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Artificial Intelligence for Health & Healthcare

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Abstract: *This paper presents a systematic review of the role of Artificial Intelligence (AI) in healthcare, highlighting its applications and challenges. AI technologies, including machine learning, natural language processing, and predictive analytics, are transforming healthcare through diagnostic assistance, treatment personalization, patient monitoring, optimization of healthcare operations, and public health. Despite the potential benefits, the integration of AI in healthcare faces significant challenges, such as data privacy and security concerns, ethical and legal issues, interoperability and integration difficulties, scalability and accessibility obstacles, and the intricacies of human-AI interaction. This review emphasizes the need for robust cybersecurity measures, ethical guidelines, clear legal frameworks, universal standards for interoperability, and equitable access to AI technologies. Recommendations for overcoming these challenges include fostering interdisciplinary collaboration, enhancing healthcare professional education, and promoting research and development. AI can realize its full potential in enhancing healthcare delivery and patient outcomes by addressing these challenges.*

Keywords: Artificial Intelligence, Healthcare, Diagnostic Assistance, Treatment Personalization, Data Privacy, Ethical Considerations

I. INTRODUCTION

The significance of AI application in healthcare cannot be overstated. AI Potential to revolutionise how we diagnosed disease, tailor treatment to individual patients, monitor health. For instance, AI-driven diagnostic tools can accurately analyse medical images, often identifying subtleties that may elude human eyes. This precision translates into earlier and more accurate diagnoses, significantly impacting patient outcomes. Similarly, in treatment personalization, AI algorithms can sift through vast datasets to identify patterns and predict which treatments will be most effective for specific patient profiles, marking a leap towards truly personalized medicine. Moreover, AI applications extend to patient monitoring, where wearable devices and remote monitoring systems offer continuous oversight of patient health, enabling timely interventions and reducing hospital readmissions. In terms of healthcare delivery, AI can streamline operations, from scheduling appointments to optimizing hospital workflows, thereby improving efficiency and patient satisfaction (Alshamrani, 2022; Farid, Bello, Ahamed, & Hossain, 2023; Shaik et al., 2023).

Purpose and Scope of the Review

This systematic review aims to meticulously examine AI's multifaceted applications and inherent challenges within the healthcare sector. By systematically compiling and analyzing current literature, this review provides a comprehensive overview of how AI technologies address healthcare challenges, enhance patient care, and improve healthcare outcomes. Additionally, this review will critically assess the obstacles and limitations faced in integrating AI into healthcare practices, from technical and ethical dilemmas to regulatory and implementation hurdles. The objective is to offer a balanced perspective that not only celebrates the achievements of AI in healthcare but also addresses the complexities and challenges that come with its adoption. The scope of this review is deliberately broad yet focused, encompassing a wide array of AI technologies and their applications within the healthcare sector. This includes, but is not limited to, machine learning models, natural language processing (NLP) tools, robotic process automation (RPA),

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and AI-driven predictive analytics. The review will explore these technologies in the context of diagnostic assistance, treatment personalization, patient monitoring and care, healthcare operations, and public health initiatives. While the potential of AI in healthcare is vast, this review will also delineate the boundaries of current applications, critically evaluating the success and shortcomings of AI technologies in real-world healthcare settings. By doing so, the review aims to paint a clear picture of the current state of AI in healthcare, identifying areas of promise, ongoing challenges, and potential pathways for future research and implementation.

Applications of AI in Healthcare

The integration of Artificial Intelligence into healthcare has opened new avenues for enhancing patient care, optimizing healthcare operations, and advancing public health initiatives. This section comprehensively explores the pivotal applications of AI across various domains within the healthcare sector.

II. LITERATURE SURVEY

Artificial Intelligence (AI) represents a transformative force reshaping the landscape of numerous sectors, from finance and education to transportation and beyond.

