Artificial Intelligence in Addressing Cost, Efficiency, and Access Challenges in Healthcare

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Abstract

Objective: The healthcare industry is undergoing a transformative phase marked by rising costs and a shortage of healthcare professionals, necessitating the adoption of information technology-based solutions (Shaheen, 2021). Methods: This study explores the integration of artificial intelligence (AI) in addressing these challenges and enhancing healthcare systems. Using a systematic literature review, we examined the role of AI in overcoming issues such as limited access, high costs, inefficiencies, and an aging population (Greenberg et al., 2020; Maphumulo & Bhengu, 2019). Our analysis focused on applications of AI in drug discovery, clinical trials, and patient care, including intelligent care systems and healthcare robotics (Chan et al., 2019; Vaishya et al., 2020). Results: The findings suggest that AI significantly accelerates drug discovery, streamlines clinical trials, and improves patient outcomes through advanced diagnostics and treatment support (Díaz et al., 2019; Woo, 2019). AI has proven particularly effective during the COVID-19 pandemic, where it aided in diagnosis, contact tracing, and treatment decision-making, highlighting its potential to address existing vulnerabilities in healthcare systems (Pavli et al., 2021). Conclusion: AI offers a paradigm shift in healthcare by providing clinicians with real-time access to robust clinical evidence and best practices, reducing reliance on anecdotal experience and cognitive biases (McNeill & Walton, 2002; Shaheen, 2021a). By harnessing the power of AI, healthcare systems can improve efficiency, reduce costs, and enhance patient outcomes, marking a significant step towards a more efficient, effective, and equitable healthcare system (Mayorga-Ruiz et al., 2019; Luengo-Oroz et al., 2020).

Keywords: Artificial Intelligence, Healthcare Efficiency, Cost Reduction, Access Improvement, Pandemic Response.

Significance | AI's integration in healthcare promises improved efficiency, reduced costs, and enhanced access, addressing systemic challenges and advancing patient care.

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1.Introduction

The healthcare industry is currently navigating a transformative phase driven by rising costs and a shortage of healthcare professionals. This revolution necessitates the adoption of information technology-based solutions to address these pressing challenges (Shaheen, 2021). Globally, healthcare systems are struggling with multifaceted issues including limited access, high costs, inefficiencies, and an aging population. The strain on these systems has been further exacerbated by pandemics such as COVID-19, which have starkly highlighted deficiencies in protective equipment, diagnostic tests, physician workload, and information sharing mechanisms (Greenberg et al., 2020; Pavli et al., 2021). Such crises not only reveal existing vulnerabilities within healthcare systems but also underscore the urgent need for reimagined care models and efficient back-office systems to address inequitable access, insufficient on-demand services, high costs, and lack of price transparency (Maphumulo & Bhengu, 2019).

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Technological advancements, particularly in artificial intelligence (AI), offer promising solutions to these challenges, although their integration into healthcare has been gradual. One significant obstacle is the vast amount of medical data and the rapid pace of advancements, which contribute to healthcare professionals' burnout as they struggle to stay updated with the latest developments (van der Schaar et al., 2021; Habermann, 2021; Vaishya et al., 2020). These interconnected challenges create an impression of complexity in healthcare delivery, which, while inherently challenging, can be streamlined through the development of intelligent care systems enabled by AI.

AI's potential to simplify healthcare is evident from its diverse applications during the COVID-19 pandemic. It has been used for diagnosis, treatment decision support, contact tracing, and the deployment of AI-driven technologies. This technological evolution promises to make healthcare less complicated and more accessible, ensuring that high-quality care is available to all. By leveraging AI, healthcare systems can improve efficiency, reduce costs, and enhance patient outcomes.

The traditional model of medical learning, which relies heavily on physicians' anecdotal experiences and incremental learning from successes and failures, is fraught with limitations (McNeill & Walton, 2002; Ross et al., 2009). Doctors typically gain knowledge from other doctors, research studies, pharmaceutical companies, and their own clinical experiences. However, this model is inherently slow and subject to individual biases and errors. Physicians may mistakenly believe in the efficacy of a treatment or the accuracy of a diagnosis based on limited personal experience rather than robust clinical evidence (McNeill & Walton, 2002; Shaheen, 2021a). Furthermore, the current healthcare environment, which demands high patient throughput to optimize reimbursement, leaves clinicians with little time to focus on secondary patient care tasks or to stay current with medical breakthroughs.

AI offers a paradigm shift in this context by providing clinicians with immediate access to the insights and best practices derived from large cohorts and clinical studies. This access reduces the reliance on individual anecdotal experience and mitigates cognitive and cultural biases (Shaheen, 2021a; Mayorga-Ruiz et al., 2019; Woo, 2019). By serving as a technological balancer in the knowledge base of healthcare providers, AI can enhance decision-making processes, ensuring that patient care is informed by the most current and comprehensive data available.

