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IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE IN DEVELOPING COUNTRIES: PERSPECTIVES AND CHALLENGES

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Abstract: *The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies into the healthcare sector has catalyzed transformative changes across the globe. This comprehensive article delves into the multifaceted impact of AI and ML on healthcare quality, data management, and clinical practices. Moreover, it examines these trends within both a global context and the specific framework of the Republic of Georgia. The purpose of this study was to specify the most important implications of AI in healthcare for developing countries and to assess perspectives and challenges of implementation. At the first stage, desk research was performed. Fifty relevant scientific articles and reports were identified, by key words, with utilization of various scientific bases and analyzed. Moreover, the major findings of the desk research, regarding implications of AI in healthcare in developing countries and challenges were used for the qualitative research. More specifically, in-depth interviews (overall 10) were conducted with various stakeholders of Georgia's healthcare system and two focus-group discussions (FGD) were moderated with medical professionals and specialists. The purpose of in-depth interviews and FGDs was assessment of attitudes and perceptions of major stakeholders about AI implementation and utilization. According to the reviewed literature, perceptions and attitudes of stakeholders are very important for the successful implementation. However, this issue is not evaluated sufficiently, especially in developing countries. According to the results of the study AI can have substantial economic benefit for the developing countries, with consideration of the monetary savings, improved level of healthcare quality and increased patient safety. As the findings of the qualitative research demonstrate attitudes and perceptions of the doctors and important stakeholders represent a challenge for the successful implementation of AI. Consequently, it is strongly recommended to centralize and prioritize this issue on a system's level in the process of policy and strategy design.*

Keywords: *AI in healthcare, implications of AI in healthcare, AI for healthcare management, AI implications in developing countries.*

INTRODUCTION

The convergence of AI and healthcare has ushered in a new era of medical innovation. AI-powered clinics and intelligent medical systems are revolutionizing healthcare practices, ranging from diagnosis and treatment to data analysis and administrative efficiency. These advancements hold great promise in enhancing healthcare quality and accessibility while optimizing resource utilization.

Transforming Healthcare Landscape AI clinics represent a paradigm shift in healthcare service delivery. Through machine learning algorithms, patient data can be analyzed rapidly and accurately, aiding in early diagnosis and predictive treatment strategies. Global initiatives in AI clinics are addressing the shortage of medical professionals, particularly in remote areas, by providing virtual consultations and intelligent diagnostic tools.

Another area where AI's impact is far-reaching is healthcare quality. It not only assists medical professionals in making accurate diagnoses but also supports personalized treatment plans based on individual patient profiles. Machine learning algorithms, when trained on vast datasets, can identify hidden patterns in patient data, leading to optimized treatment strategies and reduced adverse effects. One of the areas of healthcare quality where AI is showing promising results is hospital-acquired infection rate reduction. Recent study conducted in Mayo Clinic found that risk prediction for Hospital-Acquired-Infections (HAI) with utilization of AI model can estimate risk of infection per individual patient, based on patient's clinical features and characteristics of similar patients. This model was trained on 38,327 unique hospitalizations and a distinct model for surgical site infection prediction was trained on 18,609 hospitalizations. Accordingly, researchers conclude that this model could enable hospitals to prevent early detection of HAIs, which in turn can result in decreased length of stay, mortality, and costs (Wolff et al., 2020).

It is well acknowledged that costs of medical care and national expenditures in this regard are dramatically increasing in all countries of the world. Among several causal factors, increasing life longevity and increased number of chronic patients carry substantial part. Even though there is a lack of compelling scientific evidence justifying cost-efficiency of utilization of AI in healthcare (Khanna et al., 2022), it still can be forecasted to cause substantial savings, according to the effectiveness and process optimization it demonstrates (Mathias, 2023). Regarding cost-efficiency of AI in healthcare, special attention should be paid towards the Internet of Medical Technology (IoMT). IoMT represents the fastest growing sectors of IoT market, predicted to reach 176 billion US dollars by 2026 (Shah&Chircu, 2018). The most popular area of IoMT utilization is remote patient monitoring and such directions, as glucose monitoring, heart rate monitoring, depression and mood monitoring, Parkinson's disease monitoring, IoT connected inhalers, ingestible sensors, connected contact lenses and robotic surgery (Rizwan et al., 2017).

