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REVIEW

The impacts of artificial intelligence in healthcare

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ABSTRACT

Artificial intelligence (AI) is a system that aims to bring human thinking ability to machines and thus solve complex tasks more easily and can continuously improve itself with the data it collects. AI technologies are used in many fields, such as education, media, banking, and the defense industry. In recent years, AI has begun to manifest itself in various fields of health services, from diagnosis to treatment and patient follow-up.

AI algorithms can facilitate patients' access to healthcare services, provide remote patient monitoring, shorten the diagnosis process of diseases, provide patient-specific treatment recommendations, or allow physicians to improve their practices. Thus, it can improve patient care and increase patient satisfaction, reduce costs, and speed up healthcare services. Increasing telemedicine applications during the pandemic contributed to the acceleration of the utilization of AI in healthcare, and AI-based algorithms for diagnosing and treating diseases began to be developed rapidly. With the increasing prevalence of wearable technologies and the introduction of electronic health records, there has been a tremendous explosion in individual health data. AI has contributed to health services in collecting and processing this rapidly increasing data.

Although AI has a promising future in health, it also brings many ethical problems. AI systems make decisions based on the data they are trained on. If there is not enough data diversity or if biased data is used, AI systems may give inaccurate predictions or learn and reproduce these preconceptions.

This manuscript is a literature review examining the impacts of AI in the healthcare sector and discusses the history of AI, AI studies applied for the diagnosis and treatment of diseases, telemedicine and preventive medicine applications, and the disadvantages of AI.

Keywords: artificial intelligence, diseases, healthcare, telemedicine

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INTRODUCTION

In recent years, technological developments such as big data systems, the Internet of Things (IoT), health monitoring devices, telemedicine applications, and robotic surgeries have been used in various fields of the healthcare sector and have started to provide convenience to patients and physicians in protecting health and accelerating diagnosis and treatment processes. Thanks to big data systems, more data can be accessed by using health records, laboratory and imaging results, and information such as medical records, test results, imaging findings, and prescriptions of patients can be stored within the health cloud. IoT enables medical devices and sensors to be connected to the internet in order to collect and share data in real-time. Through IoT, communication between wearable technologies, sensors, medical devices, and other resources can be established, and information sharing can be provided (1). Mobile devices such as smartphones and tablets can be beneficial to the user by enabling patients to monitor their health status, use medication reminders, or meet with their doctors via telemedicine.

Artificial intelligence (AI) is the system used to solve tasks such as problem-solving, data analysis, and learning through computers by giving human-like thinking abilities to machines. AI includes many tools, such as deep learning, neural networks, and machine learning. An algorithm is a step-by-step approach designed to achieve a specific goal. AI advancements in the health industry aim to produce solutions to problems by using a diverse range of algorithms, such as deep learning, natural language processing, support vector machines, ensemble learning, and bioinformatics algorithms.

AI is used to speed up processes, increase efficiency, and reduce costs in numerous areas such as diagnosis, treatment, and follow-up of diseases, vaccine and pharmaceutical industry, making or reminding doctor appointments, and telemedicine with machine learning or deep learning technologies. This review discusses the areas of use of AI technologies in healthcare.

History of artificial intelligence

The emergence of AI dates back to the “Turing Test” in the 1950s. For the first time, with Alan Turing's question, “Can a man-made device move and make decisions in a way that is indistinguishable from that of humans?”, AI was conceptualized, and with the Dartmouth Conference in 1956, AI became a topic of discussion (2,3). ELIZA, developed by Joseph Weizenbaum at the Massachusetts Institute of Technology (MIT) AI laboratory between 1964 and 1967, was one of the first chatbots and the first program to test the Turing Test. ELIZA could organize text responses that simulated a dialogue with a human therapist (4). Shakey, developed between 1966 and 1972, was the first robot capable of interpreting human instructions and performing actions based on these instructions. It was considered one of the greatest achievements of that period.

