AI-Driven transformation of healthcare in Algeria: opportunities, constraints, and ethical considerations

ABDERRAHIM Wahiba

Higher School of Commerce, Kolea, Tipaza, Algeria abderrahim.wahiba95@gmail.com

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Abstract:

In an environment undergoing a profound digital transformation, Algeria is demonstrating growing interest in the potential applications of artificial intelligence (AI) in the healthcare sector. Confronted with disparities in access to care, a shortage of qualified human resources, and often-inadequate infrastructure, the country views AI as a strategic lever to modernize medical practices and enhance the quality of healthcare services.

This contribution aims to examine the prospects offered by AI within the Algerian healthcare system by identifying the main obstacles hindering its implementation. The analysis considers the technological, institutional, ethical, and political dimensions necessary for the successful adoption of such innovations. Our research relies on a qualitative approach based on an in-depth documentary analysis. It draws upon a wide range of diverse sources, including scientific publications, reports from official organizations, and articles from specialized media. Our study also incorporates concrete examples of national experiences related to the deployment of AI in the health sector.

Keywords: artificial intelligence, healthcare system, technological evolution, innovation, medical ethics.

Jel Classification Codes: O33 ;O31 ; I15 ; L86

Wahiba ABDERRAHIM, Higher School of Commerce (Algeria), *abderrahim.wahiba95@gmail.com.*

1. INTRODUCTION

Today, artificial intelligence (AI) represents a significant breakthrough in the healthcare sector, offering substantial benefits in terms of efficiency, accuracy, and cost reduction. In 2019, the World Health Organization and private companies, such as Accenture identified AI as onomic lever. In the United States alone, according to some forecasts, it could generate over 200 billion dollars in savings over a decade. Major international institutions have invested heavily in AI projects aimed at improving patient care, medical diagnosis, and administrative processes within healthcare systems.

The deployment of AI lies on the exploitation of massive data and big data, enabling the identification of links between clinical data and patient characteristics. The applications of AI in healthcare are numerous, ranging from surgical robotics to predictive medicine. These advances help reduce the workload by automating repetitive tasks and facilitating access to highly accurate diagnoses.

The integration of AI into medical fields is now essential to address tomorrow's challenges, particularly through the creation of new professions such as data scientists and AI engineers. The hospital of the future will undoubtedly rely on AI, which aims to reduce human error. However, this evolution must be accompanied by strict measures to ensure compliance with ethics and legal standards (such as the protection of patient privacy).

In the context of developing countries, integrating AI into healthcare systems faces major challenges, particularly in terms of digital infrastructure and the availability of medical data. Algeria, although it has expressed a political will to adopt this technology, still faces structural obstacles that hinder its implementation. Nevertheless, numerous initiatives are emerging, led by public, private, and academic actors, highlighting a growing interest in AI in the country.

In this context, it becomes necessary to question the conditions under which AI can be implemented in the Algerian healthcare system.

Are all the necessary measures in place, and is the Algerian healthcare system prepared to integrate AI effectively and ethically? What are the structural and regulatory barriers to this adoption?

Our article aims to investigate the conditions necessary for the successful integration of AI in Algeria's healthcare sector, with a particular focus on technological advancements, institutional readiness, and ethical challenges.

2. Methodology

Our study employs a qualitative approach based on an in-depth documentary analysis. The research draws on a diverse body of sources, including recent scientific articles, institutional reports, and specialized publications that address the digital transformation of the Algerian healthcare sector. The analysis also incorporates insights and contributions from experts gathered during scientific events held in this field.

To ensure methodological coherence and to meet the research objectives, our study was structured around four main components: a literature review on the concept of artificial intelligence and its applications in healthcare, an overview of international experiences, and an examination of practices in Algeria. Finally, a critical reflection on the ethical and political dimensions of AI adoption in the healthcare sector.

3. Literature review on artificial intelligence technologies in the healthcare sector

Artificial intelligence (AI) is applied in the healthcare sector in various forms, such as medical robotics, expert systems, neural networks, genetic algorithms, and electronic medical records.

