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Review Article

Artificial Intelligence: Applications and Effectiveness in the Healthcare Delivery System

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Abstract

Artificial intelligence (AI) is an umbrella term that denotes the use of a computer to simulate intelligent behavior with minimal or no human involvement. AI implementation will significantly benefit the healthcare industry and people's general health. Although AI cannot wholly replace clinical judgment, it can help medical experts make better clinical decisions. AI unlocks new possibilities for learning, training, exploration, and development. Machine learning (ML) and deep learning (DL) are AI techniques for disease diagnosis, patient risk detection, and appropriate treatment options. Medical data from several sources, including ultrasonography, magnetic resonance imaging, mammography, genomics, computed tomography (CT), and positron emission tomography (PET), are essential to diagnose diseases using AI applications accurately. AI techniques diagnose major diseases in cancer, neurology, ophthalmology, gastroenterology, diabetology, and cardiology. AI has dramatically improved the hospital experience and accelerated patient preparation for home rehabilitation. Algorithm-based AI suggestions are highly systematic and eliminate human inconsistencies and errors. However, the sociological and ethical complexities of AI applications need more consideration, evidence of their economic and medical benefits, and the creation of multidisciplinary methods for their wider deployment. This review aims to investigate, summarize, and simplify AI's origin, development, types, uses (diagnosis and treatment), benefits (self-care, medical training, healthcare administration), limitations, and cost efficacy. It also discusses future perspectives and research on the use of AI in medical diagnosis and treatment.

Keywords: *Algorithm-Based AI; Enhanced Hospital Experience; Enhancing Clinical Judgment; Diagnosis and Treatment; Machine Learning; Simulating Intelligent Behavior*

Abbreviations

AI: Artificial Intelligence; ANN: Artificial Neural Network; AUC: Area Under the Curve; BN: Bayesian Network; CAD: Computer-Aided Detection; CASNET: Causal-Associational Network; CBR: Case-Based Reasoning; CDM: Clinical Decision-Making; CNN: Convolutional Neural Network; CT: Computed Tomography; DL: Deep Learning; EMR: Electronic Medical Record; FDA: US Food and Drug Administration; IoT: Internet of Things; ML: Machine Learning; NIH: National Institute of Health; NLP: Natural Language Processing; NN: Neural Network; PET: Positron Emission Tomography; RBR: Rule-Based Reasoning; RNN: Recurrent Neural Network; RPA: Robotic Process Automation; SUMEX-AIM: Stanford University Medical Experimental-Artificial Intelligence in Medicine

Introduction

Artificial intelligence (AI) involves the study of algorithms that provide robots with the ability to comprehend and reason [1]. Research on AI has been ongoing since the 1950s. Alan Turing (1950) was a pioneer in the development of modern computers and AI [2]. In 1952, Arthur L. Samuel created checker-playing software for IBM, thus popularising "machine learning" (ML). Six years later, at Dartmouth, McCarthy defined AI as "the science and engineering of creating intelligent robots." In 1957, Frank Rosenblatt developed a perceptron built for image recognition. In 1960, Henry J. Kelley formulated the continuous backpropagation model, a simplified version based on chain rules by Stuart Dreyfus in 1962 [3].

In 1964, Joseph Weizenbaum presented Eliza, who could converse using pattern matching and substitution techniques and imitate human speech using natural language processing (NLP) [4]. Then, in 1966, Shakey, 'the first electronic human/mobile robot', was designed and built at the Stanford Research Institute. It could understand complicated instructions and perform necessary tasks rather than following only one-step instructions. This outcome was a turning point in robotics and AI [5].

The 1970 to 2000 era is known as "I Winter"—denoting a period of reduced funding and interest, which resulted in less notable advancements. Despite the lack of widespread attention during this time, AI pioneers continued their research. In 1971, Saul Amarel founded The Research Resource on Computers in Biomedicine at Rutgers University. In 1973, Stanford University Medical Experimental-Artificial Intelligence in Medicine (SUMEX-AIM) was established. This shared computer system enhanced networking capabilities for clinical and biomedical researchers from several universities [6-8]. As a result, the first National Institute of Health (NIH)-sponsored AI in medicine symposium was held at Rutgers University in 1975 [7]. These activities are considered the first interactions between AI pioneers in medicine.

At Rutgers University, Rohan developed a glaucoma consultation program based on the causal-associational network (CASNET) model. It was one of the prototypes to demonstrate the viability of AI in medicine (AIM) [8]. The CASNET system consists of three programs: model-building, consultation, and a database created and maintained by collaborators. The model guides physicians in disease specificity, the standard of care, and tailored treatment plans [9]. In 1976, the program was presented to the public in Las Vegas, Nevada, at the Academy of Ophthalmology convention.

The early 1970s experienced the development of MYCIN, an "awkward chaining" AI system. The system could identify probable bacterial infections and suggest alternative antibiotic treatment options. It could also specify weight-adjusted doses based on patient information entered by the physician and a knowledge base of about 600 rules. MYCIN was the foundation for subsequent rule-based systems, including EMYCIN [7,8]. Eventually, INTERNIST-1, based on the same foundation as MYCIN but with a broader medical knowledge base, was developed to help primary care physicians diagnose diseases. The University of Massachusetts launched DXplain, a decision support system, in 1986.

This application generates a differential diagnosis based on the symptoms entered. In addition, it serves as an electronic medical textbook, providing detailed explanations of diseases and additional sources. By the late 1990s, interest in ML increased, primarily in the medical field.

This renewed interest, coupled with the previous technical breakthroughs, laid the foundation for the current era of AIM [2].

