The Landscape of Artificial Intelligence Applications in Health Information Systems

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ABSTRACT
Artificial Intelligence, particularly Machine Learning, has become feasible thanks to the availability of big data, enhanced computing power and cloud storage across diverse sectors. In the realm of health information systems, these advancements continue to impact various sectors, including clinical decision support systems, AI-driven Chatbots, virtual assistants and predictive analytics for disease diagnosis and prognosis. AI helps in expediting image interpretation for medical professionals and is swiftly enhancing the efficiency of entire health systems. The introduction and utilization of AI not only mitigates costly errors but also empowers patients to leverage their data for improved health results. Hence, emphasizing ethics in AI is crucial for fostering trust and confidence. This necessitates thorough examination of issues like bias, privacy concerns, security and perceived transparency gaps. Therefore, further exploration of Fair Machine Learning, federated learning and Responsible AI is imperative. Most recently, the significance of AI applications in health information systems was particularly evident during the COVID-19 pandemic. Researchers anticipate substantial enhancements in the accuracy, productivity and workflow of AI applications over time. This conceptual paper provides an overview of the current and future trajectories of AI applications within the context of health information systems.

General Terms

Artificial Intelligence, Deep Learning, Predictive analytics, Machine Learning, Health information systems

Keywords

Fair Machine Learning, Responsible AI, Federated Learning

1. INTRODUCTION
Presently, fascinating buzzwords such as cognitive computing, big data, Internet of Things (IoT), artificial intelligence (AI) and machine learning (ML) permeate various fields such as business, healthcare, education and sports [1]. AI has emerged as a potent force across industries, revolutionizing operations and yielding notable advantages, like improved efficiency, precision and output. Its capacity to automate tasks and refine decision-making offers bespoke experiences and mitigates risks that are inherent in many organizations [2]. AI has been a pivotal factor in shaping various sectors' present and future landscapes, and is undoubtedly at the forefront of medicine and heath information systems [3]. The landscape over the past two decades has been graphically depicted in Fig. 1.

Information systems (IS) encompass interconnected components and processes designed to gather, store, analyze, process and disseminate information within an organization. Focusing specifically on healthcare, these intricate systems for managing data, information and knowledge in healthcare environments are commonly referred to as health information systems (health IS) [4]. Amidst the global health crisis of COVID-19, the medical industry sought innovative technologies to monitor and contain its spread [5][6]. Various forms of scientific innovation were utilized to help mitigate the damage of the pandemic, including AI applications such as Clinical Decision Support Systems, AI-driven Healthcare Chatbots and Natural Language Processing (NLP) for Electronic Health Record (EHR) Management [7] .

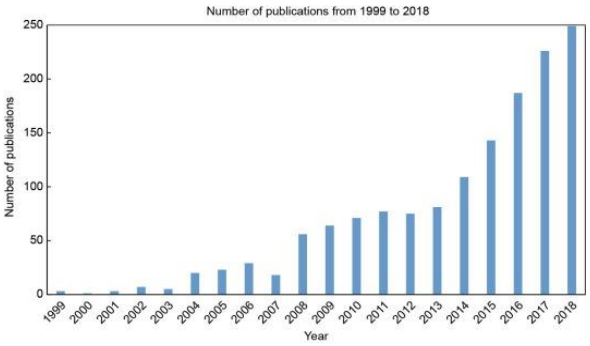

Figure 1: Growing research interest in the application of AI in health IS and biomedicine, as evidenced by the number of publications on this subject over the past two decades (G. Rong, A. Mendez, E. Bou Assi, B. Zhao, and M. Sawan, "Artificial Intelligence in Healthcare: Review and Prediction Case Studies," *Engineering*, vol. 6, no. 3, pp. 292)

The objective in healthcare is to evolve towards a more personalized, predictive, preventive and participatory model. AI stands poised to play a significant role in advancing healthcare along these dimensions, offering substantial contributions towards achieving these goals. The objective of this paper is to examine contemporary research involving the applications of AI in health IS. To achieve this, the following research questions are addressed: (1) what is the current state and direction of research regarding AI in health IS? (A scoping review); (2) what does the future hold for AI in health IS? (Proposition of a conceptual framework). Subsequent sections of this paper will delve into answering these research inquiries.

2. LITERATURE REVIEW
AI has a far-reaching history, extending beyond common perception, with roots in fields such as science and philosophy dating back to ancient Greece. In recent years, there has been a noticeable surge in AI applications within the health IS research community [1]. The digitization of healthcare information, coupled with progress in computer processing and data storage, has facilitated the deployment of advanced AI algorithms [8]; and as of 2011, the U.S. Agency for Healthcare Research and Quality (AHRQ) had curated a repository exceeding 17,000 algorithms and computer programs designed for healthcare assessment, treatment and management [9].