3.1. Medical robotics: Medical robotics (including robots and androids) is a specific branch of AI concerned with reproducing motor functions typically performed by humans or animals. It aims to execute repetitive or dangerous tasks that humans are unable to perform. Medical robotics refers to a machine that imitates human activity and functions via an electromechanical system to process medical data. Two types of robots are generally distinguished: the first is the non-autonomous robot, which follows programmed commands issued by a doctor. The second is a fully autonomous robot that functions independently. It can make decisions on its own based on medical information and is often used in surgical procedures (Eldakak, et al., 2024, p. 2). Medical robots have a wide range of functions. Some are designed to assist elderly or physically limited individuals in their daily lives.

Others, called rehabilitation robots, help patients suffering from motor disorders regain mobility through therapeutic exercises. Furthermore, surgical robots have revolutionized surgery by allowing physicians to perform highly precise operations, especially remotely. This improves both the accuracy and effectiveness of surgical interventions. These robots can reproduce the surgeon's gestures with great precision (Hadi, 2017). There are also robots used for remote diagnosis. They enable doctors and nurses to communicate with patients, analyze their data through electronic medical records, and even provide diagnoses remotely. These robots are also useful for managing chronic diseases and analyzing complex tests, helping to detect anomalies that are sometimes invisible to the naked eye.

3.2. Expert systems: Expert systems constitute a key area of AI. These are computer programs designed to replicate the competencies of human experts in a specific field by leveraging their knowledge and experience (Lakhdar Othman & Lamar Ridwan, 2013, p. 81). These systems can perform numerous functions, such as detecting changes in a patient's health condition, supporting diagnostic processes, suggesting treatment options, and interpreting medical images. Among the well-known examples are Dxplain, which assists in diagnosing diseases; Puff, which specializes in analyzing respiratory functions; and Peirs, used for thyroid testing (Al-Ritimi , 2012).

3.3. Neural networks and genetic algorithms: neural networks and artificial intelligence are widely used in the diagnosis of numerous conditions. According to experts, neural networks are used in predicting cardiac disease and analyzing liver function. Genetic algorithms, for their part, are used in medical imaging, particularly for the analysis of brain MRIs or to precisely locate affected areas based on image recognition. Applied to AI, they encompass numerous uses such as electronic health records (EHRs), decision-support systems, automatic reminders, training, and computer-assisted medical research, among others.

4. The global landscape of artificial intelligence in Healthcare

China, the United States, Canada, and the United Kingdom are among the four leading global nations in the AI sector (OECD, 2019). In 2017, China

announced the launch of a national plan aimed at generating over ten billion dollars by 2020 and nearly sixty billion dollars by 2025 (Graham Webster, Rogier Creemers, Elsa Kania, & Paul Triolo, 2017).

In 2019, the WHO listed ten ways in which technologies cloud improve health (Organization World Health, 2019), According to a study by Accenture. AI cloud generate more than 150 billion dollars annually in the United States alone through ten major applications, including robotic surgery, virtual nursing assistants, administrative workflow assistance, fraud detection, reduction of human error in medicine, connected objects, clinical trial recruitment, preliminary diagnosis, automated medical imaging, and cybersecurity (Accenture, 2017).

The challenge of AI is not primarily technical but lies in access to data (Dean arnold & Tim wilson , 2017), which is why Google was an early pioneer, transitioning from a few projects in 2012 to over 700 in 2015. Facebook also invested in creating the Facebook Artificial Intelligence Research Lab. The GAFAM companies (Google, Amazon, Facebook, Apple, and Microsoft) launched numerous AI initiatives in healthcare (Verily, Calico, Deepmind), supporting start-ups through significant funding, such as the part the partnership between Google and Sanofi, which developed the application Onduo, helping to remotely monitor patients and assist doctors (Sandeep Reddy, Jenifer Sunrise winter, & Sandosh Padmanabhan, 2021).

In 2020, the European Commission unveiled an ambitious digital strategy, projecting an annual investment of twenty billion euros in AI. It also supported projects such as Desiree, an AI-based application for breast cancer treatment, integrating clinical decision support based on past diagnoses to improve personalized care (Commission européenne, 2020).

According to the World Intellectual Property Organization, AI-related publications and patents have experienced an average annual growth rate of 28% between 2012 and 2017. In 2017, industrial players filed more than 55000 patents. In 2018, the world's first AI-powered healthcare clinic opened at the CHUM in Montreal, dedicated to practical implementation (J.Topol, 2019).