Watson, an open-domain question-answering machine, was developed by IBM in 2007. On *Jeopardy*, a 2011 television quiz show, Watson secured first place by outperforming human contestants. In 2017, Mandy, an automated patient intake chatbot for a primary care clinic, was developed. In addition, Pharmabot, a chatbot developed in 2015, helped young patients and their parents understand more about their prescribed medicines [10,11].

Deep learning (DL) represents a significant step forward in AIM. Unlike ML, which uses a predefined set of attributes and requires human intervention, DL can be trained to categorize data independently. In 2017, the US Food and Drug Administration (FDA) approved the first cloud-based clinical DL application '"arterys" for use in healthcare.

Within seconds, CardioAI (the initial Arterys product) could analyze cardiac magnetic resonance imaging scans and provide important information, including cardiac ejection fraction. Over the years, this application has broadened to include non-contrast CT scans of the head, chest, and musculoskeletal regions and liver and lung imaging [12]. Table 1 details the chronology of AI advances in the last 50 years [3,13].

Year	Research
1950	Alan Turing develops the "Turing Test"
1952	Machine learning
1956	John McCarthy coins the term "AI"
1961	Unimate, the first industrial robot, joins the assembly line at GM
1964	First chatbot: Eliza
1966	Shakey, "first electronic person"
1971	Research Resource on Computers in Biomedicine was founded: by Saul Amarel at Rutgers University
1972	MYCIN was developed
1973	SUMEX-AIM was created
1975	The first NIH-sponsored AIM Workshop Held
1976	CASNET was demonstrated at the Academy of Ophthalmology meeting
1980	Development of EMYCIN: expert rule-based system
1956	Release of Dxplain: a decision support system
2000	Deep learning
2007	IBM began the development of Deep QA technology (Watson)
2010	CAD applied to endoscopy
2011	Apple's virtual assistant, Siri, is integrated into iPhones
2014	Amazon's virtual assistant, Alexa is released
2015	Pharmabot was built
2017	Arterys: First FDA-approved cloud-based DL application in healthcare
2017	Chatbot Mandy: automated patient intake
2018-2020	AI trials in Gastroenterology

Table 1: *Chronology of the development and use of artificial intelligence in healthcare care [3,13]*

Discussion

AI in healthcare

Various healthcare care areas can benefit from AI's exciting potential [14,15]. Healthcare systems around the world have embraced the use of AI to achieve the ''quadruple objective,'' which includes improving the patient experience (increasing productivity and efficacy in care delivery); improving population health; transcribing prescriptions, treating patients remotely, and reducing per person healthcare expenses [16]; and increasing the working conditions of healthcare professionals [17,18]. Figure 1 lists key application domains for Al in healthcare care [19].

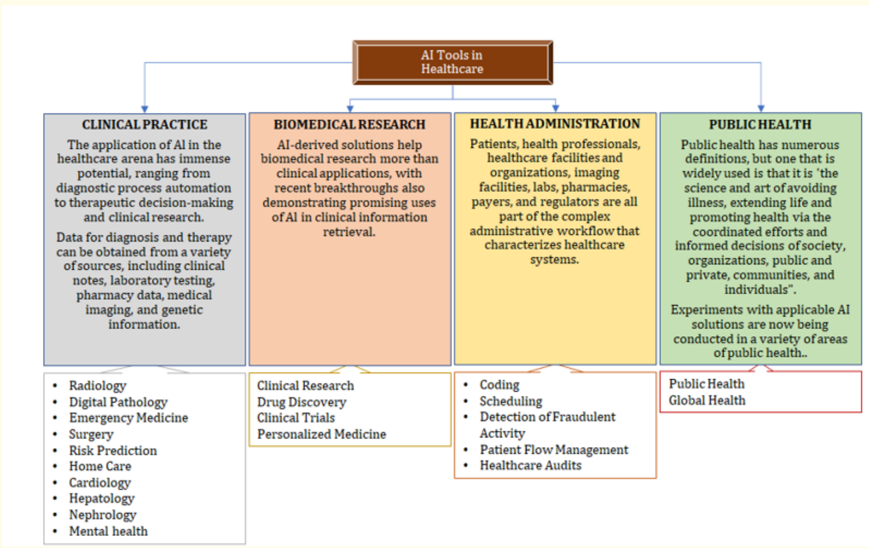


Figure 1: *Application domains for artificial intelligence in healthcare [19]*

AI algorithms are widely used in various areas of healthcare, including diagnostics, the development of treatment protocols, medication research, customized treatment regimens, clinical risk assessment, healthcare data security, image analysis, digital nursing assistants, AI-assisted robotic surgery, and health monitoring [20-22]. The ability to glean the data, process them, and generate detailed results for the user clearly distinguishes AI technology from conventional healthcare solutions. AI achieves these results by using ML algorithms and DL.

These mechanisms can recognize behavioral patterns and develop their logical ways [23]. The daily tasks of medical practice, such as patient care and management of medical resources, can be easily automated with AI [24].

The deluge of healthcare data is the primary reason for the significant increase in new AI applications that enhance the efficacy and efficiency of patient care. Big data-related healthcare applications such as wearable trackers and electronic medical records (EMRs) can be used for novel analyses [25].

Although AI is a relatively newer technology, its algorithms are highly promising in health care, including radiology, pathology, ophthalmology, oncology, diabetes, and cardiology [26]. Physicians prefer to use diagnostic technologies such as CT, ultrasound, mammography, genomics, or MRI to create a detailed 3D map of the affected area. Subsequently, AI technology uses ML and DL models to quickly analyze these system-generated images to identify the attributes of the affected area [18].

Globally, governments increasingly support using pro-AI stances in several disciplines and endeavors. For example, certain governments have actively engaged with AI in healthcare, while others have helped private companies create pertinent AI applications [27].