Several factors including nanomedicine and AI-based innovations are propelling the advancement of research in the healthcare sector [10] [11]. In the United States, there is mounting legislative pressure to remain competitive with other nations in AI development. Globally, financial constraints are increasing within the health industry due to the escalating demands of a growing and aging population. This necessitates the adoption of labor-saving technologies and methodologies to enhance population health management while accommodating a larger number of individuals and reducing costs. Whether or not AI can completely automate human roles in the health IS field, it has the potential to improve workforce efficiency. Accenture suggests that "key clinical health AI applications" could result in $150 billion in yearly savings for the U.S. healthcare industry by 2026. Even if only part of this estimate becomes a reality, it provides a strong motivation for the widespread adoption of AI in health IS [9].

The pressing need for AI in health IS primarily lies in disease diagnostics, where several notable advancements have been achieved. AI empowers healthcare practitioners to deliver earlier and more precise diagnoses across various diseases [12]. For example, machine learning techniques enable AI to analyze microarray data for gene expression analysis, facilitating the classification and detection of abnormalities, which is crucial for accurate diagnosis [13].

The social science viewpoint in America is positive, as evidenced by a PEW Research survey indicating that the majority of patients lean towards experiencing positive sentiments regarding the relevance of AI applications in health IS [14].

Despite the positive impacts of AI in health IS, there are areas that require further improvement, particularly in the context of COVID-19 and minority groups. This prompts the consideration of fair and federated machine learning models, which aim to remodel health architecture to reduce systemic bias and increase transparency [15]. Achieving a harmonious integration of the theoretical framework of AI ethics with the practical implementation of machine learning in healthcare systems presents exciting opportunities for advancement [16].

The current state and direction of research regarding AI in health IS reflect a dynamic and rapidly evolving landscape. With the exponential growth of digital health data and the increasing demand for advanced healthcare solutions, AI has emerged as a transformative force in the healthcare industry[17]. One prominent area of research focuses on leveraging AI technologies for clinical decision support systems (CDSS), which enables healthcare professionals in making informed decisions by analyzing vast amounts of patient data [13][14]. AI algorithms are being developed to enhance diagnostic accuracy and recommend personalized treatment plans based on individual patient characteristics. These AI-powered CDSS have the potential to improve health IS and patient care by improving diagnostic efficiency, reducing medical errors and optimize treatment outcomes [18].

Another key research direction involves the integration of AI into healthcare delivery systems to improve workflow efficiency and resource allocation [19]. AI-driven tools such as Chatbots and virtual assistants are being developed to automate routine administrative tasks, streamline patient scheduling and enhance communication between healthcare providers and patients [20]. Also, AI-powered predictive analytics are being utilized to forecast patient demand, optimize hospital bed utilization and allocate resources more effectively, particularly in response to public health emergencies such as the COVID-19 pandemic [20][21].

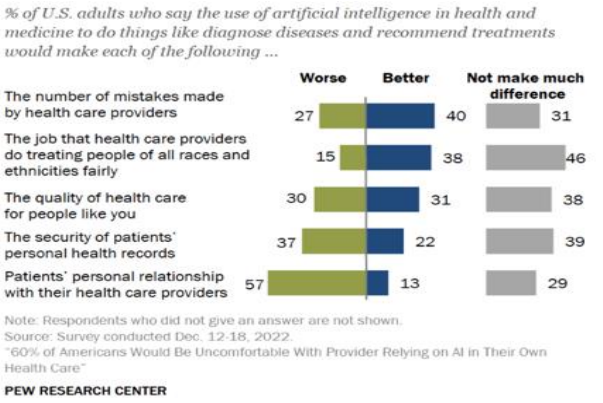

Figure 2: Americans tilt positive on AI's ability to reduce medical errors; greater concern around data security, patient-provider relationships (Tyson, A., Pasquini, G., Spencer, A., & Funk, C. (2023). 60% of Americans would be uncomfortable with provider relying on AI in their own health care.)

Research efforts are underway to address challenges related to bias, fairness, privacy and security in AI-driven health IS. As AI algorithms increasingly influence clinical decision-making and the overall architecture of health IS, ensuring the ethical and responsible use of AI is paramount [22][23][24] . Researchers are exploring methods to mitigate algorithmic biases, protect patient privacy and enhance the security of healthcare data to maintain patient trust and confidence in AI-driven healthcare systems [22][25]. This will foster trust in the system going forward, as demonstrated during the pandemic when the dissemination of misinformation and disinformation posed obstacles to a seamless healthcare system, particularly evident in the distribution and acceptance of vaccines [26].

