. Such support allows to reduce the risk of diagnostic errors and significantly accelerate the process of making important decisions related to the treatment process. The aforementioned premises were the main motivation for setting the goal of this study. The purpose of this paper was to analyze the literature on the application of artificial intelligence (AI) in healthcare. Works containing the words: artificial intelligence, management and healthcare were examined. The application of AI is wide, the tools are used to meet the basic goals of healthcare. They involve quality assurance of healthcare delivery, patient safety, and decision support systems. These systems are used for biomedical research and remote consultation, among others. The field of healthcare quality assurance system research has included papers related to quality of health care, quality of life, patient satisfaction, health failure, chronic disease, treatment outcome, clinical competence, nurse's role, length of stay, equipment design, robotics. Publications were also related to cost-benefit analysis, risk assessment, prognosis. It has been shown that artificial intelligence, precision medicine, big data, deep learning, covid-19 have increased significantly between 2018 and 2021, which can be regarded as the formation of a new thematic field related to the digitization of healthcare.*

Keywords: *artificial intelligence, healthcare, management*

JEL Classification: H0, O0, D80

Introduction

Definitions of artificial intelligence (AI) explain that it aims to mimic human cognitive functions (Steels, 1993; Helm et al., 2020; Visvikis et al., 2019; Latah and Toker, 2019; Yu et al., 2018; Davenport, Kalakota, 2019). Its application is especially widespread in healthcare. Business Insider Intelligence reports that spending on AI in healthcare will grow at an annual rate of 48% between 2017 and 2023 (AI in Medical Diagnosis, 2019). The implication of this is the rapid advancement of analytical techniques useful in medicine. These techniques include machine learning methods for structured data, such as classical support vector machine and neural networks, and modern deep learning methods, as well as natural language processing for unstructured data. The continuous and relentless development of AI is necessitated by the increasing availability of

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data and the rapid development of methods for analyzing large data collections of constantly growing (Murdoch and Detsky, 2013; Kolker et al., 2016). The data sets are facing more and more challenges as a result of new research in medicine, new diseases and treatments, and patient awareness of the need for preventive screenings. Artificial intelligence assists medical personnel and AI tools are increasingly used by professionals, but also by patients and medical facility managers when deep learning algorithms and neural networks are used for example for lifestyle management and monitoring, health information management (Racine et al., 2019; Tripathy et al., 2015).

The purpose of this paper was to analyze the literature on the application of artificial intelligence in healthcare. Works containing the words: artificial intelligence, management and healthcare. The application of AI is wide, tools are used to meet the basic goals of healthcare. They are related to quality assurance of health care delivery, patient safety, and decision support systems.

Review of the specialized literature

Artificial intelligence (AI) „in a practical sense, refers to computer systems that simulate or exhibit a specific aspect of human intelligence or intelligent behaviour, such as learning, reasoning, and problem solving" (McCarthy, 1956). AI is a range of intelligent processes and behaviours generated by computational models and algorithms (Chen and Decary, 2020). AI refers to the study and design of intelligent agents (Cañedo and Skjellum 2016), defined as systems that perceive their environment and take actions that maximize their chances for success (Kuzlu et al., 2021). According to the guidelines, AI systems are "general-purpose products", loosely regulated as long as these devices are for general well-being and pose little risk to users. The guidelines justify the use of real-world evidence to inform the performance of AI systems. In addition, the guidelines clarify the principles of adaptive design in clinical trials, which would be widely used in evaluating the operational characteristics of AI systems (Marr, 2017; Jiang et al., 2017).

AI is being used to diagnose and treat many diseases, including cancer, neurological and cardiovascular diseases (Jiang et al., 2017). Artificial intelligence can help doctors make better clinical decisions and replace humans in radiology, for example. It can also improve productivity by accurately identifying infections on X-ray and CT images, which facilitates subsequent quantification. Computer-aided platforms help radiologists make clinical decisions, such as diagnosing, tracking and predicting disease (Shi et al., 2020). In the recent decades, there has been development and integration of these tools that can help physicians in image interpretation. They are used to optimize image quality for better visualization. They help in patient selection for appropriate examination, patient preparation, image acquisition, processing and interpretation (Massalha et al., 2018). The artificial intelligence platform has a database of information that links symptoms of diseases to their causes. This reduces the risk of misdiagnosis and medical errors. The widespread use of AI leads concerns about whether artificial intelligence will replace doctors in the future (Jiang et al., 2017; Polinkevych et al., 2021).

AI system supports physicians by providing updates on medical information from journals, textbooks and clinical practices to ensure proper patient care (Pearson, 2011).

