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The Influence of AI: The Revolutionary Effects of Artificial Intelligence in Healthcare Sector

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Authors' contributions

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Review Article

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ABSTRACT

The application of artificial intelligence (AI) in healthcare is growing as it becomes more prevalent in modern business and everyday life. It is frequently regarded as a significant technological advancement in the present period. In recent times, the fields of artificial intelligence (AI) and big data analytics have been utilised in the domain of mobile health (m-health) to establish a highly efficient healthcare system. Modern medical research utilises diverse and poorly understood data, including electronic health records (EHRs), medical imaging, and complex language that is widely unorganised. The growth of mobile applications, together with healthcare systems, is a significant factor leading to the presence of disorganised and unstructured datasets. The enhanced accessibility of diverse datasets and advanced computer techniques like machine learning can enable researchers to usher in a new era of highly efficient genetic therapy. This review paper has clarified the role of machine learning algorithms in healthcare systems.

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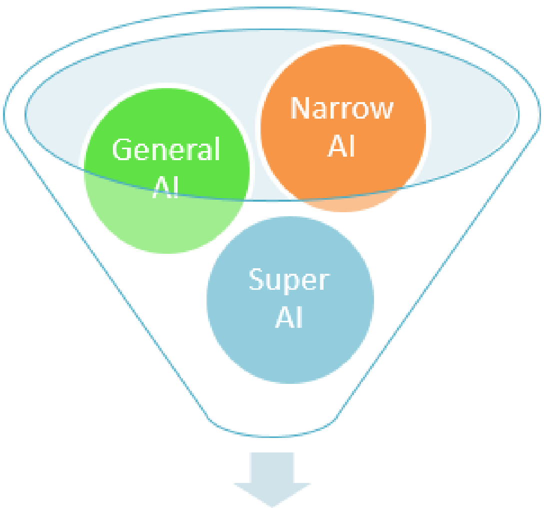
1. INTRODUCTION

Artificial Intelligence (AI) has become a highly influential technology in the 21st century, impacting several areas of our lives such as healthcare, entertainment, banking, and transportation [1]. However, for a significant number of individuals, the idea of AI remains enigmatic, frequently evoking visions of futuristic robots from science fiction or intricate algorithms comprehensible just to computer experts. AI encompasses far more than just futuristic robots or esoteric algorithms [2]. AI involves the development of computer systems capable of executing activities that usually necessitate human intelligence [3, 4]. These tasks involve a wide variety of activities, including as acquiring knowledge, logical thinking, finding solutions to problems, interpreting sensory information, and comprehending language. Machine learning, a subset of AI, is a crucial element that allows computers to acquire knowledge from data without the need for explicit programming [5, 6]. Machine learning algorithms utilize extensive datasets to detect patterns and provide predictions or judgments based on the available information. These algorithms drive a diverse range of applications, spanning from tailored suggestions on streaming platforms to identifying and preventing fraud in financial transactions [7, 8].

Natural language processing (NLP) is a crucial field in AI that allows computers to comprehend and analyze human discourse. Natural Language Processing (NLP) algorithms power virtual assistants such as Siri and Alexa, as well as language translation services and sentiment analysis tools employed in social media monitoring. Computer vision is a vital component of AI, enabling computers to analyze and comprehend visual data from their surroundings. This technique finds application in facial recognition systems, driverless vehicles, and medical image analysis, among various other domains [9-11].

The progress of AI is leading to a more significant and profound influence on society [12]. Although AI offers the potential to transform industries and enhance effectiveness and convenience, it also presents significant ethical and societal concerns. To ensure responsible and equitable deployment of AI, it is crucial to address concerns such as algorithmic bias, employment displacement, and privacy issues with careful consideration. Although there are difficulties, the potential advantages of AI are immense [13, 14]. AI has the potential to solve significant challenges faced by humanity, such as transforming healthcare with personalized treatment and addressing climate change through improved resource management [15, 16].



Picture 1. Types of AI

AI in healthcare refers to the utilization of machine learning (ML) algorithms and other cognitive technologies in medical environments [17, 18]. AI, or artificial intelligence, refers to the ability of computers and other technologies to imitate human cognitive processes, such as learning, thinking, decision-making, and action-taking. AI in healthcare refers to the utilization of machines to analyze and respond to medical data, typically with the aim of forecasting a specific result [19-21]. One important use of AI in healthcare involves the utilization of machine learning (ML) and other cognitive fields to aid in medical diagnostics. By leveraging patient data and other relevant information, artificial intelligence (AI) can assist doctors and medical professionals in delivering highly precise diagnoses and treatment regimens. Furthermore, AI has the potential to enhance healthcare by utilizing advanced data analysis techniques to generate enhanced preventive care suggestions for patients, thereby making healthcare more anticipatory and proactive [22, 23]. .

2. AI AND HEALTHCARE

Artificial Intelligence (AI) is transforming healthcare through the enhancement of clinical procedures, the improvement of patient results, and the optimization of resource allocation. Healthcare practitioners may utilize AI algorithms to analyze extensive data, detect patterns, and make prompt and well-informed decisions [24, 25]. A notable utilization of artificial intelligence in the healthcare field involves the interpretation of medical imaging. Artificial intelligence algorithms can aid radiologists in identifying anomalies in X-rays, MRIs, and CT scans, resulting in expedited and more precise diagnosis. Not only does this enhance patient care, but it also mitigates the workload on healthcare staff [26-31].

Predictive analytics is another domain where AI excels. Through the examination of patient data, such as electronic health records (EHRs), artificial intelligence (AI) has the capability to forecast the advancement of diseases, detect individuals who are susceptible to acquiring specific disorders, and provide customized treatment strategies. By adopting a proactive strategy, it becomes possible to intervene early and provide preventative care, resulting in both a reduction in healthcare expenses and the saving of lives [32-34]. AI-driven virtual assistants are revolutionizing patient involvement and assistance. Chat bots and virtual nurses offer patients continuous support, addressing inquiries, arranging appointments, and remotely monitoring symptoms. This boosts the accessibility of healthcare services and improves the overall patient experience [35, 36].

