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Artificial Intelligence in Healthcare: A Fusion of Technologies

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Abstract

Purpose: This study examines the transformative impact of artificial intelligence (AI) in healthcare, focusing on its applications in medical diagnosis, drug discovery, surgery, and disease management while addressing ethical, technological, and social concerns. **Method:** A comprehensive literature review synthesizes research on AI applications, including AI-assisted diagnosis, drug discovery, robot-assisted surgery, stroke management, and artificial neurons. **Findings:** AI has enabled significant breakthroughs in healthcare, enhancing outcomes in diagnostics, personalized treatments, and surgical procedures. Despite its promise, challenges such as privacy, safety, and equitable access remain critical concerns. **Research Limitations:** The study relies on existing literature and lacks empirical validation of AI models, with its scope limited by the rapid evolution of AI technologies. **Social Implications:** The integration of AI raises concerns about privacy, patient rights, and equitable access, particularly in underserved regions, potentially exacerbating healthcare disparities. **Practical Implications:** The study urges healthcare practitioners to adopt AI tools for improved diagnostics and treatments while advocating for regulatory frameworks to ensure ethical and safe AI integration. **Originality:** This study offers a comprehensive review of AI's transformative role in healthcare, emphasizing ethical considerations and providing actionable insights for researchers and practitioners.

Keywords

Machine Learning, Medical Research, Robot-Assisted Surgery, Artificial Neurons, AI Ethics, AI Security, AI-Assisted Medical Diagnosis, Drug Discovery

1. Introduction

The ability of computers and other technology to simulate human cognition, including learning, thinking, and acting, is known as artificial intelligence (AI) [1].

AI is also known as the study of "intelligent agents", which refers to any agent or device that is able to recognize and comprehend its environment and then react appropriately to increase the likelihood that it will succeed in reaching its goals [2].

Karthikeyan and Priyakumar also describe Artificial Intelligence (AI) as scenarios in which robots are able to mimic human intelligence in terms of analysis and learning, and by extension, solve problems. Machine learning (ML) is another name for this type of intelligence.

The ability of computers and other devices to perform tasks that ordinarily require human intelligence is known as artificial intelligence, or AI. These tasks include prediction and pattern recognition, among other things. An artificially intelligent computer is one that can make decisions, learn new things, and take action even in unfamiliar circumstances.

1.1. Artificial Neural Networks: The Core of AI Systems

Artificial Intelligence usually comprises a system that is composed of hardware and software. Algorithms are of special importance to AI from a software standpoint. An AI algorithm can be executed conceptually using an artificial neural network (ANN) [3]. It is a simulation of the human brain, which consists of a network of connected neurons with weighted communication channels between them [4]. A single neuron can respond to several stimuli from nearby neurons, and the network as a whole can alter its state in response to several environmental inputs [5]. Because of this, a neural network (NN) can produce outputs in reaction to external stimuli, much like the human brain does in response to various environmental alterations [6]. Usually, NNs are multi-layered structures with different topologies. In order to identify common features in test data and respond to the presence or absence of those features in new data instead of reacting to system feedback, researchers have developed NNs that can perform the following tasks: supervised learning, which involves inferring a function that maps an input to an output based on example pairs of inputs and outputs; unsupervised learning, which involves learning from test data that has not been labeled, classified, or categorized; and reinforced learning, which involves acting in the given environment to maximize rewards and minimize penalties, both according to some sort of accumulative nature [7].

As processing power has increased, neural networks (NNs) have become "deeper", or more layers of neurons are integrated into the network to simulate a human brain and perform learning [8]. Furthermore, other functions can be added to the NN, such as the ability to combine feature extraction and classification functions into a single deep network, which is why the term "deep learning" is used in the technical context [9].

AI mostly addresses the application of NN algorithms on a physical computing

platform from a hardware standpoint. Using a general-purpose central processing unit (CPU) in a multithread or multicore, setup to implement the NN algorithm is the simplest method [10]. It has been found that CPU and GPU co-processing is more effective than CPU alone, particularly for spiking NNs [11].

1.2. The Role of Artificial Intelligence in Modern Healthcare

Artificial Intelligence (AI) in healthcare refers to the use of computers to analyze and react to medical data, usually in an effort to forecast a particular outcome [12]. Health care refers to the process of providing or receiving medical attention. Receiving medical attention helps in the prevention and treatment of conditions that might reduce a person's quality of life and shorten their life expectancy. Despite the impression that it is a relatively recent idea, human health care has a far older history. The healthcare sector is crucial to a productive and healthy society, which makes it one of the most significant sectors in the broader big data ecosystem [13].