AI is used not only in clinical trials, but throughout the health care system. Health care system an organized plan of health services. The term is identified with the system or program by which health care is made available to the public and financed by government, private enterprise, or both. Components of a health care system include: individual and family health services available in hospitals, clinics, neighborhood centers, and similar institutions, in physicians' offices, and in clients' homes; public health services, teaching and research activities related to the prevention, detection, and treatment of disease; and third-party coverage of the system's services (health insurance) (Medical Dictionary; Yermoshenko and Trynchuk, 2016).

The functioning of the healthcare system is supported by AI tools. Mobile applications can help health care professionals, e.g., ask patients about their symptoms and provide them with medical information about their condition, help resolve clinical dilemmas, reducing the number of diagnostic and therapeutic errors committed by doctors and nurses while performing their work. (Weingart et al., 2000; Graber et al., 2005; Winters et al., 2012; Lee et al., 2013; Kister and Vovk, 2014). A well-known example is that of the Israeli company MedAware, which has developed an algorithm to help doctors prevent medication errors when using electronic medical records. A doctor, the moment he prescribes an inappropriate drug to a patient that does not fit the patient's profile, receives a warning. Similarly, when a drug interacts negatively with another drug. Artificial intelligence systems potentially prevent errors. MedEye is a device equipped with a tablet and capsule scanner that uses a camera to identify other drugs. The devices are used in hospitals in the Netherlands, Belgium, Iceland and the United Kingdom. The device verifies medications using visual recognition and machine learning, then comparing them to the hospital's information system (Leichman, 2014). AI can be useful when there is not enough data to make an informed decision or when there is so much data that it cannot be processed in a short enough time. AI should serve as a complement to medical knowledge and human intuition (Romzek, 2018).

Among AI tools, machine learning techniques and natural language processing methods can be distinguished. The first category analyzes structured data: imaging, genetic, and from genetic testing. The second explores information from unstructured data, such as clinical notes/medical diaries, for supplementation. The practical application of AI faces obstacles. There is a lack of standards for evaluating the safety and effectiveness of the systems in which it is applied. The U.S. Food and Drug Administration (FDA) has made the first attempt to develop guidelines for evaluating AI systems (Graham, J., 2016).

The amount of data collected and stored digitally in healthcare is enormous. As a result, the science of data management and analysis (big data) is also growing. It explains how organizations can transform this resource into information and knowledge to meet their goals (Murdoch and Detsky, 2013). These goals were adopted to meet the needs of the "superclient" and the "client". The "superclient" is the patient, while the "customers" are the healthcare providers (e.g., doctors and nurses). Healthcare organizations must focus on the needs of their superclients by offering superior services with the support of Big Data (Kolker, et al., 2016). Delivering public services and increasing patient value are healthcare goals enabled by the Internet of Things (IOT). IOT "is a network of physical objects. The Internet is not just a network of computers, but has evolved into a network of devices of all kinds and vehicles, smartphones, household appliances, toys, cameras, medical instruments and industrial systems, animals, people, buildings, all connected, all communicating and exchanging information based on specific to achieve intelligent reorganization, positioning, tracking, security and control, and even personal real-time online monitoring, online monitoring, online updating, process control and administration" (Kuzlu et al., 2021). The increasing use of artificial intelligence enabling cross-sectional data analysis is improving the use of IOT (Mohamed, 2020). AI and IOT face the following challenges (Pendse, 2019):

- Ensuring security due to sensitive data,
- The difficulty of connecting multiple complex technologies and devices,
- Nullifying so-called artificial stupidity - an AI program cannot perform basic tasks perfectly, AI systems' algorithms must be well suited to understand and interpret data,
- Higher levels of consumer and business confidence in data security, IoT device protection, and the integrity of the data created,
- Eliminating attacks in the cloud - removing malicious viruses.
- Providing competition to technologies.

N. Chawla claims that “the Number of connected medical devices is expected to increase from 10 billion to 50 billion over the next decade. Cisco estimates that by 2021, the total amount of data created by any IoT device will reach 847 Zettabytes (ZB) per year” (Chawla, 2020).

Data sets and processing should be completed by providing analysis results to decision makers so that they can use them in decision making processes as soon as possible (Kania, 2018). Internet technology and Big Data allow healthcare organizations to expand their services beyond their usual practices. With Internet Technology, patients are increasingly included in the healthcare process, for example, by allowing them to generate personal health data in a personalized web interface. They have more control over the flow of information between healthcare organizations and patients and between patients themselves (Anshari and Almunawar, 2015). Patients benefit from AI for medication management and wellness and lifestyle counseling. Healthcare professionals also benefit. They have help with problem solving and decision making. AI will be most effective when it works with coding experts, doctors, and other professionals.