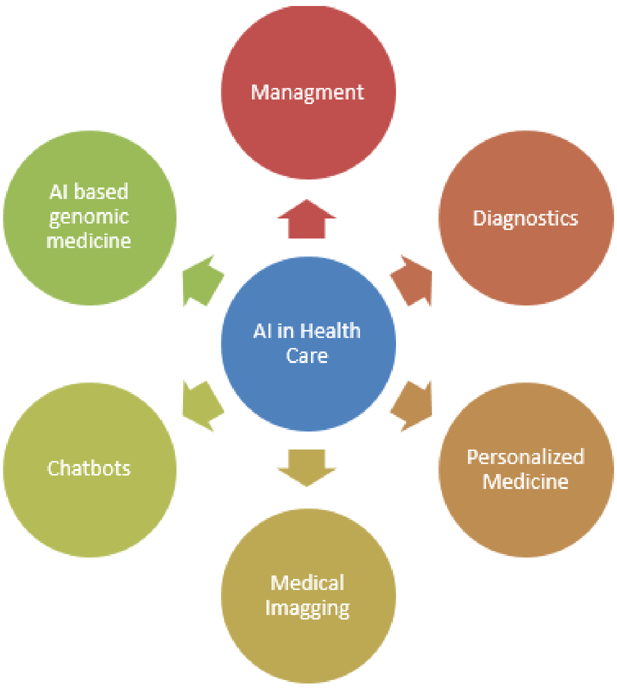


Fig. 1. Application of AI in health care

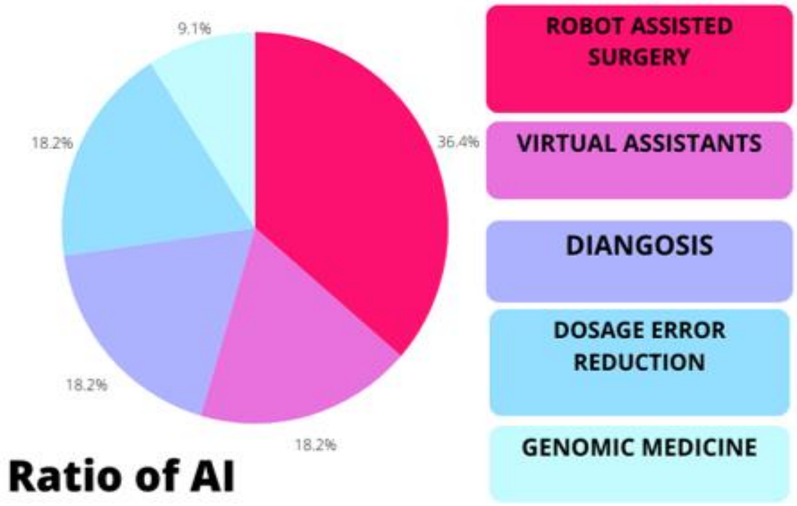


Fig. 2. Ratio of AI in different health applications

Nevertheless, the incorporation of artificial intelligence (AI) into the healthcare sector also gives rise to ethical and privacy apprehensions. To optimize the advantages of AI in healthcare and minimize potential downsides, it is imperative to tackle crucial difficulties such as protecting patient data, guaranteeing openness and accountability in algorithms, and mitigating biases in AI systems [37, 38]. Artificial intelligence (AI) has the capacity to completely transform the field of healthcare in multiple ways. AI is making substantial contributions in several critical areas:

1. **Medical Imaging:** AI algorithms possess the capability to meticulously examine medical images, including X-rays, MRIs, and CT scans, with exceptional precision. This aids radiologists in promptly identifying abnormalities and diseases within their initial stages [39].
2. **Diagnosis and Disease Prediction:** AI models may analyze patient data, encompassing medical history, symptoms, and test results, to aid doctors in formulating more precise diagnoses and forecasting the evolution of diseases [40].
3. **AI algorithms** can analyze extensive datasets to identify possible drug candidates, forecast their effectiveness, and enhance drug development procedures, thus diminishing the time and expenses needed to introduce new drugs to the market [41].
4. **Personalized Medicine:** AI can utilize genomic data and other patient-specific characteristics to customize treatment strategies for individual patients, optimizing efficacy and minimizing adverse reactions [42].
5. **Remote Monitoring and Telemedicine:** Utilizing AI-powered equipment and algorithms, patients' health conditions can be monitored remotely, allowing for telemedicine consultations. This advancement enhances the accessibility of healthcare services, particularly in rural or underdeveloped regions [43].
6. AI has the potential to enhance healthcare operations by optimizing hospital processes, simplifying administrative duties, and enhancing resource allocation. This can result in improved patient care and cost-effectiveness [44].
7. **AI-powered applications and chatbots have** the ability to offer personalized health advice, facilitate behavior change program, and actively involve patients in managing their own healthcare [45, 46].

Although AI offers great potential for revolutionizing healthcare, it also presents difficulties concerning data privacy, algorithmic bias, regulatory compliance, and ethical concerns. Tackling these obstacles will be essential in unlocking the complete capabilities of AI in healthcare, while also safeguarding patient safety and privacy.

3. DIAGNOSIS AND TREATMENT APPLICATIONS

The field of artificial intelligence has been dedicated to the identification and management of diseases since the 1970s. During this time, MYCIN, a system created at Stanford University, was built specifically for the diagnosis of bacterial infections in the bloodstream. Despite demonstrating potential for precise illness diagnosis and treatment; these early rule-based systems were not implemented in clinical practice. The AI algorithms did not demonstrate a significant improvement over human diagnosticians, and they were inadequately incorporated into clinician workflows and medical record systems [47-49].