Medical data processing with AI could really be the difference between life and death. AI can help healthcare workers, such as doctors and nurses, in their daily work. AI therefore has the potential to be a very effective tool in the global public health battle against pandemics and epidemics. Applications of AI were originally used for biomedical issues in the 1970s [14]. Since then, the healthcare industry has seen a transformation because to the growth of AI-powered applications that improve patient outcomes, lower costs, and increase overall efficiency. In the dynamic realm of healthcare, artificial intelligence chatbots have emerged as innovative tools, reshaping traditional healthcare approaches [15].

Artificial Intelligence has several uses in healthcare and is growing rapidly. Using AI, healthcare providers may find it simpler to manage patient data and administrative duties. Some scientists claim that AI in healthcare can do tasks just as well as humans [16]. We examined artificial intelligence's rapid rise in healthcare, its use, and other related areas.

1.3. Basic Concepts

The terms linked to artificial intelligence are defined in **Table 1**.

In addition, smart watches, telehealth, telemedicine, mobile Internet devices (MIDs), personalized healthcare, and mobile health (mHealth) are all included in the category of digital technologies for health called Digital Health Technologies [29], and artificial intelligence, metaverse, and data sciences are some of the more recent technology innovations that are having an impact on intelligent healthcare [30]. By using new methods of monitoring therapy adherence, such as wirelessly observed therapy (WOT), these technologies improve prevention, discover deadly diseases early, and enable remote management of chronic diseases that are not centrally located near traditional care settings [31]. With the advent of minimally invasive and disruptive medicine, the most promising new approach is to promote and distribute health services in any location, at any time. In the wake of COVID-

19, the use of AI in digital health modalities is growing [32].

Table 1. Definition of terms related to AI.

Term	Definition
Artificial intelligence (AI)	The science and engineering of building intelligent computers utilizing algorithms or principles that the machine shadows to imitate human cognitive capabilities, such as learning and problem solving, is known as artificial intelligence (AI) [17]. It seeks to imitate cognitive processes in humans. Due to the expanding availability of health data and the quick development of analysis methodologies, it brings about a perspective change in the healthcare sector [18].
Machine learning (ML)	ML is a branch of AI technology designed to increase the productivity and precision of medical professionals. Additionally, it refers to several statistical methods that let computers pick up knowledge from experience without needing to be explicitly programmed. Usually, this learning manifests as changes to an algorithm's operation [19]. It is also a technology used in healthcare that helps medical personnel take care of patients and manage health data. Artificial intelligence is used in this application, which entails teaching computers to think and learn like people [20].
Distributed Ledger Technology (DLT)	Data logging and data transmission over several data storage (ledgers) is made possible by the novel and quickly expanding technique known as DLT [21]. It can empower patients to take ownership of their data, which will ultimately foster confidence in a sector that is important to all of us [22]. An innovative and cutting-edge technique for processing electronic health record data in a clever, robust, and secure manner is described by DLT coupled with AI [23].
Natural Language Generation (NLG)	It is the branch of artificial intelligence that works with building computer programs that, given an underlying non-linguistic representation of information, can generate legible texts in different human languages [24].
Natural language processing (NLP)	The term "natural language processing" (NLP) refers to the area of research that focuses on how computers and human language interact [25]. Electronic healthcare systems can easily understand unstructured healthcare data because natural language processing (NLP) algorithms can translate, interpret, and evaluate the data's grammatical structure. In addition to cutting expenses, these methods raise healthcare standards [26].
Transformer	Critical to deep learning, Transformer has widespread application in computer vision (CV), speech processing, and natural language processing (NLP) [27]. Electronic health records, medical imaging, and COVID-19 detection are three areas where transformers are useful [28].

Particularly after COVID-19 devastated the world healthcare system, artificial

intelligence, machine learning, and digital health technologies have propelled a revolution in the healthcare sector [33]. Specifically, AI is currently incorporating new technologies—like the Internet of Things (IoT)—into consumer-use DHTs. It is anticipated that the Internet of Things will become the intelligence of things as Artificial Intelligence and Machine Learning are extensively used in healthcare systems [34]. Humans in general have reacted favorably to intelligent medical technology, or AI-powered medical technology, since it enables the 4P framework for medicine namely predictive, preventative, personalized, and participatory and consequently, patient freedom. It has already been demonstrated that incorporating AI into healthcare will enhance healthcare delivery, speed up health services, and reduce healthcare costs [35].