Table 1. Relevant Ethical code, Framework, & Guidlines

Guiding Codes and Frameworks	Reference
ACM Code of Ethics and Professional Conduct	Gotterbarn, D. W., B. Brinkman, C. Flick, M. S. Kirkpatrick, K. Miller, K. Vazansky, and M. J. Wolf. 2018. ACM code of ethics and professional conduct. https://www.acm.org/binaries/content/assets/about/acm-code-of-ethics-and-professional-conduct.pdf.
Artificial Intelligence at Google: Our Principles	Google. 2018. Artificial intelligence at Google: Our principles. Google AI. https://ai.google/principles.
Ethical OS: Risk Mitigation Checklist	Institute for the Future and Omidyar Network. 2018. Ethical OS: Risk Mitigation Checklist. https://ethicalos.org/wp-content/uploads/2018/08/EthicalOS_Check-List_080618.pdf.
DeepMind Ethics & Society Team	DeepMind. 2020. DeepMind Ethics & Society Team. https://deepmind.com/about/ethics-and-society.
Partnership on AI Tenets	Partnership on AI. 2018. Partnership on AI tenets. https://www.partnershiponai.org/tenets.
AI Now Report 2018	Whittaker, M., K. Crawford, R. Dobbe, G. Fried, E. Kaziunas, V. Mathur, S. M. West, R. Richardson, J. Schultz, and O. Schwartz. 2018. AI Now Report 2018. AI Now Institute at New York University. https://stanford.app.box.com/s/xmb2cj3e7gsz5vmus0viadt9p3kreekk.
The Trouble with Algorithmic Decisions	Zarsky, T. 2016. The trouble with algorithmic decisions: An analytic road map to examine efficiency and fairness in automated and opaque decision making. Science, Technology, & Human Values 41(1):18–132.
Executive Office of the President	Munoz, C., M. Smith, and D. J. Patil. 2016. Big data: A report on algorithmic systems, opportunity, and civil rights. Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/2016_0504_data_discrimination.pdf.
Addressing Ethical Challenges in Machine Learning	Vayena, E., A. Blasimme, and I. G. Cohen. 2018. Machine learning in medicine: Addressing ethical challenges. PLoS Medicine 15(11):e1002689. Figure 1.3.
Do No Harm: A Roadmap for Responsible Machine Learning in Health Care	Wiens, J., S. Saria, M. Sendak, M. Ghassemi, V. X. Liu, F. Doshi-Velez, K. Jung, K. Heller, D. Kale, M. Saeed, P. N. Ossorio, S. Thadaney-Israni, and A. Goldenberg. 2019. Do no harm: A roadmap for responsible machine learning for health care. Nature Medicine 25(9):1337–1340.

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At its core, AI involves the development of computer systems capable of performing tasks that typically require human intelligence, such as understanding natural language, recognizing patterns, making decisions, and learning from experience (Dwivedi et al., 2021; Păvăloaia & Necula, 2023; Taj & Zaman, 2022). In recent years, the healthcare sector has emerged as a primary beneficiary of AI's potential, leveraging its capabilities to enhance various aspects of patient care and administrative efficiency. Integrating AI technologies in healthcare is not just a futuristic vision but a present reality, driven by the exponential growth in healthcare data, advancements in computational power, and significant breakthroughs in machine learning algorithms (Dwivedi et al., 2021; Leone, Schiavone, Appio, & Chiao, 2021).

Data are critical for delivering evidence-based health care and developing any AI algorithm. Without data, the underlying characteristics of the process and outcomes are unknown. This has been a gap in health care for many years, but key trends (such as commodity wearable technologies) in this domain in the past decade have transformed health care into a heterogeneous data-rich environment (Schulte and Fry, 2019). It is now common in health and health care for massive amounts of data to be generated about an individual from a variety of sources, such as claims data, genetic information, radiology images, intensive care unit surveillance, EHR care documentation, and medical device sensing and surveillance. The reasons for these trends include the scaling of computational capacity through decreases in cost of technology; widespread adoption of EHRs promoted by the Health Information Technology for Economic and Clinical Health (HITECH) Act; precipitous decreases in cost of genetic sample processing (Wetterstrand, 2019); and increasing integration of medical- and consumer-grade sensors. U.S. consumers used approximately 3 petabytes of Internet data every minute of the day in 2018, generating possible health-connected data with each use (DOMO, 2019). There are more than 300,000 health applications in app stores, with more than 200 being added each day and an overall doubling of these applications since 2015 (Aitken et al., 2017).