IBM's Watson has garnered significant media attention for its recent emphasis on precision medicine, specifically in the areas of cancer diagnosis and treatment. Watson utilizes a blend of machine learning and natural language processing (NLP) capabilities [50]. Nevertheless, initial excitement for this utilization of the technology has waned as clients have come to grasp the challenges of instructing Watson on how to tackle specific forms of cancer and of incorporating Watson into healthcare procedures and systems. Watson is a collection of 'cognitive services' that are accessed through application programming interfaces (APIs). These services include speech and language, vision, and machine learning-based data-analysis program[51]. The majority of observers believe that the Watson APIs has the necessary technological capabilities. However, they consider the pursuit of cancer treatment to be an excessively ambitious goal. Watson and other proprietary programs have faced challenges due to competition from free 'open source' program offered by certain suppliers, including Google's TensorFlow [52, 53].

Numerous healthcare organizations have significant challenges when it comes to implementing AI. While rule-based systems integrated into EHR systems are extensively utilized, particularly within the NHS, they do not possess the accuracy of algorithmic systems that rely on machine learning. The maintenance of these rule-based clinical decision support systems proves challenging due to the constant evolution of medical knowledge [54]. Furthermore, these systems typically struggle to cope with the vast amount of data and knowledge generated by genomic, proteomic, metabolic, and other 'omic-based' approaches to healthcare [55].

The current scenario is undergoing a transformation, primarily observed in research laboratories and technology companies, rather than being prevalent in clinical settings. Almost every week, a research laboratory asserts that it has devised a method utilizing artificial intelligence or big data to diagnose and cure a disease with comparable or superior precision compared to human practitioners [56, 57]. The majority of these discoveries are derived from the examination of radiological images; however a few encompass alternative forms of imaging including retinal scanning or genomic-based precision medicine [58]. These results, which rely on machine learning models that use statistics, are introducing a new era of medicine that is centered on evidence and probability. While this is widely seen as a positive development, it also presents numerous issues in the realms of medical ethics and the relationships between patients and clinicians [59].

Technology companies and emerging businesses are likewise diligently working on the same challenges [60]. Google is partnering with health delivery networks to develop predictive models using large datasets in order to alert clinicians about high-risk illnesses, such as sepsis and heart failure. Google, Enclitic, and several other startups are creating artificial intelligence-based image interpretation algorithms [61]. Jvion provides a 'clinical success machine' that accurately identifies patients who are at the highest risk and those who are most likely to respond positively to treatment program. Each of these tools could offer decision support to clinicians who are attempting to identify the optimal diagnosis and therapy for patients [62].

Additionally, there are some specialized firms that specifically concentrate on diagnosing and providing treatment suggestions for specific types of malignancies, taking into account their genetic profiles. Due to the genetic nature of many cancers, human doctors are facing growing challenges in comprehending the whole range of genetic variations in cancer and their reactions to novel medications and regimens. Companies like as Foundation Medicine and Flatiron Health, which are currently under the ownership of Roche, focus specifically on this methodology [63-65]. Both healthcare providers and payers are utilizing machine learning models in the field of 'population health' to forecast populations that are susceptible to specific diseases or accidents, as well as to anticipate instances of hospital readmission. While these models can be helpful in making predictions, they may occasionally miss important data, such as the socio-economic status of patients, which could enhance their predictive capabilities [66, 67].

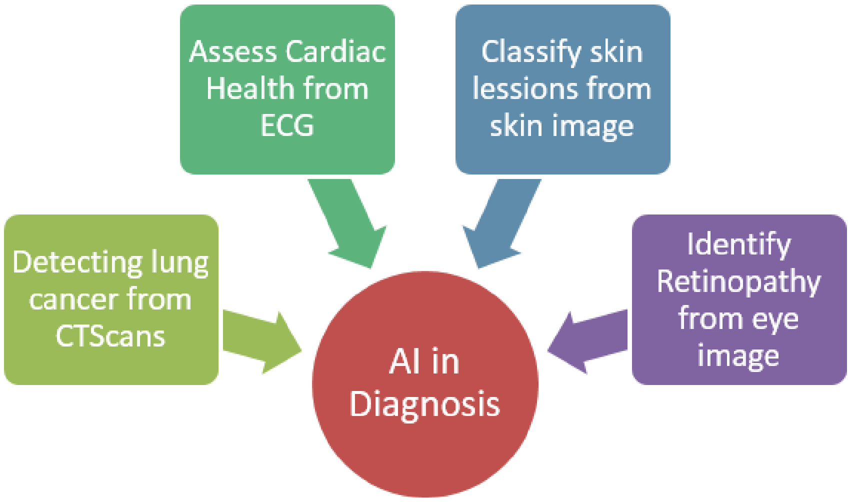


Fig. 3. Examples of AI in diagnosis

However, regardless of whether they are rules-based or algorithmic, integrating AI-based diagnosis and treatment suggestions into clinical workflows and EHR systems can be difficult at times. The challenges related to integration have likely hindered the widespread adoption of AI more than any difficulty in delivering precise and efficient recommendations. Additionally, many AI-driven diagnostic and treatment capabilities offered by technology companies are independent or focus solely on a specific area of healthcare. Certain Electronic Health Record (EHR) suppliers have started including rudimentary Artificial Intelligence (AI) capabilities, surpassing basic rule-based clinical decision assistance, in their products. However, these AI functions are still in their early developmental phases. Providers will need to either engage in significant integration initiatives alone or await the inclusion of additional AI capabilities by EHR vendors [68-70].

4. AI IN GENOMIC MEDICINE

The integration of artificial intelligence (AI) with genetic analysis has great potential in the fields of illness monitoring, forecasting, and individualized healthcare. When utilized on a wide scale, AI can efficiently surveil for developing disease risks (such as COVID-19), while genomic data can offer significant knowledge about genetic indicators linked to heightened vulnerability to particular illnesses. By training machine learning algorithms to recognize these indicators in live data, we can enable the prompt identification of impending epidemics [71-73].