AI types with healthcare relevance

Machine learning

ML to automate data analysis uses algorithms that recognize repeating patterns in data and gain knowledge from them. There are three basic kinds of ML applications: 1) supervised learning, 2) unsupervised learning, and 3) reinforcement learning (Box 1) [28]. Traditional ML is used most frequently in healthcare care to predict possible successful treatment regimens based on several factors, including patient characteristics and treatment environment [29,30]. Furthermore, ML has been used successfully in orthopedics in biomechanics, orthopedic implant design, prediction of osteoarthritis progression, and robotic surgery [31].

BOX 1 [28]

- ❖**Supervised learning** is training a model on known inputs and output data in order to predict future outcomes.
- ❖**Unsupervised learning** aides in the discovery of hidden patterns or intrinsic structures in input data.
- ❖**Semi-supervised learning** combines both strategies; some learning utilises supervised data, while others use unstructured data.

Box 1

Neural networks

Known since the 1960s, neural networks (NNs) are a more complicated variation of ML. It is used to classify characteristics, such as to predict if a patient will develop a particular disease [30]. An NN comprises networks of closely coupled computer processors or "neurons" that perform concurrent calculations for knowledge representation and data processing. The ability to learn from previous instances, evaluate nonlinear data, manage imprecise information, and generalize these data allows the model to be applied to independent data.

These characteristics have made NNs an attractive analytical tool in healthcare care [32]. For example, in a prospective multicenter investigation of 2380 patients, Rotondano., *et al.* (2011) reported that artificial NN (ANN), based on 68 clinical factors, predicted mortality from non-variceal upper gastrointestinal bleeding with 96.8% precision [33]. Furthermore, AI was used to predict survival in patients with esophageal cancer and survival prognosis in patients with esophageal adenocarcinoma [34]. In addition to these and other similar applications, AI has been used to predict the recurrence and severity of inflammatory bowel disease (IBD) and the possibility of distant metastases in esophageal squamous cell carcinoma [35,36].

Deep learning

Deep learning (DL) is a subset of AI and ML that uses multilayered ANN to deliver state-of-the-art task accuracy [37]. It can identify lesions, generate differential diagnoses, and create automated medical reports. DL is increasingly being applied in radionics to analyze clinically significant characteristics in imaging data that the human eye cannot comprehend. For example, radionics and DL are often used to analyze cancer-related images.

This combination offers enhanced diagnostic accuracy compared to earlier-generation automated image analysis techniques, known as computer-aided detection (CAD). DL is also increasingly being applied for speech recognition, making it a type of NLP [30]. Gargeya., *et al*. (2017) used DL to detect diabetic retinopathy, with 94% sensitivity, 98% specificity, and 5-fold cross-validation [38].

Similarly, Esteva., *et al*. (2017) trained a convolutional neural network (CNN) to differentiate non-melanoma from melanoma skin tumors. The findings showed that CNN performed on par with the experts [39]. In a cohort population, Weng., *et al*. (2017) demonstrated how a CNN might be used to predict cardiovascular risk [40].

Natural language processing

Natural Language Processing (NLP) is a branch of AI focusing on language comprehension and generation [41]. It aims to eliminate the gap between the operating languages used by people and computers [28]. It helps to analyze and extract data from unstructured sources, automate question answering, sentiment analysis, and summarize text [41]. Several areas of healthcare have significantly benefited from NLP. Box 2 details some NLP applications [42].

BOX 2 [42].

- ❖**Efficient billing**: Creating medical codes and extracting data from doctor's notes for billing purposes.
- ❖**Authorization approval**: Preventing delays and administrative mistakes by utilising information from medical notes.
- ❖**Clinical decision support**: Whenever necessary, assist the healthcare team's members in making decisions (for instance, predicting patient prognosis and outcomes).
- ❖**Medical policy assessment**: Creating suitable care guidelines and providing clinical recommendations.

Box 2

Rule-based systems, production systems, and expert systems

These systems are the most basic types of AI. Rules are used to represent knowledge that has been programmed into the system. Expert systems are programs that simulate the thought processes of human experts while solving knowledge-intensive problems. They are mainly responsible for the definitions of rule-based systems. Instead of describing knowledge as a set of tangible things in a declarative, static manner, a rule-based system displays knowledge as a set of rules that instructs what to do or conclude in various contexts.

The components of a rule-based system are a collection of IF-THEN rules, a group of facts, and some interpreters that regulate how the rules are applied in light of the facts. The objective of an expert system is to transform the data into a set of rules by using the information from an expert system. The performance of an expert system will be similar to that of an expert when exposed to identical data [43].

Bayesian networks

Bayesian networks (BNs) are graphical models that closely resemble clinical decision-making (CDM). They combine knowledge and data to reflect the causal probabilistic correlations between variables and provide information on the mechanisms responsible for disease development [44]. BNs are increasingly being used in CDM models in medicine. This popularity stems from their ability to perform the following tasks: (i) model complicated situations with causal relationships where a considerable degree of ambiguity is present; (ii) incorporate information from several sources, including data and expert opinions; (iii) display the information as an interpretable graphical structure; and (iv) tailor treatments and provide both diagnostic and prognostic rationale [45].

Hybrid intelligence systems

A hybrid intelligence system combines AI approaches that can be used in healthcare to address challenging medical concerns. The two most frequently used AI methodologies that may be coupled are case-based reasoning (CBR) and rule-based reasoning (RBR). Both approaches use medical information and domain expertise to diagnose patient concerns [46]. In addition, hybrid intelligence systems can influence decision-making, remote monitoring, logistics in the healthcare sector, medical diagnostics, and emerging information systems [47].