5. The application of AI in global health

Artificial intelligence (AI) has numerous applications in health. It is currently addressing many challenges and will continue to do so in the future, helping to improve healthcare, monitoring, and personalized treatments. It also enables earlier disease detection and helps reduce the impact of medical errors. AI thus promotes the emergence of the "4P" model of medicine: personalized, preventive, predictive, and participatory. The success of AI in health depends on the exploitation of big data to identify links between data and patient phenotypes. This will enable significant progress in the analysis of radiographic images, the automation of medical examinations, and the rapid diagnosis of diseases.

As for connected devices and medical technologies, numerous applications have already emerged, such as the AI-powered artificial pancreas and fall detectors for elderly or frail individuals (Andrew L, Beam & Issac S.Kohane, 2018).

A review of over 300 articles (2010-2020) highlighted seven major areas of research in AI for health: ontology creation, terminology, interoperability, recommendation systems, natural language processing, decision support, information retrieval, health data mining, and the use of social media data. These works herald a major disruption in the healthcare system driven by AI, even though the field is still in its early stages.

– In oncology, AI is being used to analyze genomic data and advanced imaging to support the development of precision medicine.

– In cardiology, an algorithm using 3D cardiac MRI has been developed to accurately predict disease progression in patients with pulmonary hypertension.

– In pharmacy, AI-based software such as Synapse Medicine, which relies on a therapeutic database, uses machine learning to detect medication-related anomalies. This technological advance helps reduce prescription errors, which affect one-third of hospitalized patients and often result in serious complications. More generally, AI can decode DNA, paving the way for the

creation of genetic profiles for patients and contributing to more diagnoses that are precise.

– In genetics, AI is capable of synthesizing DNA, paving the way for the creation of customized artificial genemos. It also supports clinicians in their diagnostic processes.

– In gastroenterology, AI is capable of detecting anomalies from genomic and imaging data. For example, it can distinguish a between benign polyp and a precancerous lesion, aiding in early diagnosis and reducing the complexity of medical decision-making in oncology.

– In dermatology and ophthalmology, deep learning enables the detection of melanoma and the screening of diabetic retinopathy. These programs require a vast database (annotated images: 50,00000 for melanoma and 128,000 for retinopathy) to achieve a high level of recognition performance (Esteva, Kuprel, & Thrun, 2017).

– Computer-assisted surgery improves precision and enables remote operations. Intelligent prosthetics (human limbs or artificial organs) aim to enhance human functions. The first robot-assisted surgery was performed in 1983 at the University of British Columbia Hospital in Vancouver (Arpad Takacs, Imre J. Rudas, Denes Akos Nagy, & Tamas Haidegger, 2016). In 1997, a humanoid robot temporarily replaced the endoscope, facilitating complex interventions. In 2004, the Da Vinci robot was successfully used at King Khalid Hospital in Saudi Arabia for bariatric surgery on a child suffering from severe obesity. This allowed the child to walk again naturally. In 2022, at the Hussein Cancer Center in Jordan, a medical team successfully performed the country's first major robotic surgery, removing a cancerous tumor using the robot (Ibtissem Si Ali & Horiya SOUKI, 2024)

– In biology, AI facilitates repetitive tasks and enhances diagnostic precision, even for rare diseases, by analyzing medical data. This enables better disease management through the prioritization of cases.

– In geriatrics, assistive robots for elderly or frail individuals represent a rapidly growing sector, helping with specific daily tasks.

Artificial Intelligence (AI) has fundamentally transformed clinical monitoring and patient care through the integration of intelligent biomedical

systems. These advancements include strain-sensing prosthetic joints, neuro-integrated robotic limbs, and bionic ocular implants for the visually impaired. Furthermore, the emergence of smart textiles for real-time physiological tracking and interconnected biosensors for the early detection of subclinical infections represents a paradigm shift toward proactive and personalized medicine.

The rise of AI in the healthcare sector necessitates specialized training for researchers and physicians. An integral AI is now part of hospital practices, including diagnostics, prescriptions, and the execution of medical procedures. In France, three university degrees in AI and global health are offered to professionals seeking to familiarize themselves with new technologies. These programs aim to help better understand the technical, ethical, organizational, and economic implications of AI.