Another interesting concept is Federated learning (FL); a learning approach aimed at tackling data governance and privacy concerns by training algorithms collaboratively, without sharing the actual data [27]. Initially used in various fields like mobile and edge devices, FL has gained attention for its applications in health IS. It allows for collaborative insights generation, such as through a consensus model, while keeping patient data within institutional firewalls [27][28]. This approach ensures data security and privacy without the need to transfer sensitive information externally [28].

AI applications in health systems is characterized by a continued emphasis on developing advanced AI algorithms, integrating these AI technologies into existing healthcare infrastructures and addressing ethical, legal and regulatory considerations to create a robust health information system [22][29] . Collaboration between multidisciplinary teams of researchers, healthcare professionals, policymakers and industry stakeholders is crucial in advancing AI research and realizing the full potential of AI to transform healthcare delivery and information systems [30].

AI models in healthcare IS should continuously learn and improve over time. This necessitates incorporating mechanisms for feedback and iterative development. Real-world data collected during implementation can be used to refine algorithms and ensure they remain relevant and effective

in dynamic healthcare settings [31]. Continuous learning allows AI systems to adapt to evolving healthcare practices, emerging diseases and variations in patient populations. This ensures that AI remains reliable and contributes to improved healthcare outcomes over the long term [32]. Developing AI models that are interpretable and fair is crucial for building trust within health IS; where users should be able to understand, at least at an important level, how AI systems arrive at their conclusions and identify any potential biases that may be present in the data or algorithms [33].

2.1 FACTORS INFLUENCING AI APPLICATIONS IN HEALTH SYSTEMS

In the rapidly evolving landscape of health systems, AI applications hold immense promise for transforming the delivery of medical services across the value chain. The adoption and integration of AI within health systems have been instrumental, yielding notable outcomes. Table 1 provides an overview of relevant literature, emphasizing significant insights in this field.

3. BEYOND COVID: AI IN HEALTH INFORMATION SYSTEMS

As the world transitions beyond the COVID-19 pandemic, the role of AI in health information systems continues to evolve. AI contributes to predictive analytics for resource allocation and empowers virtual health assistants to elevate patient care standards. Its adeptness in processing extensive datasets and optimizing workflows heralds a transformative era in healthcare management. However, while technology brings advancements, ethical considerations emerge. The conceptual high-level block diagram (Figure 3.) outlines existing health information system metrics and proposes how AI can be optimized across all aspects to yield more human-centered outputs, reflecting a nuanced approach to healthcare delivery.

Table 1: Overview of relevant literature, emphasizing key features influencing AI applications in Health IS.

KEY COMPONENTS	FEATURES
Leadership and Governance	**Strong leadership support, clear vision, goals (with clear roles and responsibilities for AI development, deployment and oversight) and a governance structure that oversees AI implementation**: Specifically, having executive sponsorship that champions AI and allocates resources to implement a clearly defined vision for the use of AI to improve healthcare delivery [34] [35].
Data Analytics	**High-quality data, robust data analytics capabilities, and a focus on data privacy and security**: This includes access to high-quality, clean and complete data that is representative of the target population. To guarantee data security and quality, robust data governance procedures with strong data analytics capabilities must be implemented to handle and examine big datasets. Thus, adherence to data privacy regulations like the Health Insurance Portability and Accountability Act (HIPAA) to protect patient information is vital [36] [37].
Change Management	**Effective change management strategy to address workforce concerns and ensure user adoption:** This means clear communication about the purpose and benefits of AI implementation; as well as training and support for health professionals on how to use AI effectively. Addressing workforce concerns about job displacement and potential negative impacts of AI encourages an innovative and accommodating culture toward emerging technology [38].
Clinical Integration	**Effective integration within existing clinical workflows; which is essential for seamless adoption by health professionals**. This entails AI tools that complement current practices and facilitate information exchange between AI systems and Electronic Health Records. Clinical integration ensures that AI functions within the established health ecosystem, minimizing disruption and maximizing its practical utility for clinicians. Ultimately, AI should enhance, rather than hinder the delivery of patient care [39][40].
Technical Infrastructure	**The ability of different health information systems to communicate and an IT infrastructure that can support AI workloads, including hardware, software and data storage:** This includes hardware with sufficient processing power and memory to handle complex AI algorithms, the ability of different health IS to communicate and exchange data seamlessly and software platforms that support AI development and deployment. It is paramount to have secure and scalable data storage solutions for managing large datasets [34][41][42].