AI tools are able to analyze data and provide information to clinical and non-clinical department managers about staffing in their departments. This information is used to monitor contractor demand, and clinical leaders can determine the most favorable ratio of mid-level staff to physicians (Artificial Intelligence in Healthcare Management).

Research methods

In the first step, in order to investigate the publication activity in the field of artificial intelligence, a bibliometric analysis of the subject area was performed in the National Library of Medicine resources - PubMed. For keyword "artificial intelligence" a sample of 153,839 publications from the years 1951 to 2021 was collected. The database was downloaded and analyzed using "VOSviewer" software for clustering and network analysis of bibliometric information.

The "co-occurrence" method, which groups keywords according to their frequency of occurrence in the same article, was chosen as the main method of data analysis using VOSviewer. Only those keywords that occurred at least 15 times in the sample were selected to construct the scientometric map. Consequently, 7 thematic clusters were created. A visualization of the results is shown in Figure 1, where the size of an item reflects its total link strength ("total link strength") and the width of a line reflects the link strength ("link strength") between two terms.

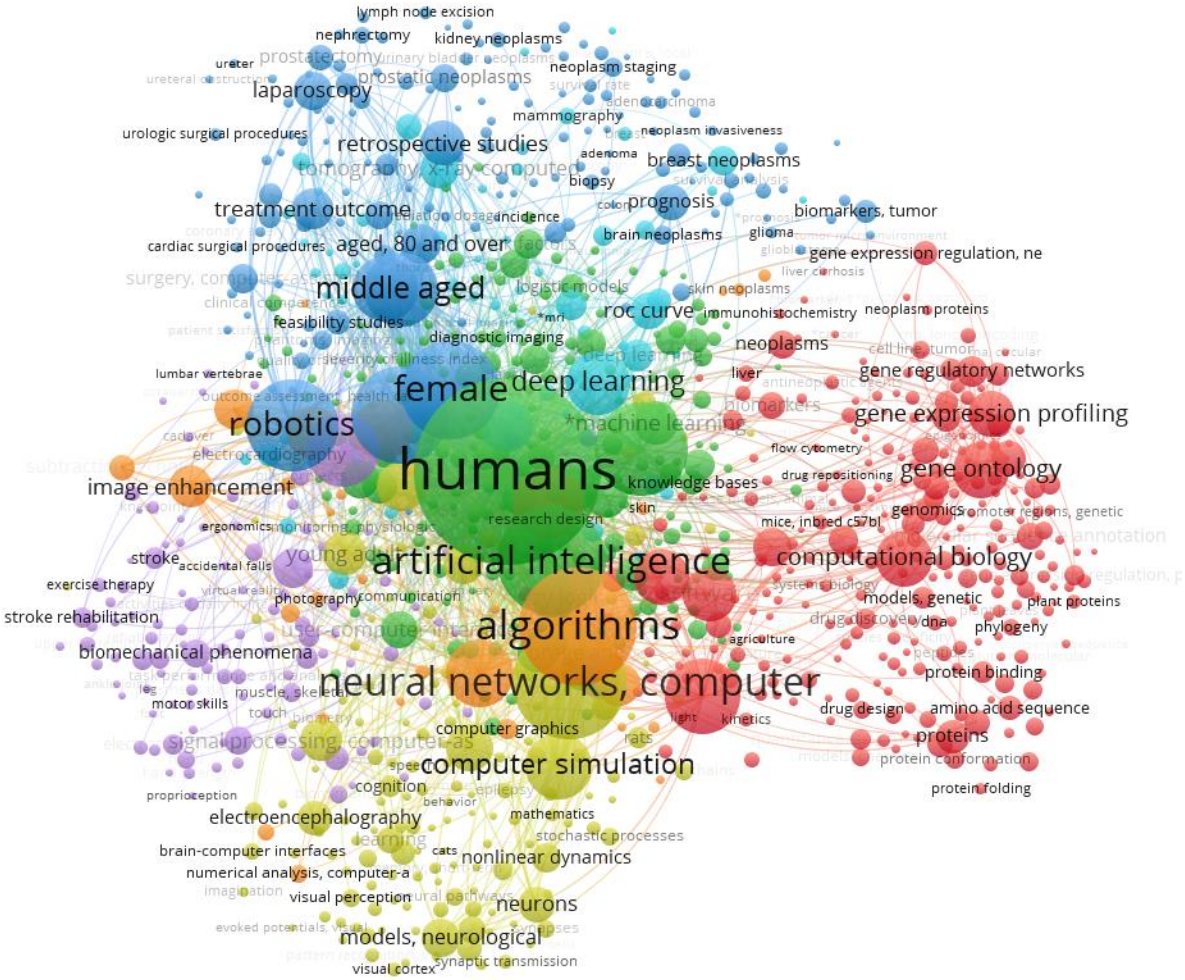

Fig. no. 1 Bibliometric map of publications for the keyword Artificial Intelligence