6. Artificial intelligence in healthcare in Algeria and its application

Algeria, through its ambitious national strategy, is announcing the progressive integration of this technology, as evidenced by the hosting of the International Congress of Neurosurgery at the University Hospital of Oran (EHU) on June 29, 2024 (congrè international de neurochirurgie d'Oran, 2024). Professor Bachir Belkebna, President of the Algerian society of Neurosurgery, highlighted the significant progress achieved in the adoption of AI for medical purposes. Since its initial use during the COVID-19 pandemic, AI is now deployed to diagnose complex conditions such as Parkinson's disease and brain tumors. Furthermore, the congress emphasized the importance of exchanging expertise between Algerian and international professionals, as well as the innovations in surgical laparoscopy and cancer pain treatment (cerveau au centre du deuxième congrès international de neurochirurgie, 2022). According to Professor Karim Bar, director general of the university hospital, neurosurgery departments use artificial intelligence to enhance diagnostic accuracy and improve therapeutic management. This approach aligns with the Ministry of Health's roadmap, which aims to train healthcare professionals in new technologies and integrate AI into daily hospital practices. Mohamed Nadjib Boufennara, Doctor in Bioinformatics, in response to questions posed by *El-Watan* during scientific events held

from April 16 to 18, 2023, by the Center for Research in Pharmaceutical Science and the University Frères Mentouri of Constantine, affirmed that Algeria is in the early stages of adopting AI. He emphasized that Algeria possesses a substantial volume of digital data that can be leveraged to establish national medical databases. However, as long as a doctor's signature remains mandatory, medical data cannot be hosted on foreign clouds or shared without consent (L'intelligence artificielle au service du diagnostic médical, 2023). According to Dr.Boufennara, AI should not be perceived as a threat. On the contrary, it must be duplicated, and, he stated, we can duplicate the best doctors and provide support to disadvantaged regions, unlike conventional medicine, which is costly and selective. In the short term, AI will not replace physicians, nor will it completely replicate human empathy; it will instead serve as a valuable assistant.

On his part, the director of the information systems and multimedia systems division at the center for scientific and technical information research (CERIST), Abdelkrim Meziane, mentioned a technological device developed within the center, designed to assist in the rehabilitation of upper limb movements in individuals who have suffered a stroke. This system uses virtual avatars whose movements are synchronized with those of the patients, creating a therapeutic interaction. By integrating *serious games*, this method encourages the patient's active engagement and supports the process of motor capacity recovery. The serious games involve different physical and cognitive levels, depending on the degree of patient involvement and the time devoted to completing the assigned tasks. This use of virtual reality would enable patients to perform remote rehabilitation exercises without having to travel to specialized healthcare facilities (l'intelligence artificielle et le numérique au service de la santé, 2024).

7. Ethical and political dimensions of artificial intelligence in the healthcare sector in Algeria

The use of AI in the Algerian healthcare system is still in its early stages. The absence of an adequate legal framework, trained professionals, and digital infrastructures hampers its development.

7.1. Major ethical issues

7.1.1. Protection of personal data: the use of AI in the healthcare sector inevitably involves the collection and processing of vast amounts of sensitive data. In Algeria, the current regulatory framework regarding the confidentiality and security of medical data remains incomplete. The lack of robust protection mechanisms for personal data exposes patients to potential privacy violations, particularly through the misuse or misappropriation of their information. This digital vulnerability hinders public trust in AI systems and delays the widespread adoption of AI in healthcare institutions (Blasimme A & Vayena E, 2019; Hela Borgi & Noha Alessa, 2023).

7.1.2. Algorithmic bias risks: Although AI algorithms, are efficient, they can reflect and even exacerbate existing biases within the training data. In the Algerian context, where ethnic, geographical, and socio-economic diversity is significant, the use of non-representative datasets may result in erroneous diagnoses or inappropriate therapeutic decisions. This raises major concerns regarding the equity of healthcare provision, particularly for marginalized or underrepresented groups. It also reinforces the need to design AI systems that are sensitive to the local cultural and social context (Margaret Richardson, Isaac Adjaye Aboagye, Hannah Ugo, & Srinivasah Shankar Balapangu, 2024).

7.1.3. Legal responsibility ambiguity: the integration of AI into clinical decision-making processes raises complex questions regarding the attribution of responsibility in cases of medical error. When algorithmic recommendations lead to misdiagnoses or inappropriate treatments, it becomes difficult to determine whether responsibility lies with the healthcare professional, the algorithm's developer, or both. This legal grey area hinders the safe implementation of such technologies and highlights the urgent need for a clear regulatory framework concerning medico-legal liability (Ibtissem Si Ali & Horiya SOUKI, 2024).