ML algorithms enable the prediction of a wide range of phenotypes, including both basic features like eye colour and more complex ones like as the response to certain treatments or susceptibility to diseases. AI and ML have proven to be highly effective in identifying genetic variants linked to unique features or diseases. Analyzing large genomic datasets enables these methods to identify complex patterns that are frequently difficult to find through manual analysis. An innovative study utilized a sophisticated neural network to detect genetic variations linked to autism spectrum disorder (ASD), accurately forecasting the presence of ASD based exclusively on genomic information [74]. Transcriptomic profiling can be used to categories tumors into clinically relevant molecular subtypes in the field of oncology. Molecular classifications, initially devised for breast cancer and then expanded to include other cancers such as colorectal, ovarian, and sarcomas, have significant consequences for the identification, prediction of outcome, and choice of treatment [75-77]. Conventional computational techniques used to classify different types of malignancies, including support vector machines (SVMs) or k-nearest neighbors, are prone to inaccuracies caused by batch effects and tend to priorities a limited number of characteristic genes, so overlooking crucial biological details [78, 79].

The emergence of high-throughput genome sequences technologies, along with improvements in artificial intelligence (AI) and machine learning (ML), has established a robust basis for expediting personalized medicine and drug discovery. The intricate nature of vast genomic data poses significant challenges in its interpretation, despite its abundance of beneficial information [80, 81]. The utilization of AI and ML has significantly enhanced the field of drug discovery. The concurrent examination of comprehensive genetic data and additional clinical factors, such as drug effectiveness or negative outcomes, enables the discovery of innovative therapeutic targets or the reutilization of current pharmaceuticals for new uses [82, 83]. A prominent obstacle in the field of drug development is the occurrence of non-clinical toxicity, which contributes to a substantial proportion of drug failures in the context of clinical trials. Nevertheless, the increasing use of computational modeling is making it possible to forecast drug toxicity, a factor that might greatly enhance the drug development procedure. This competence is crucial for effectively dealing with prevalent forms of medication toxicity, such as cardio toxicity and hepatotoxicity, which frequently result in the withdrawal of pharmaceuticals from the market [84, 85].

5. MANAGEMENT

An important feature of AI approaches is their ability to potentially facilitate holistic management of health services [86]. These programs can assist healthcare professionals and administrators in their tasks. For example, an AI system can deliver continuous, potentially real-time updates of medical information to healthcare practitioners from diverse sources, such as journals, textbooks, and clinical practices [87]. The importance of these applications is increasingly crucial during the COVID-19 period, since there is a continuous requirement for information exchange to effectively handle the global epidemic. Additional uses include the coordination of information resources for patients and the facilitation of accurate deductions for health risk alarms and health outcome prediction [88]. AI applications enhance the efficiency of hospitals and health services by enabling the following benefits:

- Clinicians can promptly access data as needed.
- Nurses can enhance patient safety while administering medication.
- Patients can actively participate in their care by communicating with their medical teams during hospital stays.

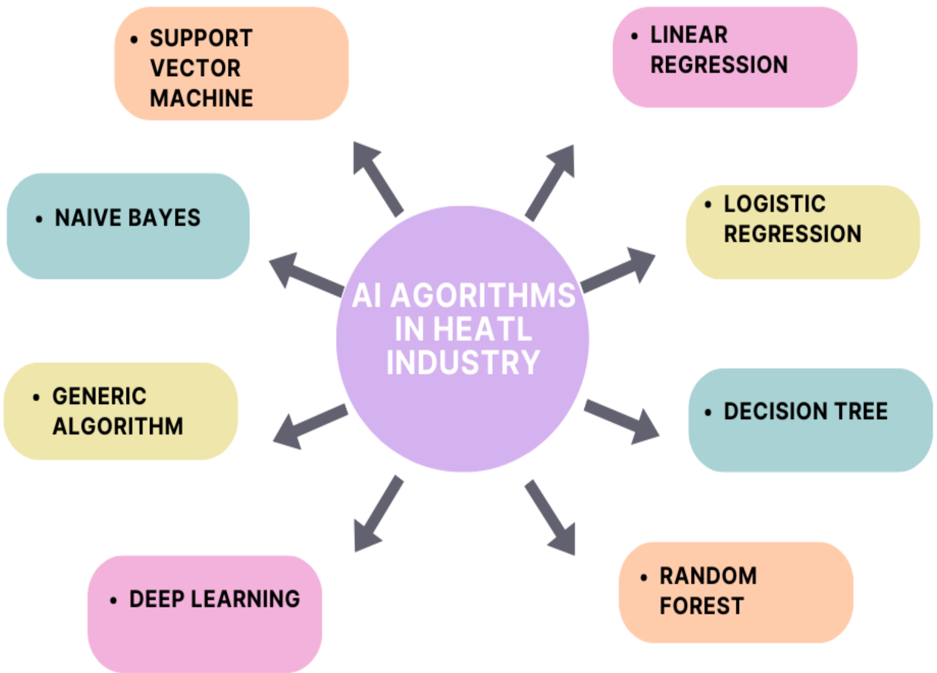


Fig. 4. AI Algorithms used in Health industry

In addition, AI can enhance logistics processes by implementing a just-in-time supply system for pharmaceuticals and equipment, utilizing predictive algorithms [89]. Furthermore, intriguing applications can facilitate the instruction of workers employed in the healthcare industry. This evidence has the potential to facilitate the integration of urban and rural health services. Health services management can utilize AI to optimize the utilization of data in electronic health records. This can be achieved by predicting variations in data across different healthcare facilities, identifying anomalies, conducting clinical tests on the data, standardizing patient representation, enhancing predictive models for diagnostic tests and analyses, and establishing transparency through benchmark data for service analysis [90, 91].