III. METHODOLOGY

Data Aggregation

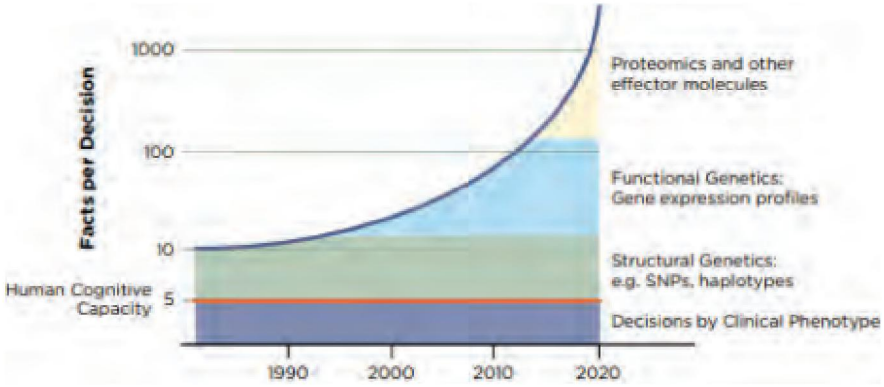

Fig.1 Growth in facts affecting provider decisions versus human cognitive capacity.

The accumulation of medical and consumer data has resulted in patients, caregivers, and health care professionals being responsible for aggregating, synthesizing, and interpreting data far beyond human cognitive and decision making capacities. Figure 1-4 predicts the exponential data accumulation and the limits of human cognition for health care decision making (IOM, 2008) The growth in data generation and need for data synthesis exceeding human capacity has surpassed prior estimates. This trend most likely underestimates the magnitude of the current data milieu. AI algorithms require large volumes of training data to achieve performance levels sufficient for "success" (Shrott, 2017; Sun et al., 2017), and there are multiple frameworks and standards in place to promote data aggregation for AI use. These include standardized data representations that both manage data at rest1 and data in motion.2 For data at rest, mature common data models (CDMs),3 such as Observational Medical Outcomes Partnership (OMOP), Informatics for Integrating

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Biology & the Bedside (i2b2), the Patient-Centered Clinical Research Network (PCORNet), and Sentinel, are increasingly providing a backbone to format, clean, harmonize, and standardize data that can then be used for the training of AI algorithms (Rosenbloom et al., 2017). Some of these CDMs (e.g., OMOP) are also international in focus, which may support compatibility and portability of some AI algorithms across countries. Some health care systems have invested in the infrastructure for developing and maintaining at least one CDM.

through funded initiatives (OHDSI, 2019; Ohno-Machado et al., 2014). Many others have adopted one of these CDMs as a cornerstone of their clinical data warehouse infrastructure to help support operations, quality improvement, and research. This improves the quality and volume of data that are computable and usable for AI in the United States, and promotes transparency and reproducibility (Hripcsak et al., 2015). It is also important for semantic meaning to be mapped to a structured representation, such as Logical Observation Identifiers Names and Codes and International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM), as these CDMs leverage these standardized representations.

Artificial Intelligence is a field of computer science that mimics human cognitive functions. It has brought a paradigm shift in the medical field mostly due to the increase in healthcare data and rapid increase of analytical techniques. In recent years AI has surpassed human performance in several medical field areas, and this is a great adoption in healthcare. Also, through the use of analytical techniques, AI has the capabilities to prevent, detect, diagnose, and treat a wide range of diseases. This research paper will discuss different types of Artificial Intelligence techniques and how AI has been used in healthcare. Also, it will provide a view of the future of Artificial Intelligence in healthcare.

A. Artificial intelligence & Machine Learning

In a medical dataset, there are two categories of data which are structured data and unstructured data. Therefore there exist different types of techniques that are used to meet healthcare requirements. Machine Learning techniques, Neural Network systems, and Modern Deep Learning techniques ensure that structured data such as genetic and imaging data is analyzed. It is necessary to understand that healthcare application uses Machine Learning procedures to try clustering patients' traits or infer the probability of the disease outcomes. Therefore the patient outcomes are determined Machine Learning. The commonly used type of machine learning in a clinical setting is supervised learning. It uses the physical traits of a patient with the help of dataset with healthcare information to provide a more targeted outcome. Modern Deep Learning is another type of learning that takes machine learning as the inputs and then feed it into a computerized neural network which simplifies the outcomes. This is useful to clinicians, especially where there are multiple possible diagnoses, modern deep learning will narrow down to one or two outcomes. Natural Language Processing methods are used to extract information from unstructured data, including medical journals and clinical notes. Natural Language processing procedures convert texts into readable structured data by a machine, which is then analyzed by Machine Learning techniques. During the diagnosis process, Natural Language Processing and the Cloud Computing use a historical database to aid in the decision-making process using relevant keywords concerning a specific disease. Therefore using these techniques, the practitioners will obtain a more accurate and efficient diagnosis for a patient hence speeding up the treatment process.