7.2. Legal and institutional challenges

Absence of a specialized legislative framework: the integration of AI into medical practices requires, first and foremost, a rigorous legislative framework tailored to current technological transformations. Currently, the

lack of a structured legal framework governing the use of AI in the healthcare sector significantly restricts the potential for deploying such technologies. It is therefore essential to establish clear and specific regulations regarding the design, experimentation, validation, and implementation of AI-based tools, while also considering ethical concerns, patient rights, and professional obligations. This framework should also include independent evaluation and ethical oversight mechanisms to anticipate potential misuse (Srikonda, 2025). Without a solid legal foundation, efforts to integrate AI will remain fragile and lack credibility at the institutional level.

According to Algerian law, Law n° 05-10 amending and supplementing the Civil Code introduced a new form of civil liability under article 140: the producer's liability for defective products. This form of liability is objective, meaning it does not depend on the producer's fault but on the defective nature of the product (whether due to a safety issue or malfunction). Thus, any manufacturer is legally liable for damages caused by a product that presents a defect. The rapid development of AI technologies reinforces the need to adapt this type of liability. The concrete application of AI systems calls for an expanded legal definition of "product" beyond what is currently outlined in Article 140. For instance, specific AI systems –such as diagnostic software and medical robots- clearly fall outside the traditional scope of this definition due to their intangible nature. Nevertheless, the article does recognize electrical energy as a product, despite its intangible nature, suggesting the potential extension of this definition to other non-material entities. Law n°03-09 on consumer protection in Algeria also broadens the concept of product to encompass anything that can be transferred, which could arguably include AI software. However, the liability chain for AI systems remains highly complex, involving multiple stakeholders, including developers, programmers, and manufacturers. Additionally, defects can arise from a wide array of causes, including coding errors or information processing failures, which are not always easily identifiable. Consequently, it becomes particularly difficult to establish clear proof of a system's defective nature.

Inequalities in access to digital infrastructure: Algeria's unequal territorial development is directly reflected in the uneven distribution of

digital resources within the healthcare sector. While certain major cities benefit from hospitals that are at least partially equipped with digital solutions, rural and remote regions remain largely excluded from this technological shift. The absence of adequate infrastructure –exceptionally stable internet connectivity, modern IT equipment, and qualified personnel- poses a significant barrier to the equitable dissemination of AI technologies. This territorial disparity risks exacerbating existing inequalities in access to healthcare, thereby contradicting the fundamental principles of an inclusive health system. To address this issue, public policy must aim to bridge the digital divide by investing in targeted initiatives, specialized training programs, and implementing a gradual, regionally adapted deployment strategy.

Sovereignty over medical data: the dominance of foreign technologies in medical data management systems raises growing concerns about national digital sovereignty. The use of foreign-hosted solutions for data storage, analysis, and security –especially those located outside Algerian territory- exposes the country to risks related to the loss of strategic control over sensitive information. In this context, reducing dependence on external digital infrastructures becomes a major national priority. It is imperative to develop sovereign and locally managed solutions that ensure secure and autonomous data governance while complying with national legislation. This would not only preserve the confidentiality of patient data and protect private life but also reinforce Algeria's strategic autonomy in critical sectors such as health (Mathilde godard, Emmanuel Bacry, Gaelle Bouvet, Florence Jusot, & Dominique LE Guludec, 2022).

8. Discussion

What emerges from this analysis is that Algeria has, in recent years, expressed an apparent willingness to modernize its healthcare system by gradually embracing the potential contributions of artificial intelligence (AI). This orientation aligns with the global digital transformation movement, which is deeply reshaping medical practices. AI is increasingly viewed as a strategic tool to enhance the quality of care, promote personalization, and optimize costs. However, despite some encouraging signs, progress remains

hesitant, hindered by a lack of an overarching vision and a lack of structural organization at the national level. Currently, AI integration efforts within Algeria's healthcare system largely stem from isolated initiatives whether from university hospitals, research departments, or individual laboratories. Each pursues its own path, often from a technical standpoint, yet struggles to fit within a coherent national strategy. As a result, the momentum remains limited, marked by uncertainty and a lack of broad-based knowledge sharing. The absence of coordination between key stakeholders further exacerbates regional disparities, leaving certain areas relatively connected and others lagging behind in digital and healthcare development.