Physical robots

Robots perform predefined activities such as lifting, relocating, welding, assembling goods in factories and warehouses, and sending supplies to hospitals. The new generation robots are highly collaborative with people and quickly learn a desired task with minimal guidance. In addition, they are becoming smarter by integrating additional AI capabilities into their "brains" [30]. Robots can be beneficial in several circumstances, such as evaluating changes in human performance during rehabilitation [48]. First allowed to be used in the United States in 2000, "surgical robots empower surgeons" "superpowers" by improving their ability to visualize and make accurate and less invasive incisions and suture wounds [29], while human surgeons continue to hold the thread for crucial decisions. Robotic surgeries are preferred in gynecological, prostate, and head and neck operations [30].

Automating robotic processes

This technology performs organized digital administration tasks, such as those involving information systems, as if they were human users following a script or set of rules. They are cost-efficient, easy to program, and more transparent in their activities than other types of AI. To behave as a semi-intelligent user of information systems, robotic process automation (RPA) incorporates a combination of workflow, business rules, and a "presentation layer" interface with information systems. They are used in the healthcare industry for routine tasks, including billing, prior authorization, and updating patient records. When integrated with other technologies, such as image recognition, they may extract data from faxed photographs and feed them into transactional systems [30,49].

AI augmentation in diagnosis and treatment

It is impossible to prevent infectious diseases, but preventing their spread requires ongoing research and data collection. Thus, responding quickly and with correct data considerably impacts people's social and financial lives worldwide [18].

Researchers have used AI-based approaches such as ML and DL models to identify skin, liver, and heart diseases and Alzheimer's disease, pneumonia, and cancer, which warrant an early diagnosis. Extensive research has provided strong evidence for using AI in therapy decisions and disease diagnosis. For example, in a real-world investigation, Dabowsa., *et al*. (2017) used a backpropagation NN to diagnose skin diseases to achieve the best treatment precision [50]. Ansari., *et al*. (2011) employed a recurrent NN (RNN) to diagnose liver disease caused by the hepatitis virus with 97.59% precision, while a feedforward NN provided 100% accuracy [51].

Owasis., *et al*. (2019) achieved an area under the curve (AUC) of 97.057 in the diagnosis of gastrointestinal conditions using an RNN and long- and short-term memory [52]. In addition, ANN has been used to identify gastro-esophageal reflux disease and atrophic gastritis and to predict outcomes for gastrointestinal bleeding, survival of esophageal cancer, IBD, metastasis in colon cancer, and gastro-esophageal squamous cell carcinoma [53].

Tigga., *et al*. (2020) sought to determine the risk of developing diabetes by analyzing the patient's lifestyle, daily routines, health issues, and other factors. The survey included 952 participants, distributed offline and online. A similar method was used in the Pima Indian Diabetes database. The random forest classifier stood out as the best algorithm [54]. Alfian., *et al*. (2018) demonstrated a customized healthcare monitoring system that uses Bluetooth-based sensors and real-time data processing. It collects information on vital indicators of the user, including blood pressure, heart rate, body weight, and blood sugar, through sensor nodes and transmits them to a smartphone [55].

Oikonomou., *et al*. (2019) provided an overview of the data types observed in chronic disease settings. In addition, they presented extreme value theory using multiple ML methods to estimate better the severity and hazard of chronic illnesses [56].

In a study by Ijaz., *et al*. (2018), personal healthcare gadgets that recognize and assess a person's biological signals were used in conjunction with the Internet of Things (IoT) to create a healthcare monitoring system for home-based patients with diabetes and hypertension. The system immediately informs the medical staff when the patient has an emergency event [57].

Shabut., *et al*. (2018) introduced a test to develop a clever, adaptable, empowered master to perform a predetermined TB discovery. They administered an AI approach to achieve parallel grouping, starting from the 19th lower request shading minutes. Their test demonstrated 98.4% precision, especially for identifying the explicit counteracting agent identification for TB antigen [58].

Srinivasu., *et al*. (2021a, b) suggested an efficient method that could help clinicians diagnose skin diseases. The system coupled NNs with MobileNet V2 and long- and short-term memory and demonstrated 85% accuracy, outperforming other state-of-the-art deep models of DL NNs. The system used this approach to evaluate, process, and relegate the expected picture data based on several criteria. This system demonstrated higher precision and quick turnaround than the conventional Srinivasu PN approaches, which have a 78% accuracy rate [59,60].

Dilsizian and Siegel (2014) described the potential use of an AI system in diagnosing cardiac diseases using imaging scans [61]. Many organizations have also used CAD models on photographs and movies from narrowband imaging, chromoendoscopy, and endocystoscopy to examine optical biopsies of colorectal polyps.

The diagnostic accuracy of these CAD models ranges from 84.5% to 98.5% [62]. Tran., *et al*. (2019) identified research lacunae and proposed future research objectives based on global trends and breakthroughs in AI applications associated with stroke and heart disease [63].

A study published in *The Lancet* by Liu., *et al*. (2019) found that AI is at least as good as humans when assessing medical images such as MRI, X-ray, and CT scans. AI, in contrast, did not exceed human diagnosis. In a small subgroup of trials comparing diagnostic accuracy between AI and physicians, DL algorithms successfully recognized disease conditions in 87% of the cases compared to clinicians (86%). At 93% and 91% precision rates, respectively, AI and HCP achieved comparable success rates in the analysis of medical images from healthy individuals [64].

Cazacu., *et al*. (2019) combined ANN with endoscopic ultrasound to distinguish chronic pancreatitis from pancreatic carcinoma, with 95% sensitivity and 94% specificity [65].

ENDOANGEL, a CNN-based system developed in 2019, provides an objective evaluation of bowel preparation every 30 seconds during the colonoscopy withdrawal phase, with 91.89% precision. A recent randomized controlled trial found that ENDOANGEL-assisted colonoscopy, compared to unaided colonoscopy, significantly reduced the number of adverse drug reactions (9% vs. 17%; OR, 2.15; 95% CI, 1.31 - 3.62; p = 0.0026) [66].