The integration of AI in healthcare not only promises to address the immediate challenges of cost and staffing but also to create a more efficient, effective, and equitable healthcare system. As we continue to confront and learn from healthcare crises like COVID-19, the role of AI in reshaping the landscape of medical care becomes increasingly clear. By harnessing the power of AI, we can develop intelligent care systems that are capable of delivering superior care with fewer complications, ultimately benefiting patients and providers alike. This technological evolution marks a significant step towards a future where healthcare is both accessible and of the highest quality.

2. Applications of AI in Healthcare

2.1 AI for Drug Discovery

Artificial intelligence (AI) technology has significantly accelerated the drug discovery process in healthcare, particularly for pharmaceutical companies. AI automates the identification of targets and analyzes off-target compounds, aiding in drug repurposing (Díaz et al., 2019). Consequently, AI-driven drug discovery streamlines the process, reducing redundancy and increasing efficiency in both the AI and healthcare sectors (Chan et al., 2019).

Leading biopharmaceutical companies have already discovered several remedies through AI. Pfizer utilizes IBM Watson, a machine learning-based system, to find immuno-oncology treatments (P. Agrawal, 2018). Sanofi collaborates with Exscientia's AI platform to seek metabolic disease medications, while Genentech, a Roche subsidiary, employs GNS Healthcare's AI system in its cancer treatment research. Most major biopharmaceutical companies have similar partnerships or internal programs.

Proponents of AI and machine learning predict a new era of drug development that is faster, cheaper, and more effective. While some remain skeptical, the majority of experts believe these tools will become increasingly crucial. This transformation presents both challenges and opportunities for scientists, especially when combined with automation (Chan et al., 2019).

2.2 AI for clinical trials

A clinical trial is a structured procedure where newly developed treatments are administered to people to evaluate their effectiveness. This process traditionally requires substantial time and financial investment, yet the success rate remains relatively low. To address these challenges, clinical trial automation has emerged as a significant advancement for both AI and the healthcare sector. Artificial Intelligence in healthcare not only streamlines these trials by eliminating time-consuming data monitoring tasks but also enhances the accuracy of data analysis and outcomes. AI-assisted clinical trials can manage vast amounts of data efficiently, leading to precise and reliable results. Notably, some of the most prominent applications of Artificial Intelligence in healthcare for clinical trials include automated data collection, predictive analytics, and patient recruitment optimization (Shaheen, M. Y. (2021).

2.2.1 Intelligent Clinical Trials

Traditional linear and sequential clinical trials have long been the gold standard for ensuring the efficacy and safety of new drugs. These trials, characterized by distinct and defined stages of randomized controlled trials (RCTs), were primarily developed to evaluate mass-market pharmaceuticals. Despite advancements in other fields, this method has remained largely unchanged for decades.

Artificial intelligence (AI) presents a transformative potential to shorten clinical trial cycle durations while enhancing productivity and clinical development outcomes. This report, the third in a series on AI's impact on the biopharma value chain, highlights these advancements (Lee, 2021; Angus, 2020).

In recent years, biopharma companies have accessed increasing volumes of scientific and research information from various sources, known as real-world data (RWD). Despite this, many companies lack the expertise and tools to effectively utilize this data. By applying predictive AI models and advanced analytics, researchers can unlock the full potential of RWD, leading to a better understanding of diseases, identification of relevant patients, and discovery of key investigators. This approach also supports revolutionary clinical study designs (Woo, 2019).

With a robust digital infrastructure, AI algorithms can cleanse, aggregate, code, preserve, and maintain clinical trial data. Enhanced electronic data capture (EDC) systems further reduce human error in data collection and facilitate seamless system integration (Mayorga-Ruiz et al., 2019).

2.2.2 Clinical Trial Cooperation and Model Sharing

Researchers from various fields are making extraordinary strides to support the global response to COVID-19 through scientific collaboration. To make a significant impact with AI tools, scalable strategies for data, model, and code sharing, as well as adaptation to local contexts and cross-border collaboration, are essential (Luengo-Oroz et al., 2020).

AI applications require extensive data. Currently, numerous data-sharing initiatives focusing on COVID-19 operate at global, national, and local levels. These initiatives encompass diverse resources such as genetic sequences, genomic analyses, protein structures, clinical patient data, medical imaging, event data, epidemiological information, movement data, social media comments, news articles, and scientific literature. However, the hyper-fragmentation of these data-sharing activities poses a challenge, potentially limiting advancements to specific projects and communities. Establishing scalable methods for data, model, and code sharing can accelerate the development and dissemination of new applications. At this juncture, global, open, comprehensive, comparable, and verifiable data-sharing initiatives are crucial for fostering cooperation across different communities and regions (Lip et al., 2020; Luengo-Oroz et al., 2020).

Open science, supported by multi-stakeholder AI collaborations operating internationally, can expedite information dissemination and capacity building within national health systems (Shaheen, 2021b). For instance, the Epidemic Intelligence from Open Sources (EIOS) network leverages open-source data for the early detection, verification, and assessment of public health threats (Sucharitha & Chary, 2021). This network, comprising governments, international organizations, and research institutes, collaborates to share real-time information about outbreaks, adhering to the principle of collaboration over competition in early detection. Global standards and database interoperability are pivotal in enabling a unified response and decision-making at various levels, according to epidemiologists. As the pandemic progresses, understanding the epidemiological characteristics and risk factors of different demographics will require considering health system capacities, public health measures, environmental factors, and the societal impacts of COVID-19 (Sucharitha & Chary, 2021).