In the 1970s, AI started to be used in medical applications, and the first artificial medical advisor, INTERNIST-1, emerged (5). In this system, search algorithms were used to find a diagnosis from patients' symptoms. During these years, MYCIN was developed by Stanford University to identify bacteria giving rise to severe infections and to recommend appropriate doses of antibiotics to patients (6). In the 1980s, DXplain was designed at the Massachusetts General Hospital computer science laboratory to make it easier for doctors to diagnose (7). It was similar to INTERNIST-1 but had the ability to derive more diagnoses from the symptoms entered.

In the 2000s, AI applications in health gained momentum. IBM Watson was developed to respond to questions on a quiz show. It beat the best contestants to take first place. Watson was built as a question-answering computing system using natural language processing, information retrieval, knowledge representation, automatic reasoning, and machine learning technologies (8). In 2017, the Watson system identified RNA-binding proteins associated with amyotrophic lateral sclerosis (9).

Telemedicine

Telemedicine refers to delivering healthcare services across distances using information and communication technologies (10). Telemedicine applications can be used in "real time," involving active communication between doctors and patients via telephone or video calls, and through "store and forward" methods that enable clinicians to store and transmit data for later evaluation and interpretation. It facilitates access to healthcare, especially where access to clinicians is limited. Remote Patient Monitoring (RPM) is a subset of telemedicine, enabling healthcare professionals to monitor, investigate, and report on patient conditions remotely.

There has been an increase in the use of telemedicine during the COVID-19 outbreak, and it has provided significant benefits in reducing the spread of COVID-19, monitoring isolated patients, and identifying patients in need of hospital care (11). AI-equipped smartphones have enabled remote assessment of a patient's likelihood of being infected by analyzing the sound of speaking or coughing, and AI-enabled chatbots have contributed to reducing the increased triage burden by classifying patients according to their symptoms, helping to refer patients to home quarantine, the emergency department, or a COVID-19 clinic (12).

Integrating AI into telemedicine has contributed to the clinician's decision-making process by providing alternatives for interpreting medical images. AI methods in smartphones or wearable devices have been used to increase patients' treatment compliance, providing opportunities such as reminding patients of the time of medication intake and monitoring heart rhythm with smartwatches (13).

ChatGPT, an AI language model, launched by OpenAI, functions as an AI-powered chatbot that is able to comprehend natural language conversations and answer user queries. A ChatGPT-powered chatbot provides information about medical diseases and answers patients' questions about clinical features, prescription drugs, and therapeutic procedures. For medical staff, it summarizes patients' medical information and can help them perform RPM to maintain patient health. ChatGPT can offer solutions as a computer program that aids patients in managing their treatment, akin to a virtual assistant alerting them to adhere to their medical prescriptions and providing information about their current health condition. Digital platforms, including websites, voice assistants, and mobile applications, can be used to reach these virtual assistants. Nevertheless, ChatGPT in healthcare has shortcomings regarding medical ethics, privacy, security, consent, and liability.

Diagnosis of diseases

By processing biochemical and clinical test data with big data analysis methods, AI has become available in the diagnosis and treatment process of many diseases.

With the onset of digitalization, the interpretation of images by computers has been the subject of intense interest; thus, computer-aided detection (CADe) and computer-aided diagnosis (CADx) algorithms have emerged. Although there were initially high expectations from these systems, they were not very effective in the clinical field due to high false positive rates. AI has been increasingly used by radiologists for the early diagnosis of various diseases and the reduction of diagnostic errors. It has been reported that AI-supported systems perform at least as well as radiologists, show lower false diagnosis rates than radiologists, and reduce the workload of radiologists (14). Similarly, AI is a tool that cardiologists can use to analyze electrocardiography and echocardiography graphics. The Ultromics platform, founded at a hospital in Oxford, has used AI to analyze echocardiography scans to detect heart rate patterns and ischemic heart disease (15).

The first application of AI in the surgical field was by Gunn in 1976 when he tried to diagnose acute abdominal pain using computer analysis, and AI made an accurate diagnosis (16).