6. PREDICTIVE MEDICINE

Another pertinent subject is the utilization of artificial intelligence (AI) in predicting and diagnosing diseases, as well as assessing treatment outcomes and evaluating prognoses. AI's ability to discern significant correlations in unprocessed data enables it to provide assistance in diagnosing, treating, and predicting outcomes in various medical scenarios. It enables healthcare providers to adopt a proactive approach in managing the beginnings of diseases. Furthermore, it is feasible to make predictions in order to identify risk factors and determinants for each individual patient, which can aid in targeting healthcare interventions for improved results. AI techniques can assist in the design and development of novel pharmaceuticals, as well as in the monitoring of patients and the customization of treatment plans for individual patients. Physicians derive advantages from having increased time and succinct data to enhance their patient-related decision-making. The implementation of AI-driven machine learning has the potential to revolutionize the field of medicine by enabling the development of predictive models for pharmaceuticals and diagnostic tests that can continuously monitor patients throughout their lifetimes [92-94].

7. CLINICAL DECISION-MAKING

An important focus of keyword analysis is the potential for AI applications to assist doctors and medical researchers in making clinical decisions. Jiang et al. state that AI has the potential to enhance physicians' clinical decision-making and potentially supplant human judgement in healthcare-specific functional domains. Bennett and Hauser argue that algorithms can enhance clinical decision-making by expediting the process and the quantity of treatment delivered, hence positively influencing the cost of healthcare services. Hence, AI technologies have the potential to assist medical professionals in their tasks and streamline their work. Redondo and Sandoval have discovered that algorithmic platforms can offer virtual assistance to aid doctors in comprehending the meaning of language and acquiring knowledge to resolve business process inquiries in a manner similar to that of a human[95-97].

8. MEDICAL ROBOTICS

Aside from healthcare professionals, specific medical robots provide aid to patients. Exoskeleton robots, such as those, can aid those with paralysis in regaining the ability to walk and achieving independence. An intelligent prosthesis serves as another illustration of technology in operation. These bionic limbs are equipped with sensors that enhance their responsiveness and accuracy beyond that of natural body parts. Additionally, users have the choice to cover these limbs with bionic skin and connect them to their muscles. Robots have the capability to assist in the processes of rehabilitation and surgery. The Hybrid Assistive Limb (HAL) exoskeleton, developed by Cyberdyne, is specifically designed to aid in the rehabilitation of patients suffering from lower limb disorders caused by conditions like spinal cord injuries and strokes. This advanced technology utilizes sensors placed on the skin to accurately detect electrical signals within the patient's body. In response, the exoskeleton facilitates movement at the joints, effectively assisting in the patient's recovery process [98-101].

9. FUTURE PERSPECTIVES

The expanding capabilities of artificial intelligence in healthcare have made it increasingly feasible to utilize it for enhancing medical practices. The boundless potential of utilising AI in healthcare is evident with the advancements in AI-powered medical instruments and sophisticated algorithms capable of interpreting vast data sets. Deep learning artificial intelligence (AI) can expedite disease detection, offer customized treatment strategies, and automate tasks like drug research and diagnostics. Furthermore, it exhibits potential for enhancing patient results, augmenting safety, and diminishing expenses related to healthcare provision. The prospects for utilizing artificial intelligence in healthcare are undeniably promising and brimming with opportunities for continued advancement. As society progresses towards a more interconnected digital era, the utilization of artificial intelligence (AI) in the healthcare sector will prove to be an indispensable resource that has the potential to revolutionize the methods by which physicians provide medical treatment and administer healthcare. Artificial intelligence in healthcare has immense potential to bring forth significant improvements, enhance health outcomes, and provide superior patient experiences [102, 103].

We firmly assert that AI will play crucial role in the future healthcare services. Machine learning is the fundamental capacity that drives the development of precision medicine, which is universally recognized as a crucial advancement in healthcare. Despite the initial difficulties encountered in developing diagnosis and treatment suggestions, we anticipate that AI will eventually achieve expertise in this field. Considering the swift progress in artificial intelligence (AI) for the examination of images, it is probable that a computer would eventually scrutinize the majority of radiology and pathology images. The utilization of speech and text recognition is currently prevalent in tasks such as patient communication and the recording of clinical notes, and its usage is expected to grow [104, 105].

The primary obstacle for AI in healthcare lies not in the capabilities of the technology themselves, but rather in guaranteeing their integration into routine clinical practice. In order for widespread adoption to occur, regulators must grant approval to AI systems. These systems must also be integrated with electronic health record (EHR) systems and standardized to a significant extent, ensuring that similar products function in a comparable manner. Additionally, clinicians must be educated on how to use these systems, and their costs must be covered by either public or private payer organizations. Furthermore, continuous updates in the field are necessary to keep these issues will eventually be resolved, but their resolution will require significantly more time compared to the maturation of the technologies themselves. Consequently, we anticipate a restricted use of AI in clinical practice over a span of 5 years, followed by a more widespread implementation within a decade. It is becoming increasingly evident that AI systems will not extensively replace human clinicians, but rather enhance their efforts in providing patient care. Over time, human doctors may transition towards jobs and work designs that utilize distinctively human abilities such as empathy, persuasion, and holistic integration. The only healthcare providers who may face job loss in the future are those who are unwilling to collaborate with artificial intelligence.

10. CONCLUSIONS

Artificial intelligence (AI) is increasingly being applied to healthcare, as it becomes more widespread in contemporary business and daily existence. Artificial intelligence has the capacity to assist healthcare providers in multiple ways, encompassing patient care and administrative duties. While the healthcare industry benefits from a majority of AI and healthcare breakthroughs, the tactics they support can vary significantly. Although several publications assert that artificial intelligence (AI) may match or surpass human performance in certain tasks, such as detecting illnesses, it will take a considerable amount of time before AI completely supplants humans in various medical roles within the healthcare industry.