AI applications in healthcare

AI technologies have significant potential to improve safety within and outside hospital settings by providing solutions to predicted harms, gleaning existing and new data, and serving as part of quality improvement activities. For example, AI can help to lead preventative and early intervention initiatives by identifying patients at high risk of injury in the hospital. Similarly, AI can be used in outpatient, community, and home settings.

Together with digital methods, AI technologies can enhance patient-provider communication and reduce the incidence of avoidable damage. Currently, accessible information is beneficial, but additional data made available by technologies such as sensors can improve forecasts [67].

Increasing research has demonstrated how AI technologies may be applied in various healthcare settings, including chest radiograph interpretation, cancer detection on mammograms, CT scan analysis, brain tumor identification on MRI, and prediction of Alzheimer's disease progression using PET.

Applications have also been demonstrated in pathology, including the detection of malignant skin lesions, the interpretation of retinal imaging, the detection of arrhythmias, the use of RNA and DNA sequencing to direct immunotherapy, and the detection of hyperkalemia from electrocardiograms.

Also, AI has improved the interpretation of genomic data, the identification of genetic diseases by facial features, and the evaluation of embryo quality to increase the success of *in vitro* fertilization. It has also assisted in diagnosing polyps through colonoscopies and genomics [68].

AI outperformed the standard algorithm the American College of Cardiology guidelines provided in predicting CV risk [69]. It has also been used to accurately predict response to medication therapy in patients with Alzheimer's disease by evaluating amyloid imaging data [36,69]. AI can be applied in low- and middle-income countries to improve TB detection in a support system. It can be used to analyze staining images or scan ordered X-rays for patients with TB and COVID-19 symptoms [70].

AI is predicted to reduce treatment costs by up to 50% while improving patient outcomes by 30% - 40% [71]. Virtual AI treatment based on cognitive-behavior therapy can help patients with social anxiety [72]. AI has also been used in clinical nephrology under various circumstances. For example, it is beneficial in predicting the reduction of the glomerular filtration rate in patients with polycystic kidney disease and in determining the risk of progression of IgA nephropathy [73].

In the Netherlands, AI technologies are used to analyze the healthcare system, identifying treatment errors and workflow inefficiencies, thus reducing avoidable hospitalizations [2].

The Da Vinci robotic surgical system developed by Intuitive Surgical has transformed surgeries, primarily those of urology and gynecology. 3D vision and several magnification options in the robotic arms of the device allow the surgeon to make tiny incisions with great precision [74].

In addition to existing technologies, certain breakthroughs in various development stages will help physicians improve their profession. For example, Watson Health, developed by IBM, effectively detects signs of cancer and heart disease [2]. In a double-blind validation study, Somashekhar., *et al*. (2017) demonstrated that it is a highly reliable AI system for use in the detection of cancers. Similarly, IBM Watson effectively uncovered new RNA-binding proteins that were changed in amyotrophic lateral sclerosis [75].

AI may also improve knowledge sharing by collecting vast amounts of operating video and EMR data from surgeons worldwide to create a library of methods and approaches that can be compared to results. Computer vision may be used in video databases to grasp unusual instances or anatomy and to understand and integrate data from the preoperative, intraoperative, and postoperative stages of treatment. Such sophisticated studies have the potential to provide disruptive innovation in the generation and validation of evidence-based best practices to improve care quality. AI and multimodal data integration can improve surgical decision-making throughout all stages of treatment for both individual patients and the entire population [76].

The AI-assisted care program at Stanford University is amplifying its efforts to include healthcare conversational agents and Intelligent Hand Hygiene assistance. Hand hygiene assistance uses depth sensors and computer vision technologies to ensure complete hand hygiene for physicians and nursing personnel, minimizing hospital-acquired illnesses [77]. Figure 2 details the general deployment of AI technology in healthcare settings [27].

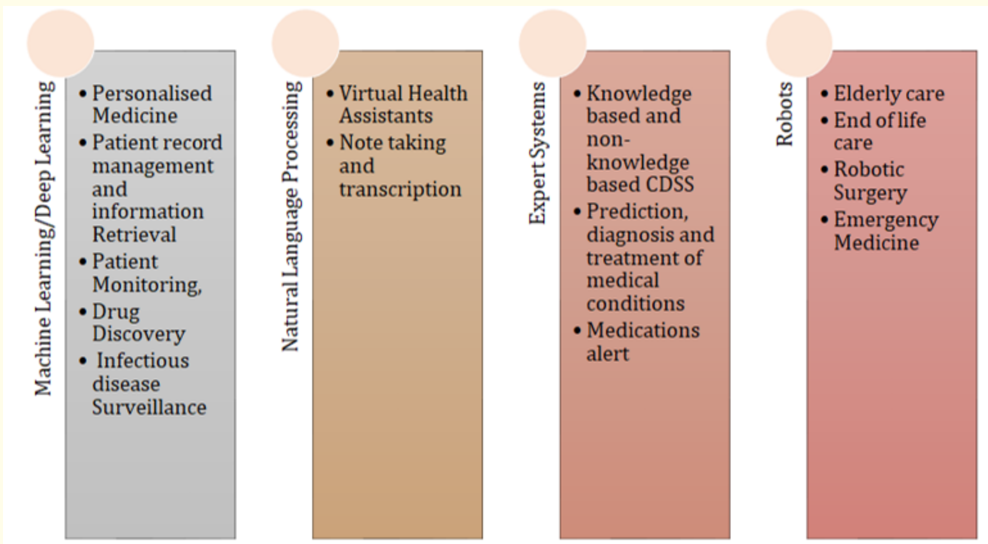


Figure 2: *Application of artificial intelligence (AI) techniques in healthcare [27]*

AI in public health

AI and its subfields can benefit public health due to the rapid expansion in the production and accessibility of health-related data and improvements in data storage, processing power, and analytical capabilities. AI will underpin precision medicine. It also has the potential to enable better targeting of population health treatments and policies for those who are the most in need. Figure 3 details AI technologies' possible public health functions [78].