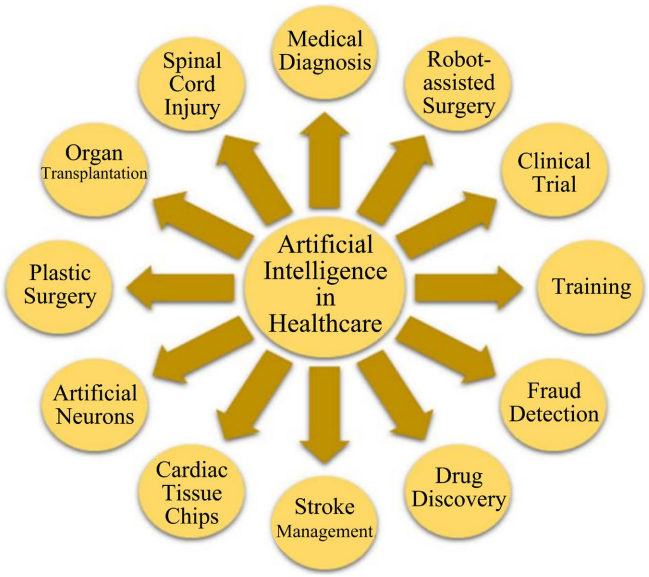

Figure 1. Application of artificial intelligence in healthcare [36].

By giving them access to patient data, digital health solutions give medical professionals a more comprehensive picture of their patients' health. Additionally, they enable doctors to give their patients more health-related facts [37]. The collection of data from various sources, including wearables, telemedicine, mHealth, telehealth, MIDs, and other AI-powered medical technology, results in big data. This data accelerates the use of machine learning (ML) and artificial intelligence (AI) in healthcare systems by allowing these sources to learn from the data they obtain, including research information, user experience, and big dataset analysis [38].

Furthermore, patient healthcare records, or electronic health records, contain a variety of data of patients. By connecting these health statistics with cutting-edge AI technologies, precise insights into patient treatment can be obtained. AI has also become a popular option for big data applications in the medical field [39]. Big data analytics also helps healthcare providers to enhance clinical services by employing analytical algorithms to improve EHRs. Better data analysis is achieved

through these analytics, which also use AI advancements to filter large data on multiple criteria [40]. The purpose of this review is to shed light on AI's involvement in healthcare, with a particular emphasis on the following important areas in **Figure 1**. AI is widely employed in many sectors of healthcare to enhance patient health outcomes and offer healthcare at reduced costs. We've covered how artificial intelligence is being applied to a range of healthcare and related products and applications in this review article.

2. Methodology

This study adopts a comprehensive literature review technique to evaluate the influence and applications of artificial intelligence (AI) in healthcare. The technique is structured into three primary stages: data gathering, data analysis, and synthesis of key findings.

2.1. Data Acquisition

The first phase entailed identifying relevant literature on the application of AI in healthcare. A thorough search was undertaken utilizing academic databases, including PubMed, IEEE Xplore, Google Scholar, and ScienceDirect, to extract peer-reviewed articles, conference papers, reports, and case studies published between 2010 and 2023. Search phrases included "artificial intelligence in healthcare", "AI-assisted medical diagnosis", "robot-assisted surgery", "AI in drug discovery", "stroke management using AI", and "artificial neurons in medicine". Boolean operators like "AND" and "OR" were employed to ensure a comprehensive search. Inclusion criteria were as follows:

- Studies that focus on AI applications in healthcare.
- Research that highlights ethical, technological, or societal consequences of AI in healthcare.
- Articles published in English and peer-reviewed.

Exclusion criteria included studies that focused only on AI outside of healthcare, non-peer-reviewed articles, and papers not directly addressing the major areas indicated in the goal of this research.

2.2. Data Analysis

The analysis phase includes categorizing the literature based on the major emphasis of the AI application. Articles were categorized into five categories:

1) AI-assisted medical diagnostics,
2) Drug development and medical research,
3) Robot-assisted surgery,
4) AI in stroke therapy, and
5) Artificial neurons. Key details from each publication were retrieved, including the individual AI technologies mentioned, their healthcare applications, and any highlighted ethical, technological, or social concerns.

The qualitative analysis method was utilized to discover repeating themes,

trends, and issues in the literature. This strategy helps to integrate results on the practical applications of AI and the ethical challenges that follow its adoption in healthcare settings. Textual data were tagged based on important themes, and commonalities were mapped across diverse research to find patterns and emerging technologies in AI healthcare applications.