An AI-assisted diagnostic system was developed to classify malignant and benign lung nodules based on computed tomography (CT) data, and it was shown that this system can be applied to differentiate lung nodules accurately (17). In this study, Gong J et al. included a total of 243 pulmonary nodules, of which 76 were benign and 167 were malignant (81 were stage

1 and 86 were stage 3) according to biopsy results, and as a result of the study, they reported that a CADx scheme was feasible to discriminate between benign and malignant lung nodules accurately, and that there was a positive correlation between CADx performance and cancer stages (17).

Gudigar et al. declared that various medical imaging tools such as X-ray, CT, and ultrasound (US) using AI techniques have contributed substantially to the fight against the pandemic by aiding in the early diagnosis of COVID-19 (18). AI algorithms applied to lung CT scans of COVID-19 patients showed that pneumonia developed most frequently in the right lobe of the lung (19).

A study by Wang et al. proposed a new hybrid chest CT-based method to automatically detect COVID-19, using a diagnostic technique based on wavelet Renyi entropy (WRE) and a three-segment biogeography-grounded optimization (3SBBO) algorithm, which outperforms many AI algorithms (20).

AI has also started to be used in breast cancer detection. In related studies, it has been shown that the performance of AI methods developed in breast cancer detection is similar to human performance, and it has been revealed that AI may play an essential role in the field of breast cancer screening in the future (21). In one study, the interpretations made by 101 radiologists (28,296 independent interpretations) on 2,652 digital mammography exams (653 malignant) collected from seven countries were compared with the interpretations of the AI system, and it was shown that the performance of the AI system was not statistically inferior to the performance of radiologists. The AI system evaluated in this study was reported to achieve cancer detection accuracy similar to that of an average breast radiologist (14).

A study has shown that an AI-based method can classify thyroid nodules as benign or malignant. In this study, image features were extracted from thyroid US images in the spatial domain using deep learning, and in the frequency domain using Fast Fourier Transform (FFT). A stepwise classification scheme was created using these features, and it was found that thyroid nodules could be successfully classified (22).

Magnetic Resonance Imaging (MRI) is able to detect inflammation in the joints of patients with rheumatoid arthritis (RA) before it manifests clinically and can play a crucial role in early diagnosis. By collecting MRI data from healthy controls and patients with suspected progression to RA, specific patterns predicting the development of RA can be deduced. However, manually classifying a great deal of MRI data is impractical. Consequently, research has been conducted to detect early RA from MRI data using AI techniques, and an AI algorithm based on MRI data has been shown to increase the rate of early RA detection compared to specialized physicians (23).

In ophthalmology, AI is applied to fundus photographs, optical coherence tomography, and visual fields to detect diabetic retinopathy, macular edema, and macular degeneration. It is suggested that deep learning in ocular imaging can be combined with telemedicine to screen, diagnose, and monitor important eye diseases in primary care (24).

AI methods have also significantly progressed in interpreting small bowel capsule endoscopy images. In a study in which 7,556 small bowel capsule endoscopy images were analyzed with an AI neural network algorithm, lesions and their localization were detected with higher sensitivity and accuracy than the conventional model (25).

AI tools can analyze speech patterns to predict psychotic events and to recognize and screen for features of neurological diseases such as Parkinson's disease (26). Furthermore, AI algorithms may be helpful in the diagnosis of autism spectrum disorder by analyzing transcripts of spontaneous speech and assessing behavioral features or in the diagnosis of acute appendicitis in children by analyzing blood tests (27,28).

The use of AI in medical pathology can help in lesion detection, classification, and prognosis prediction. Kosaraju et al. developed a new deep-learning AI model called Deep-Hipo for pathological image analysis and reported that this model performed more efficiently and accurately than other AI methods in analyzing gastric cancer pathological images. Although there are several convolutional neural network-based techniques to precisely analyze histopathological images for cancer detection, cancer subtype classification, and risk prediction, most of them perform patch-based examinations because of the large size of histopathological images. Still, these patches do not consist of adequate information or patterns. Deep-Hipo, on the other hand, was reported to extract two patches of the same size at both high and low magnification levels and to capture complex morphological patterns in both large and small receptive fields of the whole slide image, thus outperforming the latest deep learning methods (29).