Despite notable advancements, the utilization of AI in healthcare is still in its nascent phase. Ongoing research consistently enhances the technology, leading to significant breakthroughs in various industries in the future. Artificial intelligence (AI) and machine learning have significant potential to make valuable contributions in the healthcare industry, which is currently experiencing rapid digital change. These technologies have the ability to greatly enhance the quality of life for patients.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. For AI, AI Allen institute for AI: About; 2022.
   Available: https://allenai.org/about
2. Arinez JF, Chang Q, Gao RX, Xu C, Zhang J. Artificial intelligence in advanced manufacturing: Current status and future outlook. Journal of Manufacturing Science and Engineering. 2020; 142(11).

3. Calico: Calico labs; 2022. Available:https://www.calicolabs.com
4. Crunchbase: Hugging face - funding, financials, valuation & investors; 2022. Available:https://www.crunchbase.com/organization/hugging-face/company_financials
5. DARPA: Learning With Less Labeling (LwLL). Available:https://www.darpa.mil/program/learning-with-less-labeling
6. DARPA: Low resource languages for emergent incidents (LORELEI). Available:https://www.darpa.mil/program/low-resource-languages-for-emergent-incidents
7. DARPA: Machine common sense. Available:https://www.darpa.mil/program/machine-common-sense
8. DARPA: Memex (archived). Available:https://www.darpa.mil/program/memex
9. DARPA: Science of artificial intelligence and learning for open-world novelty (sail-on). Available:https://www.darpa.mil/program/science-of-artificial-intelligence-and-learning-for-open-world-novelty
10. Eide N. It's early days, but AI will define industry winners and losers, KPMG says; 2012. Available:https://www.ciodive.com/news/its-early-days-but-ai-will-define-industry-winners-and-losers-kpmg-say/562553
11. Foundation NS.: Quantum information science; 1999. Available:https://www.nsf.gov/pubs/2000/nsf00101/nsf00101.htm
12. Foundation NS. About America's seed fund powered by NSF; 2022. Available:https://seedfund.nsf.gov/about
13. Frank A. Are we in an AI summer or AI winter?; 2021. Available: https://bigthink.com/13-8/are-we-in-an-ai-summer-or-ai-winter
14. Gonsalves T. The summers and winters of artificial intelligence. In: Advanced methodologies and technologies in artificial intelligence, computer simulation, and human-computer interaction. IGI Global. 2019;168–179.
15. Gurman M. Apple accelerates work on car project, aiming for fully autonomous vehicle; 2021. Available:https://www.bloomberg.com/news/articles/2021-11-18/apple-accelerates-work-on-car-aims-for-fully-autonomous-vehicle
16. IBM: Quantum computing; 2022. Available:https://research.ibm.com/quantum-computing
17. Ireland C. Alan Turing at 100; 2012. Available:https://news.harvard.edu/gazette/story/2012/09/alan-turing-at-100
18. Kejriwal M. Domain-specific knowledge graph construction. Springer; 2019.
19. Kejriwal M, Knoblock CA, Szekely P. Knowledge graphs: Fundamentals, techniques, and applications. MIT Press; 2021.
20. Pearl J. Graphical models for probabilistic and causal reasoning. Quantified representation of uncertainty and imprecision. 1998;367–389.
21. Ruff KM, Pappu RV. Alphafold and implications for intrinsically disordered proteins. Journal of Molecular Biology. 2021;433.
22. Hamid S. The opportunities and risks of artificial intelligence in medicine and healthcare; 2016. Available: http://www.cuspe.org/wp-content/uploads/2016/09/Hamid_2016.pdf Access on 2020 May 29.
23. Casadesus-Masanell R, Ricart JE. How to design a winning business model. Harvard Business Review; 2011. Available: https://hbr.org/2011/01/how-to-design-a-winning-business-model Access on 2020 Jan 8.
24. Baima G, Forliano C, Santoro G, Vrontis D. Intellectual capital and business model: A systematic literature review to explore their linkages. J Intellect Cap; 2020. Available:https://doi.org/10.1108/JIC-02-2020-0055
25. Secinaro S, Calandra D, Secinaro A, Muthurangu V, Biancone P. Artificial Intelligence for healthcare with a business, management and accounting, decision sciences, and health professions focus. Zenodo; 2021. Available:https://zenodo.org/record/4587618#.YEScpl1KiWh Access on 2021 Mar 7.
26. Jacoby WG. Electoral inquiry section loess: A nonparametric, graphical tool for depicting relationships between variables q. In; 2000.