Beyond data sharing, there are currently limited initiatives focused on exchanging trained AI models for suggested applications. Challenges such as unique computational, design, and infrastructural requirements, lack of documentation, verification and interpretability issues, and legal concerns regarding confidentiality and intellectual property need to be addressed. Sharing pre-trained and validated AI models can facilitate quicker adaptation of solutions to diverse scenarios. Examples of broadly useful algorithms include those for diagnosing diseases from images, predicting patient outcomes, filtering misinformation based on social media propagation patterns, and extracting knowledge graphs from extensive collections of scholarly papers (Luengo-Oroz et al., 2020; Shaheen, 2021a; Harrer et al., 2019).

2.3 Patient Care

Artificial intelligence is increasingly shaping patient outcomes in healthcare by providing comprehensive support throughout the care process. Medical AI companies are developing systems designed to assist patients at every stage of their journey, from diagnosis to treatment. Clinical intelligence systems, in particular, analyze extensive medical data to offer actionable insights, ultimately enhancing patients' quality of life. Below are some key examples of clinical intelligence systems that significantly contribute to improving patient care:

2.3.1 Maternal Care

A promising approach to reducing maternal mortality and complications involves identifying high-risk pregnancies and enhancing care through advanced technologies. By leveraging artificial intelligence (AI) and electronic health data, healthcare providers can predict which expectant mothers are at significant risk for complications during delivery. This predictive capability allows for early intervention and customized care plans. Additionally, integrating digital technology can improve patient access to both routine and specialized care throughout pregnancy. Evidence indicates that high-risk obstetric patients who deliver in lower-acuity clinics face higher risks of severe maternal morbidity compared to those in high-acuity facilities with more comprehensive resources and expertise. Thus, improving the capabilities of lower-acuity clinics or ensuring that high-risk pregnancies are managed in higher-acuity settings can significantly mitigate these risks and enhance maternal health outcomes.

2.3.2 Healthcare Robotics

In addition to the invaluable role played by medical personnel, advanced robotics are increasingly supporting patient care. For instance, exoskeleton robots have shown promise in helping paralyzed individuals regain mobility and independence (Shi et al., 2019). Similarly, smart prostheses represent a significant leap in prosthetic technology. These bionic limbs, equipped with sensors, offer greater responsiveness and precision compared to natural limbs. They can also be fitted with bionic skin and integrated with the user's muscle signals for enhanced functionality.

Robots are making strides in rehabilitation and surgical procedures. A notable example is Cyberdyne's Hybrid Assistive Limb (HAL) exoskeleton, which aids in the rehabilitation of patients with lower limb disorders such as spinal cord injuries and strokes. By utilizing sensors placed on the skin to detect electrical signals, HAL facilitates joint movement in response to the user's neural commands (Cruciger et al., 2016).

2.3.3 Genetics AI Data-Driven Medicine

From genome sequencing to the insights gleaned from fitness and activity trackers, today's healthcare consumers are more engaged in their personal medical care than ever before. The aggregation and integration of this vast array of data are paving the way for a more predictive understanding of individual health and medical conditions. Data-driven medicine not only enhances the precision and responsiveness of genetic disease detection but also ushers in the era of personalized medical treatments (Hummel & Braun, 2020).

2.3.4 AI-powered Stethoscope

A key advantage of digital stethoscopes over traditional models is their ability to capture accurate readings even in noisy environments. This feature enhances diagnostic precision and makes it possible for individuals without specialized training to use the device, as noted by Prabu (2021). Consequently, digital stethoscopes reduce the risk of COVID-19 transmission and facilitate improved medical care in remote or underserved areas, as well as for patients with chronic conditions.

Advancements in artificial intelligence (AI) and machine learning enable computers to identify disease patterns and anomalies from extensive clinical data. For example, just as blood flow through normal arteries differs from flow around a blood clot, AI can discern subtle variations in health data to support accurate diagnoses (J. Agrawal, 2018).

Conclusion

Artificial intelligence (AI) is increasingly transforming healthcare, enhancing both patient treatment and administrative tasks. While AI's role in healthcare is growing, it remains in its early stages. Innovations have shown that AI can match or even exceed human performance in specific areas, such as diagnosing diseases. However, replacing humans in a broad range of medical roles is still a distant prospect. Ongoing research and advancements in AI and machine learning hold promise for significant improvements in healthcare, potentially elevating patient care and quality of life. The field is poised for substantial growth, making it one of the fastest-evolving sectors in the digital age.

Author contributions

T., conceptualized and developed the methodology. A.R.S. and M.T.S., prepared the original draft and collected data and reviewed and edited the writing. K.F.B. and M.S.R., analyzed the data and reviewed and edited the writing.

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Competing financial interests

The authors have no conflict of interest.

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