B. Treatment Design

Advanced treatment in healthcare has resulted from the adoption of AI technology, which has upgraded the treatment tactics and aiding the analysis process that provides a satisfying treatment strategy as well as monitoring treatments. Also, Artificial Intelligence has the capabilities of analyzing and accurately recognizing signs and symptoms of medical images such as X-rays, CT scan, MRI, and ultrasounds. This makes there to be faster diagnostics, thereby reducing the period at which a patients waits for diagnosis from months to hours. Also, AI has facilitated the invention of medical assistant systems such as Modernizing Medicine which gathers information about a patient, record diagnosis, aid in the testing process, and arrange billing information using the cloud computing. Also, the technique of using a public database that holds information from many patient and doctor cases assists physicians to arrive at betterpersonalized

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treatments or discover similar cases using AI technology to extract data. In future, clinicians will be required to adopt more extensive AI techniques to cater for better care design and to satisfy patients with long their long haul treatment program.

C. Managing Medical Data & Records

Data management is the vital role of Artificial Intelligence in healthcare where it is responsible for collecting or gathering, storing, normalizing, and tracing the source of the data. Compiling and investigating data are the essential steps in healthcare, therefore data management the widely used technique in Artificial Intelligence. Furthermore, healthcare data is generated in large volumes every day; this has made more data analytic tools to be implemented. These tools have helped healthcare organizations to collaborate with patients and make informed decisions on large data and storing it to reduce wastage. Artificial Intelligence allows simulation of smart behaviour in a computer system, and this can increase the quality of patient care since the simulation will coordinate the experience, information and human contact of clinicians with the power of AI.

D. Future of Artificial Intelligence

AI has a positive impact on doctors and patients in healthcare because of the ability to gather and analyze a large amount of medical data yielding quicker and more accurate diagnoses of a large section of the population. Therefore if there are a portion of people who are not able to access specialized healthcare, then they might achieve the advantage through Artificial Intelligence. Also, another important expectation is that healthcare expenses will continue falling due to more accurate diagnoses. As AI technology is widely used in healthcare, the doctors will change the way they treat patients whereby they will broaden the possibilities to predict and treat diseases. This will reduce healthcare expenses, and it will now be easier to progress medical care in rural areas where access to healthcare is limited.

IV. CONCLUSION

In conclusion, integrating Artificial Intelligence into healthcare holds immense promise for transforming patient care, enhancing diagnostic accuracy, personalizing treatment plans, optimizing healthcare operations, and improving public health surveillance. However, realizing the full potential of AI in healthcare requires navigating a complex landscape of challenges, including data privacy and security, ethical and legal considerations, interoperability and integration issues, scalability and accessibility concerns, and the dynamics of human-AI interaction. To overcome these challenges, a comprehensive approach involving strengthened data protection measures, ethical oversight, legal clarity, investment in interoperability, and efforts to ensure equitable access to AI technologies is essential. Moreover, enhancing the education and training of healthcare professionals on AI's capabilities and limitations will be crucial for fostering effective human-AI collaboration. As we move forward, it is clear that AI will play a pivotal role in shaping the future of healthcare. By addressing the challenges and adhering to the recommendations outlined, stakeholders can ensure that AI technologies are implemented responsibly and effectively, leading to improved healthcare outcomes, greater efficiency in healthcare delivery, and a more equitable healthcare system for all. The journey toward AI-enabled healthcare is complex and ongoing. However, with collaborative effort and commitment, the benefits for patients, providers, and society can be profound and far-reaching.

V. FUTURE SCOPE

Development AI has a positive impact on doctors and patients in healthcare because of the ability to gather and analyze a large amount of medical data yielding quicker and more accurate diagnoses of a large section of the population. Therefore if there are a portion of people who are not able to access specialized healthcare, then they might achieve the advantage through Artificial Intelligence. Also, another important expectation is that healthcare expenses will continue falling due to more accurate diagnoses. As AI technology is widely used in healthcare, the doctors will change the way

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