AI for home care and self-care of patients

AI may revolutionize how people address their illnesses, particularly long-standing diseases such as cardiovascular disease, diabetes, and mental health problems. Patients already assume significant responsibility for their treatment, including administering injections, taking medications, changing their food and nutrition, exercising, and caring for their wounds.

AI may help patient self-care through conversational agents such as chatbots, systems to monitor health and predict risks, and specific technologies that cater exclusively to people with disabilities [70]. Figure 4 lists the roles of AI in-home healthcare [79-83].

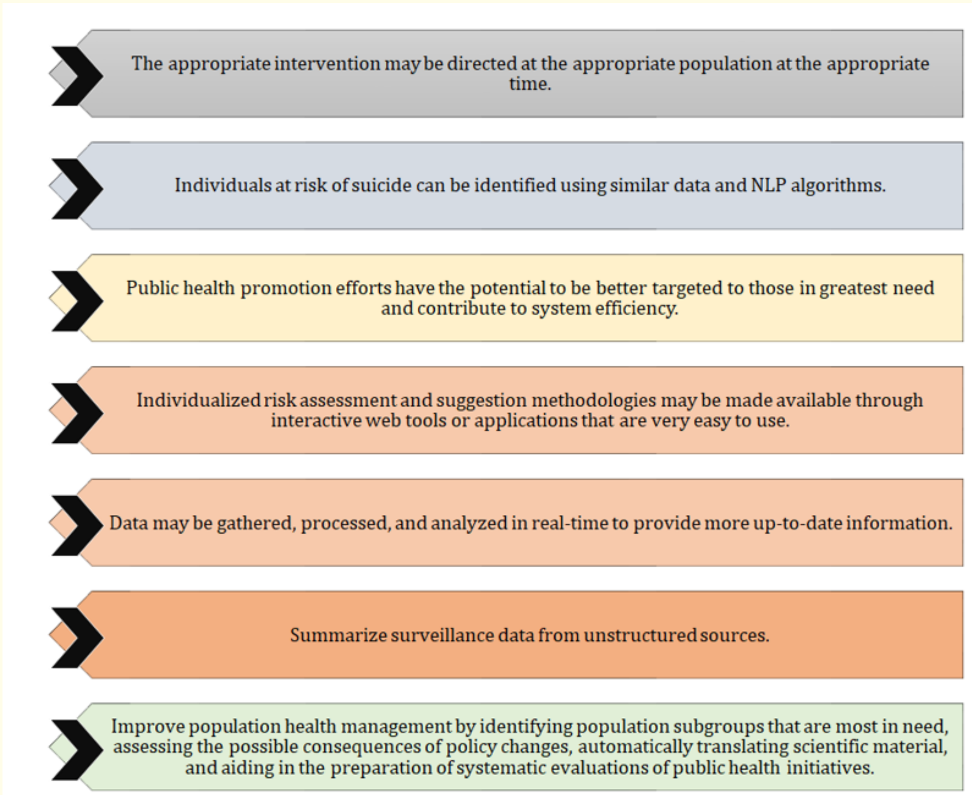
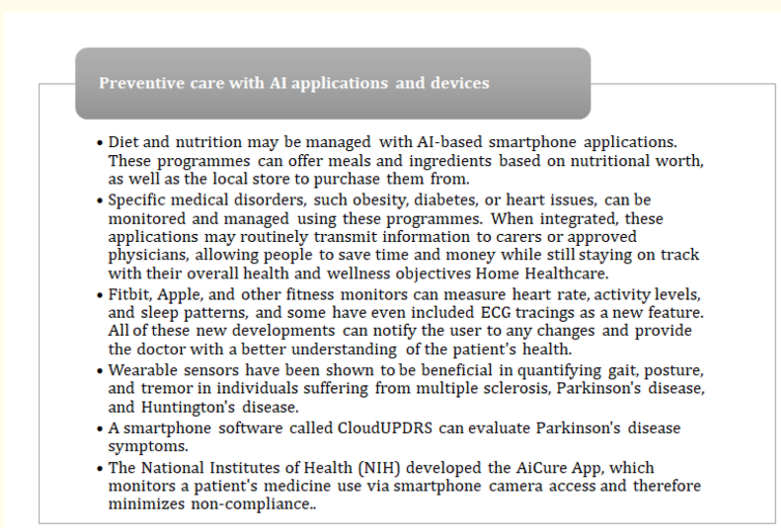


Figure 3: *Potential public health functions of artificial intelligence technologies [78]*