The interpretation of clusters is based on the keywords appearing in them, while it should be indicated that this division is rather conventional, as both clusters and terms are interrelated. However, it is worth noting that in the last 2-3 years, artificial intelligence research is strongly related to the topics of machine learning, deep learning and Covid-19.

In the second step, a concept analysis was conducted to understand the place of artificial intelligence in the healthcare system. The National Library of Medicine's PubMed scientific database and the VOSviewer program were also used in this case. A sample of papers was selected based on the query artificial intelligence AND management AND healthcare. Literature from 1990-2021 was selected, and a total of 581 papers were found. A thesaurus was also created to automatically link similar keywords (e.g., covid-19 and sars-cov-2) and to remove possible misspellings (e.g., artificial intelligence and * artificial intelligence). A total of 2304 keywords were included in the indicated sample, of which 93 occurring at least 10 times were selected for clustering.

The clustering results are shown in Figure 2.

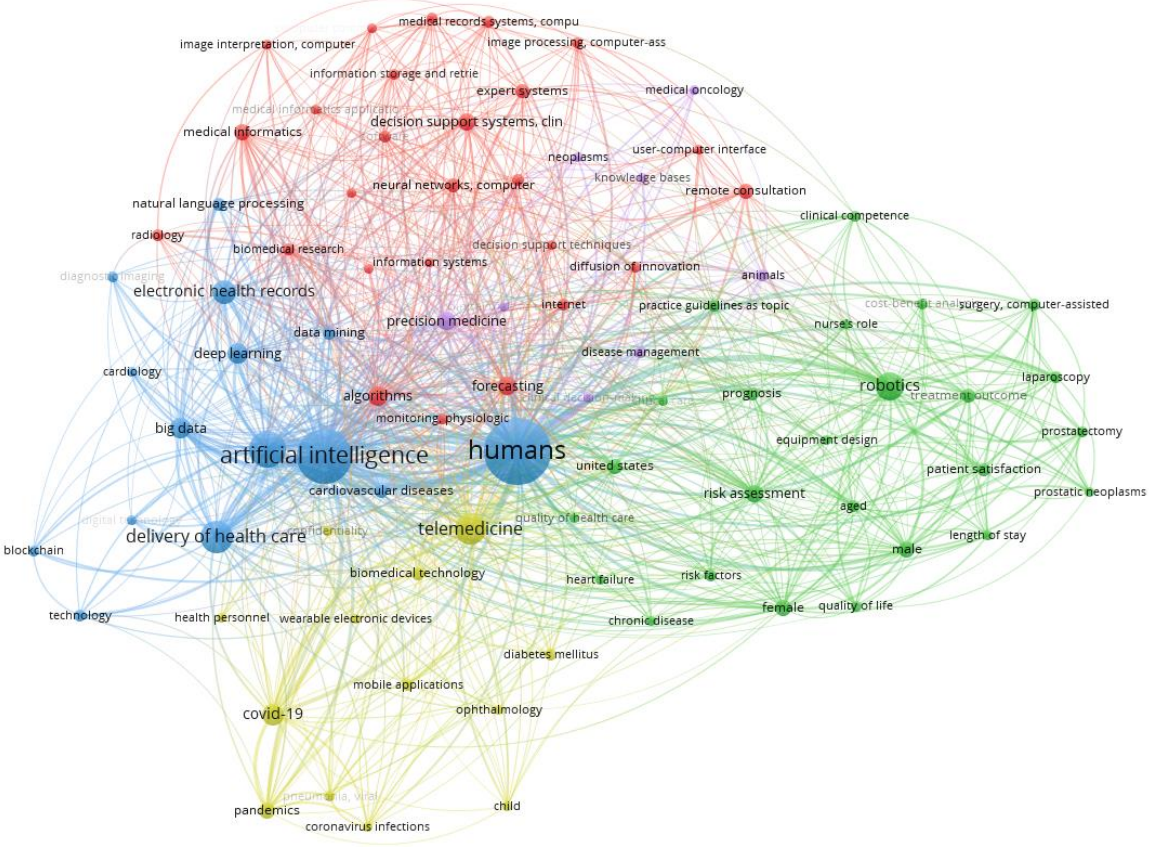

Fig. no.2 Bibliometric map of publications for keywords: Artificial Intelligence, Management and Healthcare

Results and discussion

In the analysis, we identified several clusters that can be broadly defined as follows:

1. Databases (green cluster). This cluster is at the center of the analysis and generally represents the most prominent group of concepts. It is closer to the data processing problem. The key elements of the cluster are data collection and processing, risk prediction (including various diseases), and generation of knowledge bases.