Nevertheless, the benefits of integrated AI are far from merely theoretical. Clinically, AI enables more accurate and faster diagnostics through enhanced medical data analysis, thus reinforcing clinical decision-making. It also opens the door to predictive medicine, enabling the anticipation of chronic conditions and the avoidance of unnecessary hospitalizations. From an economic perspective, automating repetitive tasks (such as administrative processing or medical record management) holds the promise of cost reduction and error minimization. Ultimately, from a human perspective, AI can help make healthcare more personalized and enhance access to medical services through telemedicine, particularly in remote areas. Yet, to bring these advances to fruition, several key conditions be met:

Firstly, talent development must encompass both fields. It is essential to train healthcare professionals in digital tools and to familiarize engineers with the challenges of the medical world. This cross-disciplinary skill development is vital for designing relevant, usable, and field-adapted solutions. Algerian universities have a crucial role to play in developing hybrid curricula and fostering bridges between medicine, engineering, and data science.

Secondly, safeguarding health data is fundamental to its effective exploitation. Since health data fuels AI, this fuel must be handled with caution. Ensuring rigorous, ethical, and sovereign data management is essential. Local storage, information security, and protection against external interference are all critical. Relying on foreign servers or unmastered

proprietary technologies would compromise the country's digital sovereignty. The creation of a national health data cloud could provide a secure and sustainable solution. Thirdly, the clarification of ethical rules is imperative. Medical AI raises sensitive issues, including algorithmic bias, opaque decision-making, and automated diagnostic errors. It is therefore necessary to regulate its use with precise rules, ensure algorithm transparency, and clearly define who is accountable in the event of malfunction. A national ethical charter, specifically dedicated to the use of AI in healthcare, would help establish a framework of trust. Fourthly, the development of a clear and proactive legal framework is needed. Legislation must address data management, the use of intelligent systems, and the scientific validation of technologies prior to their market deployment. In parallel, public authorities should adopt a proactive stance, funding research, supporting infrastructure, and assisting institutions in their digital transformation efforts.

Ultimately, centralized governance is crucial for providing strategic direction during this transformation. This implies coordinating the relevant ministries, researchers, economic actors, and healthcare professionals around a national roadmap. A dedicated national structure for health AI, bringing together multidisciplinary experts, could coordinate efforts, set priorities, and assess outcomes.

9. Conclusion

Artificial intelligence today constitutes a major lever for transforming the healthcare system in Algeria. By providing concrete solutions to persistent issues, it offers promising prospects for improving the quality of care while optimizing the use of available resources. Owing to its capabilities, AI can help address structural shortcomings by enabling, for instance, early diagnosis, more effective hospital management, predictive medicine, and the expansion of telemedicine. However, for this technological transition to yield a truly positive and lasting impact, it must be framed within a rigorous governance structure. This requires in-depth reflection on the ethical implications and the adoption of structural policy choices that can support this shift responsibly. Establishing a clear and coherent regulatory framework is a fundamental condition for the success of this transformation. This

notably involves ensuring the protection of personal medical data, defining responsibilities in cases of errors or failures in AI systems, and limiting algorithmic biases that may distort results. Moreover, any national AI integration strategy must imperatively take into account digital access inequalities. It is crucial to prevent the widening of gaps between urban and rural areas, which could further exacerbate disparities in healthcare. In this dynamic, the question of technological sovereignty acquires strategic importance. Algeria has every interest in investing in the development of local expertise through training, applied research, and the networking of public and private stakeholders in the sector. This would allow not only for control over sensitive data, but also the capacity to design solutions tailored to the country's cultural, linguistic, and healthcare specificities.

In conclusion, AI has the potential to profoundly reshape the healthcare landscape in Algeria. Yet, in order to translate this potential into real and inclusive progress, its implementation must be approached with caution, guided by an ethical and human-centered vision that serves the public interest. This requires mobilizing all relevant stakeholders (efficient public authorities, healthcare professionals, researchers, and citizens) around a shared ambition to place technology at the service of a more just, more efficient, and fundamentally human healthcare system.

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