2.3. Synthesis of Key Findings

The third phase entailed combining the results from the analyzed literature. The key findings were categorized according to the different uses of AI in healthcare, with an emphasis on the technological breakthroughs, benefits, and limitations. Ethical considerations such as privacy, patient autonomy, data security, and the repercussions of AI-driven judgments in healthcare were also explored.

This assessment technique gives an organized and complete overview of how AI is currently being deployed in healthcare, showing both its transformational potential and the limitations that need to be solved for wider adoption.

3. Healthcare Uses of Artificial Intelligence

3.1. AI-Assisted Medical Diagnosis

Artificial Intelligence is widely applied in medicine, where it can help progress treatment, care for patients with chronic illnesses, suggest targeted actions for complex conditions, and enhance the standard of medical care. Additionally, the development of different AI techniques has led to the early detection, identification, and management of referrals for diseases [41]. AI is a potent image analysis technology that radiology experts are using more and more to reduce diagnostic errors in the context of prevention and to diagnose various diseases early.

Artificial intelligence (AI) is a clever and useful technology that cardiologists can utilize to enhance their decision-making while evaluating ECG and echocardiogram charts. According to a paper from an Oxford hospital, the Ultromics platform uses artificial intelligence (AI) to analyze echocardiogram scans, which identify ischemic heart disease by sensing heartbeat patterns [42]. Using body imaging modalities, AI has also shown promising results in the early diagnosis of diseases like skin and breast cancer, eye conditions, and pneumonia [43]. The onset of diabetes was predicted in real time using ML models in a recent study. Based on the findings, the most effective model for predicting the various diabetes factors was a two-class augmented decision tree [44].

An AI-powered computed tomography device aid is the AI-RAD Companion Chest CT. The AI-RAD companion automates picture dataset post-processing using AI-powered algorithms. Automating routine procedures with repetitive steps and a large patient load can let radiologists concentrate on more important matters. Compared to hand comments, which take 30 minutes to calculate severity scores, our system can do it in roughly 10 seconds every case. These results can be used to monitor the progression of abnormalities in COVID-19 patients and promptly assess the severity of the lung infection [45]. From the day of its

founding to the present, these developments show how artificial intelligence (AI) has surpassed human intelligence. In some tasks, it's predicted that AI will eventually outperform humans, which could be advantageous for people [46]. By using AI-powered algorithms to generate medical images, AIRad Companion helps radiologists diagnose patients more accurately and with less effort and error.

As can be seen above, In the realm of artificial intelligence (AI) applications in medical imaging, both the Ultromics platform and the AI-RAD Companion Chest CT stand out as powerful tools. However, they cater to different medical needs and exhibit unique trade-offs in functionality, precision, and scope. The Ultromics platform and AI-RAD Companion Chest CT represent two transformative AI-driven tools in medical imaging, each catering to distinct needs. Ultromics specializes in echocardiography, offering unmatched precision in cardiac imaging, predictive analytics for heart disease progression, and automation of manual measurements, making it ideal for cardiology-focused institutions. However, its limited scope and high cost may restrict adoption. In contrast, AI-RAD Companion Chest CT supports chest CT imaging, offering broader functionality by analyzing lung, cardiovascular, and musculoskeletal conditions. It seamlessly integrates into existing workflows, automates quantifications, and provides cost-effective multi-organ diagnostics, making it suitable for multidisciplinary healthcare facilities. While Ultromics offers superior accuracy in its niche, AI-RAD Companion delivers versatility and value for diverse chest imaging needs. The trade-off between specialization and generalization, cost, and integration capabilities makes the choice highly dependent on an institution's clinical focus and resource availability. Both tools demonstrate the potential of AI in transforming healthcare.

3.2. Drug Discovery and Medical Research

Drug discovery AI methods have evolved from machine learning, bioinformatics, and cheminformatics models [47]. These innovations can significantly cut down on the high expense and length of time associated with finding new drugs [48]. Pharmaceutical science has been paying close attention to artificial intelligence technologies as deep learning algorithms have produced better outcomes when predicting qualities. AI's use in early medication development has significantly increased. According to a previous study, Eve, an AI-based robot scientist, completed the medication development process quickly and affordably [49]. Moreover, the development of AI tools in healthcare fosters the creation of novel COVID-19 viral genotypes and variations. Also, it helps in the development of medications and vaccines to obtain potent therapeutic and preventive agents for containing the COVID-19 pandemic [50].