27. Kumar S, Kumar S. Collaboration in research productivity in oil seed research institutes of India. In: Proceedings of fourth international conference on webometrics, informetrics and scientometrics. 2008;28–1.
28. London School of Economics. 3: Key measures of academic influence. Impact of social sciences; 2010.
    Available:https://blogs.lse.ac.uk/impactofsocialsciences/the-handbook/chapter-3-key-measures-of-academic-influence
    Access on 2021 Jan 13.
29. Oxford University Press. Oxford English Dictionary; 2020.
    Available:https://www.oed.com
30. Wartena C, Brussee R. Topic detection by clustering keywords. In: 2008 19th international workshop on database and expert systems applications. 2008;54–8.
31. Redondo T, Sandoval AM. Text Analytics: The convergence of big data and artificial intelligence. Int J Interact Multimed Artif Intell. 2016;3.
    Available:https://www.ijimai.org/journal/bibcite/reference/2540
32. Kalis B, Collier M, Fu R. 10 Promising AI applications in health care. 2018;5.
33. Kayyali B, Knott D, Van Kuiken S. The 'big data' revolution in US healthcare [Internet]. McKinsey & Company; 2013.
    Available:https://healthcare.mckinsey.com/big-data-revolution-us-healthcare
    Access on 2020 Aug 14.
34. Sousa MJ, Dal Mas F, Pesqueira A, Lemos C, Verde JM, Cobianchi L. The potential of AI in health higher education to increase the students' learning outcomes. TEM J. (In press); 2021.
35. Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. J Med Syst. 2020;44.
36. Agrawal A, Gans JS, Goldfarb A, Exploring the impact of artificial intelligence: Prediction versus judgment. Inf Econ Policy. 2019;1.
37. Ahmed MA, Alkhamis TM. Simulation optimization for an emergency department healthcare unit in Kuwait. Eur J Oper Res. 2009;198.
38. Aisyah M, Cockcroft S. A snapshot of data quality issues in Indonesian community health. Int J Netw Virtual Organ. 2014;14.
39. Andrews JE. An author co-citation analysis of medical informatics. J Med Libr Assoc. 2003;91.
40. Aria M, Cuccurullo C. Bibliometrix: An R-tool for comprehensive science mapping analysis. J Informetr. 2017;11.
41. Baig MM, et al. A systematic review of wearable patient monitoring systems—Current challenges and opportunities for clinical adoption. J Med Syst. 2017;41.
42. Bennett CC, Hauser K. Artificial intelligence framework for simulating clinical decision-making: A Markov decision process approach. Artif Intell Med. 2013;57.
43. Bert F, et al. HIV screening in pregnant women: A systematic review of cost-effectiveness studies. Int J Health Plann Manag. 2018;33.
44. Biancone P, et al. Management of open innovation in healthcare for cost accounting using EHR. J Open Innov Technol Market Complex. 2019;5.
45. Biancone PP, et al. Data quality methods and applications in health care system: A systematic literature review. Int J Bus Manag. 2019;14.
46. Burke EK, et al. The state of the art of nurse rostering. J Sched. 2004;7.
47. Burton RJ, et al. Using artificial intelligence to reduce diagnostic workload without compromising detection of urinary tract infections. BMC Med Inform Decis Mak. 2019;19.
48. Calandra D, Favareto M, Artificial Intelligence to fight COVID-19 outbreak impact: An overview. Eur J Soc Impact Circ Econ, 2020;1.
49. Carter D. How real is the impact of artificial intelligence? Bus Inf Surv. 2018;35.
50. Chakradhar S. Predictable response: Finding optimal drugs and doses using artificial intelligence. Nat Med. 2017;23.
51. Chen G, Xiao L. Selecting publication keywords for domain analysis in bibliometrics: A comparison of three methods. J Informet. 2016;10.
52. Chen X, et al. A comparative quantitative study of utilizing artificial intelligence on electronic health records in the USA and China during 2008–2017. BMC Med Inform Decis Mak. 2018;18.
53. Cho BJ, et al. Classification of cervical neoplasms on colposcopic photography using deep learning. Sci Rep. 2020;10.

54. Choudhury A, Asan O. Role of artificial intelligence in patient safety outcomes: Systematic literature review. JMIR Med Inform. 2020;8.
55. Choudhury A, Renjilian E, Asan O. Use of machine learning in geriatric clinical care for chronic diseases: A systematic literature review. JAMIA Open. 2020;3.
56. Collins GS, Moons KGM. Reporting of artificial intelligence prediction models. Lancet. 2019; 393.
57. Connelly TM, et al. The 100 most influential manuscripts in robotic surgery: A bibliometric analysis. J Robot Surg. 2020;14.
58. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. Future Healthc J. 2019;6.
59. Doyle OM, Leavitt N, Rigg JA. Finding undiagnosed patients with hepatitis C infection: An application of artificial intelligence to patient claims data. Sci Rep. 2020;10.
60. Dumay J, Cai L. A review and critique of content analysis as a methodology for inquiring into IC disclosure. J Intellect Cap. 2014;15.
61. Dumay J, Guthrie J, Puntillo P. IC and public sector: A structured literature review. J Intellect Cap, 2015;16.
62. Egghe L. Theory and practise of the g-index. Scientometrics. 2006;69.
63. Elango B, Rajendran D. Authorship trends and collaboration pattern in the marine sciences literature: A scientometric Study. Int J Inf Dissem Technol. 2012;1.
64. Engqvist L, Frommen JG. The h-index and self-citations. Trends Ecol Evol. 2008;23.
65. Falagas ME, et al. Comparison of pubmed, scopus, web of science, and google scholar: Strengths and weaknesses. FASEB J. 2007;22.
66. Fleming N. How artificial intelligence is changing drug discovery. Nature. 2018;557.
67. Forina M, Armanino C, Raggio V. Clustering with dendrograms on interpretation variables. Anal Chim Acta, 2002;454.
68. Forliano C, Bernardi P, Yahiaoui D. Entrepreneurial universities: A bibliometric analysis within the business and management domains. Technol Forecast Soc Change. 2021;1.
69. Gatto A, Drago C. A taxonomy of energy resilience. Energy Policy. 2020;136.
70. Gu D, et al. Visualizing the intellectual structure and evolution of electronic health and telemedicine research. Int J Med Inform. 2019;130.
71. What is precision medicine? Genetics home reference; 2018.
Available:https://ghr.nlm.nih.gov/primer/precisionmedicine/definition
Access on 2018 Aug 13.
72. Makary MA, Daniel M. Medical error—the third leading cause of death in the US. BMJ. 2016; 353.
73. Jiang F, Jiang Y, Zhi H, Dong Y, Li H, Ma S, Wang Y. Artificial intelligence in healthcare: Past, present and future. Stroke Vasc Neurol 2(4).
74. Quazi S, Jangi R. Artificial Intelligence and machine learning in medicinal chemistry and validation of emerging drug targets; 2021.
75. Garvin JH, Kim Y, Gobbel GT, Matheny ME, Redd A, Bray BE, Meystre SM. Automating quality measures for ***heart failure using natural language processing: A descriptive study in the department of veterans' affairs. JMIR medical informatics. 2018;6(1):e9150.
76. Bejnordi BE, Veta M, Van Diest PJ, Van Ginneken B, Karssemeijer N, Litjens G, CAMELYON16 Consortium. Diagnostic assessment ***of deep learning algorithms for detection of lymph node metastases in women with breast cancer. Jama. 318(22):2199-2210.
77. Mesko B. The role of artificial intelligence in precision medicine; 2017.
78. Van Hartskamp M, Consoli S, Verhaegh W, Petkovic M, Van de Stolpe A. Artificial intelligence in clinical health care applications. Interact J Med Res. 2017;8(2):100.
79. Mesko B. Artificial intelligence is the stethoscope of the 21st century. The Medical Futurist; 2019.
80. Rajkomar A, Yim JWL, Grumbach K, Parekh A. Weighting primary care patient panel size: A novel electronic health record-derived measure using machine learning. JMIR Medical Informatics. 2016;4(4):e6530.
81. Sullivan T. Next up for EHRs: Vendors adding artificial intelligence into the workflow. Healthcare ITNews. Updated 13