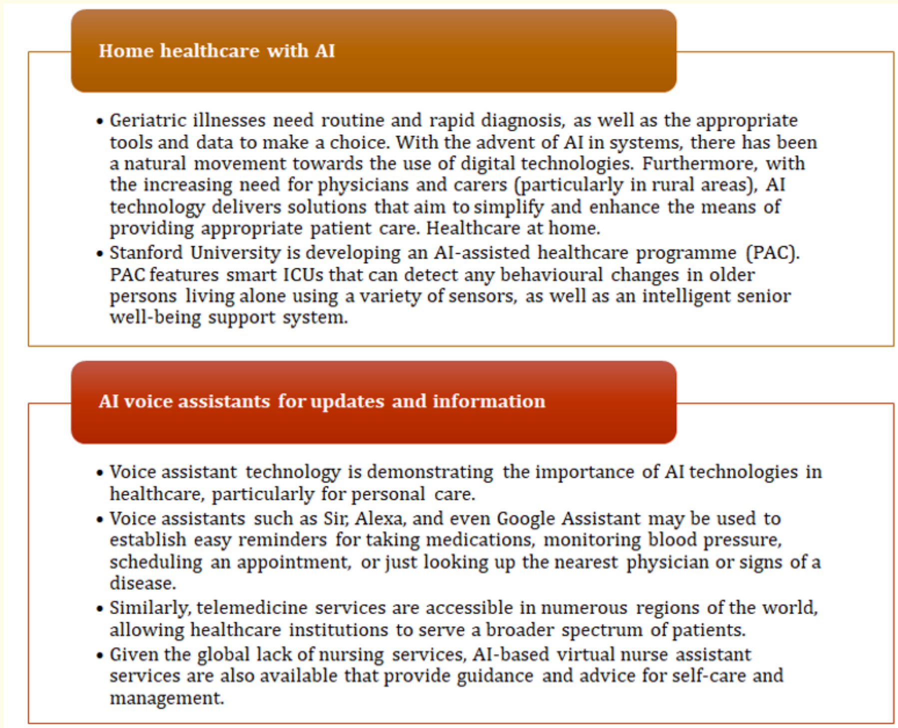


Figure 4: *Roles of artificial intelligence for in-home healthcare [79-83]*

AI in medical training

As medical knowledge expands, technologies such as AI will be required to enable HCPs to use this information successfully in practice [84]. Through in-depth data analysis, AI helps HCPs better understand patient trends and requirements. The ability to critically analyze AI applications, similar to examining a research article that outlines a novel treatment, procedure, or surgical approach, should be taught in an AIM curriculum [85].

AI can assist clinicians in identifying diseases and recommending treatment regimens by combining massive volumes of data and supplementing their decision-making process. Primary care providers can use AI to take notes, assess patient conversations, and upload needed data directly into the EHR systems.

These programs will gather and analyze patient data before presenting them to primary care physicians, together with information on patient medical needs. AI may also relieve clinicians of the strain of memorization. Clinical interview transcriptions are already being automated using speech recognition [86].

According to a 2016 study, clinicians spend 49.2% of their office days working on the computer and digital medical reports, compared to 27% spent face time with patients. Clinical. When the physicians were in the examination room with the patients, they dedicated 52.9% of their time to EHR and other tasks.

Compared to physicians who did not use these services, those who used documentation support, such as dictation help or medical scribe services, spent more time directly interacting with patients. Furthermore, increased use of AI in medicine improves productivity, accuracy, and effectiveness, reduces manual work, and frees up primary care physicians' time [86].

AI in hospital administration

Compared to patient care, the application of AI in healthcare settings is less game-changing, although it may increase efficiency [87]. AI can continuously evaluate data created inside healthcare institutions' task management systems to comprehend better workloads, network dependency, and prospects for automating healthcare facilities [88].

By automating administrative tasks such as preauthorization of insurance, tracking late payments, and keeping track of records, AI may help reduce the HCP burden, ultimately resulting in financial savings [89]. As actual clinical data are continuously collected by an AI hospital/clinic management platform, ML can continue to refine its performance for developing long-term healthcare institutions [90]. AI may help reduce the daily clinical workload of physicians [91].

AI limitations and adverse effects

Even with its potential to provide new insights and facilitate how clinicians and consumers interact with healthcare data, AI can pose significant risks regarding privacy and medical blunders. The possibility of patient damage due to decisions made by an AI-based healthcare tool is something current healthcare and safety systems worldwide have not adapted to [31,92].

AI systems are often trained using a subset of the data obtained, with the remainder saved for testing. Thus, if the data obtained are biased (i.e., if the data target a specific race, gender, or age group), the final model will be skewed. The possibility of constructing a biased report exists even with impartial or unbiased data [93]. Overreliance on AI can reduce the situational awareness of physicians and increase their risk of being caught off guard. Another risk of relying on AI is that if it stops working or cannot provide essential services, there must be a safety valve, which means professionals will still be required [94].

Another area for improvement of AI applications is the inability to quickly transfer models (such as regression, classification, clustering, and NLP) that one organization has developed and deployed for a particular purpose to another business without recalibration. Due to privacy concerns, data exchange between healthcare organizations is often limited or unavailable, leading to fragmented data, which reduces the precision of a model [94].

A significant concern is the possibility of fraud and inaccuracy while implementing AI in healthcare sectors. In the United States, hospital medical mistakes are the third leading cause of mortality. AI applications also create ethical concerns, such as incorrect decision-making, compromise or failure to preserve patient health data, and the likelihood that the data will be used maliciously.

Finally, using AIM could make the field susceptible to adversarial attacks regarding financial motivations and technological shortcomings. Therefore, caution has been recommended when introducing AI in clinical settings [31]. Figure 5 describes AI's general beneficial and unfavorable implications in healthcare delivery systems [95,96].

AI in the healthcare marketplace

The increasing use of AI has dramatically altered the working of healthcare sectors. Delving into project details makes it easier to determine the cost of building and executing an AI application; moreover, the estimated cost of deploying complete AI solutions can range from USD 20,000 to USD 1,000,000. Although expensive, AI solutions are profitable in the long term.