Researchers at Hyderabad, India's TCS Innovation Labs are using artificial intelligence (AI) to find new chemicals that could target particular regions of the novel coronavirus (SARS-CoV-2) [51]. Artificial Intelligence in Medicine (AIM) has seen a substantial growth in specialization in recent years due to the growing impact of AI on the medical field. This underscores the necessity of conducting a

systematic review of study findings and advancements in Artificial Intelligence Medicine. Microsoft's Hanover Project in Oregon has looked at scientific data to personalize a patient's cancer treatment plan. Generative AI can be utilized in clinical research to generate synthetic data that will improve datasets and boost diversity [52].

Furthermore, metaverse apps allow researchers to conduct experiments in a controlled and immersive environment. Using the metaverse can help researchers who are physically separated from one another in their study collaboration. Through the metaverse, they can do joint study in a virtual environment that is comparable to that of researchers in the same room [53]. ChatGPT, another AI-based application, may be utilized in clinical studies to facilitate data gathering and offer details regarding clinical trials. It can assist in identifying important findings and distilling relevant papers, enabling medical researchers to skillfully manage vast amounts of Internet-based material. Furthermore, ChatGPT is utilized by a chatbot to assist medical researchers in interpreting medical terminology. But if chatbots are used in medical research, further moral questions might surface [54].

3.3. Robot-Assisted Surgery

Over 4000 surgical robots are utilized in practice every day, demonstrating the widespread adoption of these devices [55]. Robotic surgical instruments enable physicians to make incisions in a patient's body and carry out various surgical procedures. This kind of surgery has the potential to lessen pain, bleeding, scarring, infection, and recovery time following surgery as compared to normal surgical methods. Controlled access surgery has been transformed by the development of robotic technology, which have addressed some of the drawbacks of the laparoscopic approach [56]. Robotic systems are not meant to replace surgeons or do tasks on their own; rather, they are designed to function more ergonomically and with greater flexibility. That is why they are called "master-slave systems"-the surgeon operates them [57].

3.4. AI in Stroke Management

One common and frequently occurring condition that claims lives is stroke [58]. Recent years have seen an increase in the use of AI techniques in stroke-related trials, particularly in the three critical areas of stroke care-early illness prediction, diagnosis, and treatment [59]. Machine learning programs may be able to distinguish an ischemic stroke from a hemorrhagic or any other type of stroke, reducing the risk of ignoring cases such as meningitis, coma, encephalitis, acute demyelination, abscess, and subdural hematoma.

3.5. Artificial Neurons

Alzheimer's disease is a neurological disorder that causes emotional, behavioral, and motor problems as well as the gradual loss of a person's spirit. It is devastating

for both the patient and their family [60]. Artificial neurons that might be implanted into the brain to heal damage caused by neurodegenerative disorders like Alzheimer's disease have been developed by an international research team. The researchers created tiny silicon devices called chips that mimic the operation of real neurons by simulating biological ion channels [61]. The goal is to create these chips in order to fix the essential functions of the nervous system and undo the damage caused by autoimmune reactions. The silicon chips are perfect for use as medical implants or in other bioelectronic devices because they function similarly to biological neurons and only require 140 nanowatts of electricity, which is one-billionth of the power required by the microprocessors used to create artificial neurons [36].

4. Challenges with Using Artificial Intelligence in Healthcare

4.1. Technical Challenges

In theory, AI models should have straightforward characteristics and capabilities so that Health Care Professionals (HCPs) can effectively use them [62]. However, there are a few obstacles to the use of AI in healthcare. These include the high cost of enhancing data validity, the difficulty of creating and maintaining the IT infrastructure needed to support the AI process, and the increased expenses of storing and backing up data for research. Furthermore, bias, brittleness, and inapplicability outside of the training domain are only a few of the flaws that AI algorithms may have [63]. In order to solve the concerns with cost, technology infrastructure, and the use of AI systems for HCPs, healthcare providers should create and execute an efficient strategic plan for using AI in healthcare. According to [64], physicians' opinions on the use of AI in healthcare were influenced by a number of factors, including workload, desire to acquire AI training, risks associated with using AI, and its reliability. Another factor that has been shown to impede the use of AI is the absence of accountability for AI. To enable AI to be used securely in the future, it is advised that medical and nursing curriculum include AI training.