March 13 March 2018. Accessed 23 August 23 August 2019. (2018). Available:https://www.healthcareitnews.com/news/next-ehrs-vendors-adding-artificial-intelligence-workflow

82. Quazi S . Role of Artificial Intelligence and machine learning in bioinformatics: Drug discovery and drug repurposing; 2021.
83. Cho Gyeongcheol et al. Review of machine learning algorithms for diagnosing mental illness. Psychiatry investigation. 2019:16(4):262–269. DOI: https://doi.org/10.30773/pi.2018.12.21.2
84. Olsen TG, Jackson BH, Feeser TA, Kent MN, Moad JC, Krishnamurthy S, Soans RE. Diagnostic performance ***of deep learning algorithms applied to three common diagnoses in dermatopathology—Journal of Pathology Informatics. 2018;9.
85. Nick TG, Logistic Regression CKM. Topics in biostatistics. Methods Mol. Biol. 2007;404.
86. Zhang WT, Kuang CW. SPSS statistical analysis-based tutorial; 2011.
87. Hosmer Jr DW, Lemeshow S, Sturdivant RX. Applied logistic regression. John Wiley & Sons. 2013;398.
88. Lee EK, Yuan F, Hirsh DA, Mallory MD, Simon HK. A clinical decision tool for predicting patient care characteristics: Patients return within 72 hours in the emergency department. In AMIA annual symposium proceedings. American Medical Informatics Association. 2012;495.
89. Roysden N, Wright A. Predicting health care utilisation after behavioural health referral using natural language processing and machine learning. In AMIA annual symposium proceedings. American Medical Informatics Association. 2015;2063.
90. Morid MA, Kawamoto K, Ault T, Dorius J, Abdelrahman S. Supervised learning methods for predicting healthcare costs: Systematic literature review and empirical evaluation. In AMIA annual symposium proceedings. American Medical Informatics Association. 2017;1312.
91. Lee J. Patient-specific predictive modelling using random forests: An observational study for the critically ill. JMIR medical informatics. 2017;5(1): e6690.
92. Rahimian F, Salimi-Khorshidi G, Payberah AH, Tran J, Ayala Solares R, Raimondi F, Rahimi K. Predicting the ***risk of emergency admission with machine learning: Development and validation using linked electronic health records. PLoS medicine. 2018;15(11):e1002695.
93. McWilliams CJ, Lawson DJ, Santos-Rodriguez R, Gilchrist ID, Champneys A, Gould TH, Bourdeaux CP. Towards a ***decision support tool for intensive care discharge: Machine learning algorithm development using electronic healthcare data from MIMIC-III and Bristol, UK. BMJ Open. 2019;9(3):e025925.
94. Langley P, Iba W, Thomas K. An analysis of Bayesian classier. In Proceedings of the Tenth National Conference of Artificial Intelligence; 1992.
95. Rish I. An empirical study of the naive Bayes classifier. IJCAI 2001 workshop on empirical methods in artificial intelligence. 2001;3(22):41–46.
96. Doing-Harris K, Mowery DL, Daniels C, Chapman WW, Conway M. Understanding patient satisfaction with received healthcare services: A natural language processing approach. In AMIA annual symposium proceedings. American Medical Informatics Association. 2016;524.
97. Grover D, Bauhoff S, Friedman J. Using supervised learning to select audit targets in performance-based financing in health: An example from Zambia. PloS one. 2019;14(1): e0211262.
98. Wagholikar KB, Vijayraghavan S, Deshpande AW. Fuzzy naive Bayesian model for medical diagnostic decision support. In 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society IEEE. 2009;3409–3412.
99. Zhang Z. Introduction to machine learning: k-nearest neighbours. Annals of translational medicine. 2016;4(11).
100. Li C, Zhang S, Zhang H, Pang L, Lam K, Hui C, Zhang S. Using the K-nearest neighbour algorithm for the classification of lymph node metastasis in gastric cancer. Computational and mathematical methods in medicine; 2012.
101. Sarkar M, Leong TY. Application of K-nearest neighbours' algorithm on breast cancer diagnosis problem. In proceedings

of the AMIA Symposium. American Medical Informatics Association. 2000; 759.

102. Huang Z, Dong W, Wang F, Duan H. Medical inpatient journey modelling and clustering: A Bayesian hidden Markov model-based approach. In AMIA annual symposium proceedings. American Medical Informatics Association. 2015;649.

103. Zou J, et al. A primer on deep learning in genomics. Nat Genet. 2019;51.

104. Wick RR, Judd LM, Holt KE. Performance of neural network base calling tools for Oxford Nanopore sequencing. Genome Biol. 2019;20.

105. Wager S, Athey S. Estimation and inference of heterogeneous treatment effects using random forests. J Am Stat Assoc. 2018;113.

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