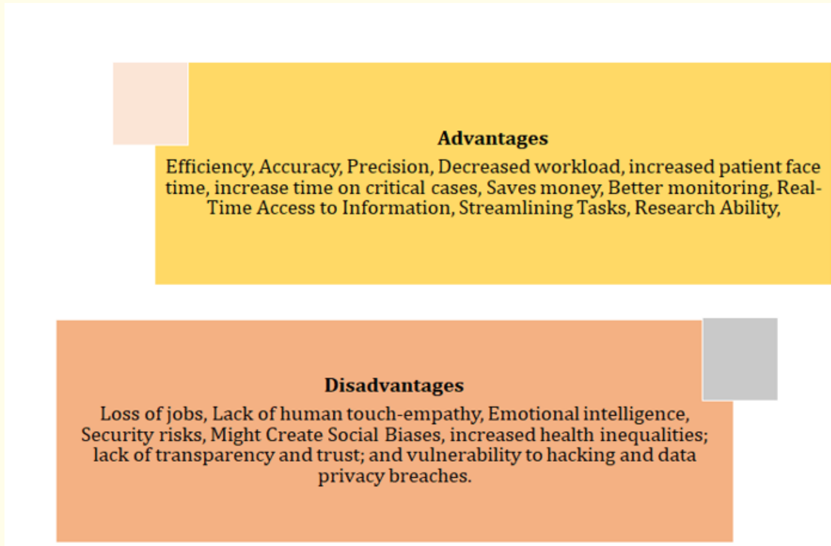


Figure 5: *Beneficial effects and adverse implications of AI in healthcare systems [95,96]*

They allow healthcare organizations to deploy more complex technology that is more precise and apt to specific activities, making them cost-effective. As a result, AI is being used to increase the efficiency and effectiveness of healthcare systems. The main factor influencing the adoption of AI applications is the potential cost savings for the healthcare system [97].

In their assessment, Bohr., *et al*. (2020) predicted that AI applications may save the US government $150 billion annually in healthcare expenses by 2026. A considerable portion of these cost savings can be attributed to the paradigm shift in healthcare from a reactive to a proactive strategy, emphasizing health maintenance rather than disease treatment. This shift may result in fewer hospital stays, medical visits, and therapies [42].

According to *Fortune Business Insights*, worldwide AI in the healthcare market is expected to increase from "$13.82 billion in 2022 to $164.10 billion in 2029, at a CAGR of 42.4%" [98].

Future of AI in healthcare

AI is evolving rapidly and becoming increasingly sophisticated by the day. Considering the rapid increase in its capabilities, it is reasonable to be curious about how AI will impact the healthcare sector [99].

ML is known to enable the use of precision medicine, universally acknowledged as a much-needed improvement in healthcare. Most radiology and pathology images will be reviewed by a machine at some point, considering the tremendous advances in AI for imaging analysis. In addition, speech and text recognition are increasingly used for patient communication and the recording of clinical notes [30].

Automated systems can help physicians improve diagnoses, perform surgical operations, predict disease spread, and personalize therapies, significantly contributing to precision medicine.

The field of precision medicine is an emerging approach to treating and preventing diseases considering individual gene diversity, environment, and lifestyle to generate 'custom-made' therapy. The ability of AI to analyze massive data volumes makes it a preferred tool for early diagnoses and for suggesting lifesaving treatments more rapidly than traditional approaches [100]. AI and digitalization can also enable remote monitoring of patient health concerns, thus extending the home care system [101].

The development and deployment of professional service robots with highly advanced humanoid features replace or enhance the assistance offered by caregivers. These machines can directly support geriatric individuals, patients with dementia, and people with health problems.

For example, the Care-O-bot developed by Fraunhofer IPA, currently in its fourth version, is a cross-platform interactive mobile robot that effectively assists people with memory impairments and older people with activities of daily living [102]. In addition, Abel, a humanoid robot that resembles a young child, can comprehend and respond to human emotions [103].

The major challenge for using AI in several healthcare fields is not whether these technologies will be powerful enough to be beneficial but guarantee their acceptance in daily clinical practice. To achieve their widespread use, AI systems must be authorized by regulators, connected to EHR systems, standardized to the point where similar products perform similarly, taught to physicians, paid for by public or private payer organizations, and updated in the field over time.

Although these challenges are expected to be overcome, they will take considerably longer than the technologies themselves. Therefore, the use of AI technologies in clinical practice may be limited within the next 5 years but more widespread in the next 10 years [30].

AI systems may partially replace human physicians, but they will complement patient care. Human physicians may eventually gravitate toward duties and work arrangements that use humans' distinctive abilities, such as empathy, persuasion, and integration of the larger picture. HCPs that refuse to collaborate with AI may not be relevant and up-to-date, risking their employment over time [30]. Box 3 discusses the additional prospects of new AI systems [104].

BOX 3 [104].

- ❖ The advent of AI-enabled technology will help friends and family and the care team to communicate more effectively in order to provide better care for their elderly loved ones.
- ❖ Some robots can also notify elders about upcoming social activities in their community, encouraging them to get out and mingle.
- ❖ Installing AI-powered sensors in the house can help detect whether a senior has fallen or been involved in an accident.
- ❖ A large number of the AI applications for smartphones already on the market might less intrusively monitor health data, including the daily activities, nutrition, and even lifestyle of the elderly.

Box 3

Conclusion

The most effective means to improve CDM and patient outcomes is by combining the efforts of physicians and technologies. AI is associated with an outstanding ability to perform the required tasks in the medical industry with minimal human intervention. AI is the preferred tool for CDM, data analysis, and training. Accurate deployment of this technology results in an objective and rapid diagnosis. Furthermore, AI may eliminate human errors during therapy and surgery to ensure patient safety, which is essential. Thus, AI will be significantly used in future healthcare solutions. Overall, the future of AI in healthcare is promising. The rapid advancement of AI capabilities will substantially improve medical care, improving the lives of countless people worldwide.

Conflict of Interest Statement

The authors declare that this paper was written without any commercial or financial relationship that could be construed as a potential conflict of interest.

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