Treatment of diseases

IBM Watson, a well-known AI system in the world, is designed to help physicians examine electronic health records of their patients, access academic publications related to diseases, and examine documents related to the disease with features including machine learning, data mining, and natural language processing. A study conducted in India found that the treatment recommendations provided by the Watson oncology system to 638 patients with breast cancer had 90% similarity to the treatments recommended by the tumor detection board working in this field, and saved a significant amount of time. The researchers used both the manual method and the Watson system to collect and analyze the data and then compared the time taken to provide treatment recommendations. They found that the manual approach took an average of 20 minutes, which decreased to 12 minutes as physicians became more familiar with it, while Watson took only 40 seconds to analyze the data and provide a treatment recommendation (30).

Today, robots are used in various surgical procedures to assist surgeons. The Da Vinci robotic surgery system is one of the systems often preferred by doctors in this context. The Da Vinci robotic surgery AI system has made surgical treatment more minimally invasive with the advantages of clearer image, more precise and comfortable operation, and even remote operation. With these advancements, it has provided high surgical success and low complication rates (31).

Three-Dimensional Printing (3DP) is a rapid prototyping technology using AI technology. Based on digital model files from CT or MRI data, it creates objects by printing layer by layer with powdered metal or other adhesive biomaterials with AI technology. Clinical imaging data are transferred to intelligent software. After artificially choosing regions of interest, the software outputs three-dimensional reconstructions. This method makes it possible to obtain an exact model of the injured part reconstructed from real CT scan data, make detailed plans before surgery, and perform a pre-simulated surgery on the model. After 3DP printing and sterilization, implants can be surgically implanted in place of human tissue injured for various reasons (32). Feng ZH et al. reported that pedicle screw placement with 3DP template guidance in spine surgery is both safe and easier than conventional methods, and the risks of neurovascular damage and radiation exposure are reduced (33).

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies are novel types of digital holographic imaging technologies akin to 3DP. VR is a virtual digital image created by an intelligent computer algorithm that allows surgeons to practice and improve their surgical skills on a virtual system without making severe surgical errors. It cannot be applied in actual surgery due to the paucity of real-world experience. AR technology can provide a virtual reconstruction of the critical region, and by adding the virtual image to the actual image, it can recognize complex anatomical structures and guide the surgeon before or during surgery (34). MR combines virtuality and reality with real-time interaction and exact matching. With a wearable MR device or a device such as Hololens, the surgeon can immerse himself in a more complex surgical world, create a better treatment program, and develop robust doctor-patient communication (35).

AI also has original applications in rehabilitation. Physically and socially supportive robots can be utilized in the rehabilitation of individuals. Smart mobile and wearable devices can be used to gather information to assess the achievement of personalized rehabilitation goals (36). Sensors in wearable technologies can be used to explore whether individuals perform their exercise regimes appropriately (37). Although its longterm effectiveness has not yet been proven, some studies indicate that patients with musculoskeletal dysfunction can be treated with simple mobilization using skilled or sensitive robotic hands (38).

Preventive medicine

Especially in many low- and middle-income countries, obstacles to routine vaccination activities are encountered. Moreover, quarantines imposed during the COVID-19 pandemic further disrupted routine vaccination services, affected people's demand for vaccines, and increased the risk of outbreaks of vaccine-preventable diseases (39). Studies show that vaccination records may contain errors. Some critical information, such as batch numbers on vaccine vials, is missing. Additionally, many vaccination-related data are entered manually by healthcare personnel (40). In recent years, developments in mobile technologies have effectively eliminated gaps in vaccination programs. Scanning vaccine vials with barcoding tools can help reduce data drift and transcription errors by uploading information directly to Internet Information Services (IIS). By scanning patient identification barcodes, it may be possible to provide data entries for demographic information and previous immunization records from electronic medical record software. AI can also help increase vaccination rates through features such as vaccination reminders and promotional campaigns (40). AI programs have effectively monitored COVID-19 cases and vaccine distributions during the pandemic, ensuring fair vaccine distribution (41).