2. Computer Simulation (yellow cluster). A special feature of the Computer Simulation cluster is its "technical" orientation with respect to artificial intelligence problems. In particular, it covers the topics of signal processing computer, neural networks, linear models, nonlinear dynamics, brain-computer interfaces, learning.

3. Biomarkers (dark blue cluster). This cluster is a rather broad group of concepts. It includes, among others, issues of age changes, sex distribution, prediction and prevention of certain diseases.

4. Genetic (red cluster). Just like the previous cluster, the Genetic cluster is a broad group of concepts. It combines groups of papers devoted to gene expression regulation, signal transduction, gene ontology, gene regulatory networks, neoplasms, molecular sequence annotation. Papers in computational biology, cluster analysis and support vector machine are particularly important in this context.

5. Recovery of Function (purple cluster). This cluster has an intermediate and somewhat integrative role. It includes issues of pilot projects, biomechanical phenomena, feedback, equipment failure analysis.

6. The Imaging cluster (orange cluster) plays a similar role. It is also characterised by a relatively lower intensity of terms. Publications in the Imaging cluster concern pattern recognition

automated, reproducibility of results, models statistical, image interpretation computer, sensitivity and specificity, imaging three-dimensional, image enhancement.

7. The last cluster is the Deep Learning cluster (sky blue cluster). The strength of its impact is also relatively smaller. However, its problems are no less important. It concerns ROC curve analysis, diagnosis differential, image processing computer-assisted, diagnosis computer-assisted, mammography.

The clustering resulted in a network map that demonstrates indeed that artificial intelligence is a broad and diverse field of research that is active in several areas simultaneously. The two largest areas are Decision Support Systems (red cluster) and Quality Assurance Systems in Healthcare (green cluster).

Decision Support Systems are mainly concerned with expert systems, forecasting, databases, algorithms, user-computer interface, image processing and interpretation, neural networks, medical informatics, software, medical record system, diffusion of innovation, which are used for biomedical research and remote consultation, among others.

The field of research on Quality Assurance System in Health care included papers related to quality of health care, quality of life, patient satisfaction, health failure, chronic disease, treatment outcome, clinical competence, nurse's role, length of stay, equipment design, robotics. Publications were also related to cost-benefit analysis, risk assessment, prognosis.

There are also two smaller research areas that have been named Data Processing Systems (blue cluster) and Assistive Technology Systems (yellow cluster).

Data Processing Systems is an area related to research on artificial intelligence and its competition with humans, as well as research on machine learning, deep learning, big data, data mining, natural language processing, digital technology, blockchain, diagnostic imaging. In addition, electronic health records, delivery of health care, cardiology, cardiovascular diseases have a strong focus within this cluster.

The Assistive Technology Systems cluster is devoted to issues that increase researcher interest in new issues arising from pandemics, covid-19. A lot of papers in this cluster are also devoted to wearable (Wu and Luo 2019; Flis, 2020; Chawla, 2020).

The research presented in the analyzed papers collected in the PubMed database shows that the application of artificial intelligence is growing and continues to cover new areas. However, it has not been observed that special attention has been given to human resource management. This issue is considered in the papers on management (Koszembar-Wiklik and Machnik-Słomka, 2017; Wrzalik, 2013; Rachwalski, 2021; Leszczyński, 2021).

Conclusions

Although the first mention of artificial intelligence dates back to 1951, the concept of AI is widely studied in current scientific literature.

Artificial intelligence is quite often used as an element of computer simulation when considering signal processing computer, neural networks, linear models, nonlinear dynamics, brain-computer interfaces, learning. It has particular application in healthcare, mainly in the area of clinical research. The increasing amount of data in health care and the rapid development of information technology, the increase in patient awareness in performing preventive examinations will increase the demand for the use of artificial intelligence tools in the future. The problem may be that patients will prefer personal interaction with a human rather than a machine which may inhibit the development of AI tools. The authors believe that managers have a large management role in the healthcare system. They, too, should support the development and purchase of new AI tools so that they are useful, among others, in human resources management and not only used in the relationship between medical staff and patients.

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