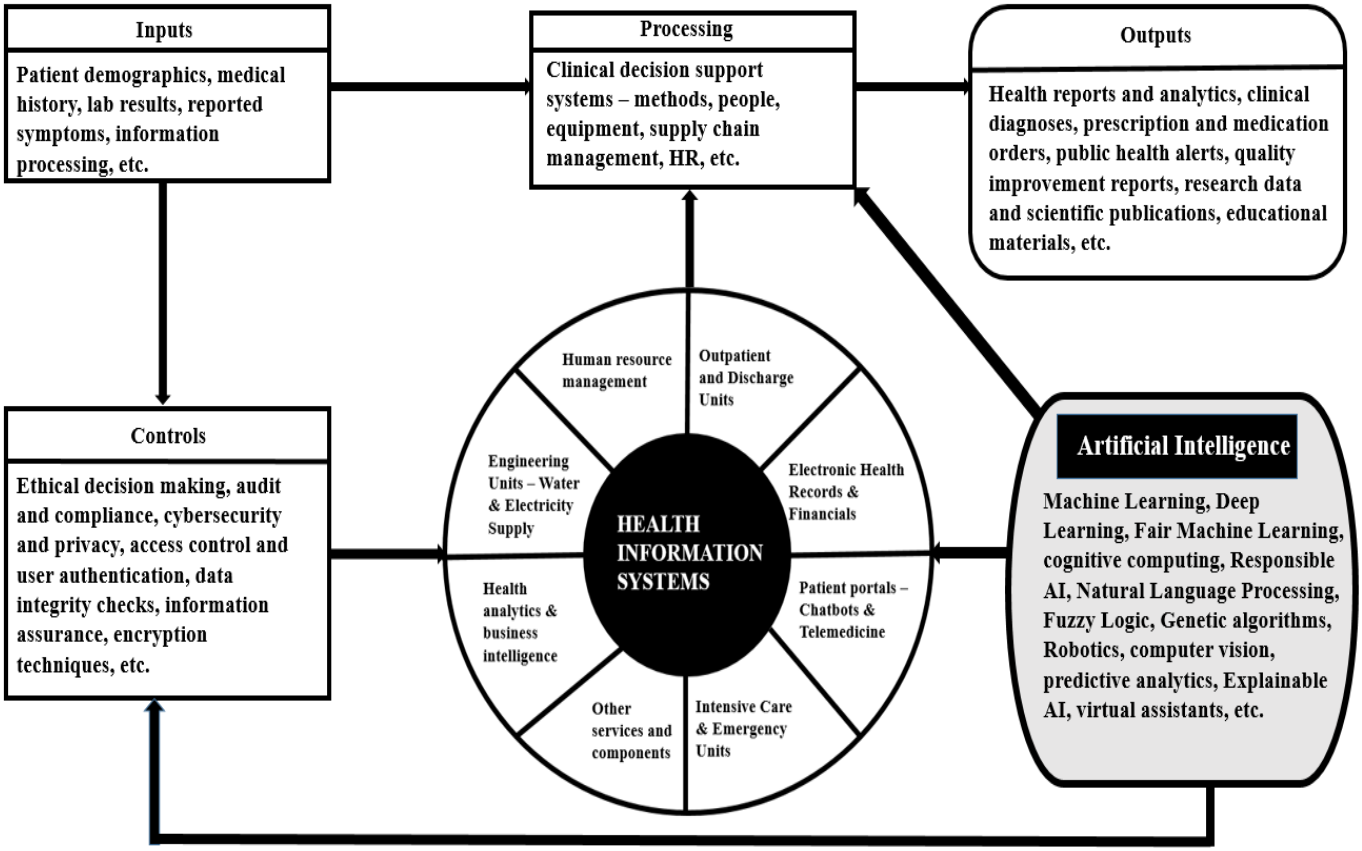

Figure 3: A high level conceptual block diagram summarizing the present and future landscape of AI in health information systems

4. FUTURE PERSPECTIVES

The integration of AI and fair machine learning into health IS holds immense promise for shaping healthcare delivery and patient prognosis. As we look towards the future, the convergence of AI technologies and ethical considerations in health IS presents a compelling vision of more equitable, efficient and patient-centered healthcare systems. One key future aspect is the progression of AI-driven clinical decision support systems. These systems leverage machine learning algorithms to analyze big data of patient data and improve personalized diagnostic and treatment recommendations within the health ecosystem.

5. CONCLUSION

The landscape of artificial intelligence applications in health information systems has shown rapid evolution over the last two decades. From predictive analytics and clinical decision support to virtual health assistants and personalized medicine, AI has improved how health information is collected, processed, analyzed and utilized across the value chain. However, challenges such as data privacy, algorithm bias, and ethical considerations must be carefully addressed to maximize the benefits of AI while minimizing risks. There is the need for continued research, collaboration and innovation to harness the full potential of AI to shape the future of healthcare and improve the well-being of individuals and communities worldwide.

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