As in the rest of the world, the population over 65 years of age is increasing gradually in Türkiye, and it is estimated to increase to 12.9% of the entire population in 2030 and 22.6% of the entire population in 2060 (42). As life expectancy increases over time, the number of patients with various chronic diseases such as Alzheimer's and dementia, or those who live alone at home and need external care, is rising. In recent years, the use of robots in elderly care has reduced caregivers' burden, and the quality of life of elderly individuals has increased with mobile applications and smart homes. Thanks to social robots, it has been observed that the daily life activities of individuals with dementia increase and their stress decreases (43). AI can be helpful in the follow-up of chronic diseases like diabetes, hypertension, sleep apnea, and chronic bronchial asthma in elderly individuals by using wearable, non-invasive sensors (44).

Disadvantages of AI in healthcare

Although AI has many advantages in the health sector, making decisions instead of humans in diagnosis and treatment and the implementation of these decisions bring some risks. Moreover, the digitalization of diagnosis and treatment processes may cause an increase in job anxiety among people working in this field. Being less physically and cognitively active due to technological dependence may lead to the emergence of psychological or musculoskeletal problems or a decrease in self-esteem because of the social isolation that technological dependence may result in. Feelings of dissatisfaction due to being examined and treated in a digital environment may also occur in patients.

Large datasets are required for AI systems to categorize or predict various tasks appropriately, and this data may be personal or sensitive. Since patient records are confidential in the health sector, there may be problems in terms of data accessibility, confidentiality, and security. The decision-making process of AI relies on the data that is provided. Consequently, AI systems that lack variety or contain flawed data may eventually lead to improper results being deduced and reproduced. Therefore, it might not be appropriate to accept the decisions of AI systems completely. When AI works on insufficient or erroneous data, it may provide incorrect diagnosis or treatment recommendations. In this case, it is uncertain whether this responsibility lies with the technology company that designed or implemented the erroneous algorithm or with the clinician who gave the final decision.

Furthermore, technological innovations may be more expensive and lack the empathy and creativity that humans have; they may produce different results across races and genders (45,46). A study by Obermeyer et al. found racial bias in a commonly used commercial algorithm, highlighting that Black patients were clinically more ill compared to their White counterparts for a given projected risk score. This prejudice was due to the algorithm's prediction of healthcare costs rather than disease, implying that less budget was spent on Black patients than on White patients (47).

Moreover, there is a significant difference between the accuracy, precision, and abilities of AI systems. To illustrate, the progress from GPT-3 to GPT-4 is one of the best examples of groundbreaking improvements in AI's capability to comprehend and process complex data. To clarify this point, GPT-4 passed the bar exam and was in the top 10% of all examinees, whereas GPT-3.5 was in the bottom 10%. The differences in results are due to GPT-4's capability to manage an extensive range of data types, including photographs and written content, as well as the advantage of training on 45 gigabytes of data in contrast to 17 gigabytes of data for GPT-3. This improvement in performance makes GPT-4 more costly to implement than GPT-3 (48). Hence, when AI is utilized in underserved communities, it will be crucial not to be tempted to use cheaper and less effective forms of AI that may exacerbate health inequalities in these communities.

In conclusion, AI technologies are used in numerous fields such as medical imaging, diagnosis, treatment, pandemic response, patient care, preventive medicine, and telemedicine. Nevertheless, as AI advances in healthcare, it brings with it various technical and ethical challenges. AI cannot replace human connections and cooperation, even though it operates reasonably efficiently. Human functions like teamwork and leadership are not likely to be achieved, as machines are not able to form connections with humans. Machine learning's ability to transform data into insights could impact the medical field by taking over much of the work of radiologists and pathologists. However, clinical medicine requires evaluating vast amounts of data—from physical exams to laboratory results, imaging studies to genetic data—and the ability to manage this complexity puts doctors ahead of machines. In the future, it is necessary to prioritize ethical frameworks, and the technical and social aspects of AI to ensure its effective integration into healthcare. The goal is for AI technologies to comply with patient-centered care and ethical procedures with the contribution of clinicians, researchers, managers, and ethicists. Research aimed at improving the fairness, transparency, and reliability of AI is essential to both reduce bias and provide equitable healthcare.

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