4.2. Ethical and Social Challenges

The effectiveness of AI raises ethical concerns about a number of issues, including accountability when AI is used in decision-making, the capacity of AI to make incorrect judgments, issues with AI yield authentication, the confirmation of the protection of sensitive data, inherent biases in the data used in AI system tests, preserving public confidence in the development and benefits of AI systems, impacting the public's sense of dignity and social isolation in care settings, implications for HCPs' roles and skill requirements, and the potential for AI to be used maliciously.

AI may provide safety and reliability challenges when it comes to decision-making, treatment delivery, and equipment control in the healthcare industry. AI may make mistakes that are difficult to identify or have unfavorable outcomes that could have dire repercussions [65]. Furthermore, explainability is a primary

barrier to AI's application in a variety of fields. In order to increase the acceptance of AI-based applications in the decision-critical sector and overcome the lack of understanding of these applications, "Explainable artificial intelligence (XAI)," a branch of AI research, is necessary [66]. XAI in healthcare enables physicians and patients to understand the reasoning behind diagnosis conclusions made by AI [67]. Because these healthcare applications use private, sensitive data that is restricted by legal restrictions, they also present data privacy and security challenges. If sensitive medical data needs to be analyzed without decrypting it, homomorphic encryption allows computations to be performed on encrypted data. Though resource-intensive, this can be useful for scenarios like research where direct access to plaintext data is not necessary [68] [69]. AI may be used to protect healthcare computers against cyberattacks and identify them, but it can also be exploited to access sensitive data or flooded with inaccurate or biased information in ways that make it difficult to track down [70]. Therefore, before incorporating AI into healthcare systems, it is important to emphasize key medical-ethical values including beneficence, autonomy, equity, and non-maleficence [71].

Ethical considerations in AI-powered healthcare are exemplified by situations concerning bias, transparency, and accountability. For example, a 2019 study demonstrated that an AI system employed by U.S. healthcare providers to allocate resources significantly preferred white patients over Black patients, even when both groups exhibited equal medical needs [72]. This occurred because the algorithm relied on healthcare spending as a proxy for health state, inadvertently reflecting existing racial inequities in access to care. This case emphasizes the need of using representative datasets to train AI algorithms to ensure equitable treatment.

Another instance is AI applications in cancer diagnoses, where technologies like IBM Watson for Oncology attracted criticism for making therapy recommendations that were not necessarily clinically proven [73]. The lack of explainability in how these AI systems obtained their results produced trust concerns among clinicians, who were unwilling to adopt them in practice. This underlines the need for transparency and explainable AI (XAI) to promote reliability in clinical decision-making.

5. Disadvantages of Artificial Intelligence in Healthcare

While AI has proven to be beneficial in the healthcare industry, there are certain known drawbacks to this healthcare technology [74]. Some medical professionals dispute that AI is rapidly taking the place of healthcare professionals and worry that AI may destroy rather than advance the medical field [75].

Not only do AI tools lack human empathy, but they are also highly expensive [76] and advanced training is needed to use them. Another factor limiting AI tools in some cases is a deficiency of reliable data, which the AI needs to keep "learning."

For machine learning and deep learning models to accurately classify or predict

different tasks, large datasets are required. However, given that health care organizations typically are reluctant to share health data and that patient records are private, the healthcare sector faces a combination of challenges when it comes to data accessibility [77].

6. Conclusions

There are several uses for AI in the healthcare profession. These technologies are designed to support medical imaging and diagnostic services, combat pandemics, offer virtual patient care, boost patient engagement and adherence to treatment plans, lessen the administrative burden on healthcare providers, stimulate the development of new drugs and vaccines, track patient compliance with exercises, and perform gait analyses for technology-assisted rehabilitation.

But as AI advances in healthcare, it also faces ethical and technical obstacles. Because it uses private and sensitive data that is restricted by legal panels, it presents concerns about data security and privacy. AI is more advantageous when it operates effectively, but it can't take the place of the interpersonal relationships that build teams. Goals related to human activities like cooperation and team management cannot be accomplished by computers since they are unable to develop human-machine bonds. This work contributes to the body of research on the application of artificial intelligence (AI) in medical diagnosis, drug discovery and research, robotic assisted surgery, stroke management, and artificial neurons. Furthermore, this is the most recent revision to the literature addressing the technological, social, and ethical difficulties HCPs encounter when implementing AI in healthcare.

Further research could concentrate on doing a more thorough systematic literature review as this study is based on a broad literature evaluation, which can offer a deeper understanding of this research issue.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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