To return to the topic of healthcare quality mentioned above, according to the report delivered at the conference for the Association of Professionals in Infection Control Epidemiology utilization of IoT for hand hygiene “showed a 61.4% decrease in HAIs (Hospital-Acquired-Infection) across 10 hospitals that use technology” (www.cleanhands-safehands.com). Hand hygiene is one of the most important areas in infection control in hospitals and one of the most challenging, as well, about compliance from medical personnel. To illustrate this technology, in the badges of clinicians there is Bluetooth technology, which communicates with IoT sensors affixed to soap and sanitizer dispensers in patient care areas. Once a clinician walks into or out of a patient's room, IoT sensors detect this, and doctors have a certain number of seconds to dispense sanitizer or soap. If they don't dispense, real-time voice reminder sound reminds saying “please sanitize”. In case of rooms where patient has *Clostridioides difficile* the voice changes to “soap

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and water only” upon exit, as sanitizer does not kill *C. difficile* spores. Furthermore, according to the data from ten hospitals, from the same study it has shown prevention of 372 total infections per year, translating into 9.5 million US dollar direct cost savings and 39 lives saved each year (Fitzpatrick, 2020).

Literature review

In the realm of healthcare, the integration of artificial intelligence has been a subject of profound investigation by healthcare experts. An array of seminal works and scholarly articles underscores the paramount significance of amalgamating technologies to propel the advancement of healthcare. These scholarly works provide a comprehensive view of the contemporary landscape of artificial intelligence within the healthcare domain, underscoring its capacity to revolutionize industry. Specifically, it demonstrates its potential to enhance diagnostic capabilities, individualize treatment strategies, and elevate the quality of patient care. Additionally, these scholarly contributions conscientiously recognize the multifaceted challenges of ethical, regulatory, and technical nature that necessitate meticulous consideration to facilitate the broad and conscientious adoption of artificial intelligence in healthcare.

To be specific, one of these foundational papers by Topol provides an overview of the potential of AI in healthcare, from diagnostics to treatment recommendations (Topol, 2019). It emphasizes AI's ability to augment and improve human clinical decision-making. - "Artificial Intelligence for Healthcare: On a Par with Human Clinical Decision Making?" In the research process, Manu Agarwal Senior Manager – Growth, as a knowledgeable and cooperative contributor, has facilitated the acquisition of valuable insights and information. Furthermore, the report featured on the Markets and Markets (Markets and Markets, 2023)) presents a notable projection for the artificial intelligence in healthcare market. According to this report, the market is poised for substantial growth, with an expected transition from USD 14.6 billion in 2023 to a noteworthy USD 102.7 billion by 2023. This growth trajectory is underpinned by a projected compound annual growth rate (CAGR) of 47.6% during the stipulated forecast period.

Justus Wolff et al's article “The Economic Impact of Artificial Intelligence in Health Care” presents a systematic review of cost-effectiveness studies related to the economic impact of artificial intelligence (AI) in the healthcare industry (Wolff et al., 2020). The central objectives of the study are to assess the quality of these studies and to highlight areas for potential improvement. This article offers a valuable review of the state of economic impact assessments in the context of AI in healthcare. It highlights the need for more robust and comprehensive studies to better inform decision-making in this rapidly evolving field.

Judy Mathias article “Use of AI to predict risk of HAIs” reports on a study conducted by researchers at the Mayo Clinic Arizona, which focuses on the development and evaluation of an artificial intelligence (AI) model for predicting the risk of healthcare-associated infections (HAIs) (Mathias, 2023).

The study aimed to create an AI model capable of estimating individualized risk for HAIs by considering a patient's clinical characteristics and those of similar patients. This article presents

promising results from the application of AI in healthcare, particularly in the context of HAIs. The AI model's ability to outperform traditional models and reduce costs is a significant advancement in the field. The findings highlight the potential of AI to enhance patient care and reduce the burden of HAIs on healthcare systems, underscoring the importance of continued research and development in this area.

Additionally, "Challenges and Opportunities for Machine Learning in Healthcare" - Obermeyer and Emanuel (2016) discuss the potential of machine learning in healthcare while also highlighting challenges, such as bias in algorithms and data privacy concerns (Ghassemi et al., 2020). Literature review effectively captures a range of perspectives on AI and machine learning in healthcare. It emphasizes the potential benefits of AI in improving patient care, reducing costs, and enhancing clinical decision-making. However, it also acknowledges the challenges related to bias, data privacy, and the need for more comprehensive economic impact assessments. Enhancing healthcare quality through AI is an ongoing process that holds immense promise for improving patient outcomes, reducing healthcare costs, and enhancing the overall healthcare experience. It is essential for healthcare providers to continue to research, develop, and implement AI technologies while ensuring they meet the highest standards of accuracy, privacy, and ethical considerations.

The exponential growth of healthcare data necessitates advanced management strategies. AI and ML play a pivotal role in processing and analyzing these massive datasets to extract meaningful insights. Predictive modeling, data-driven decision-making, and patient risk stratification are some of the areas where AI shines in healthcare data management.

Machine learning algorithms are redefining clinical practices by enabling early disease detection, prognosis prediction, and treatment response monitoring. These algorithms continuously learn from new data, evolving their accuracy over time. AI's ability to analyze multi-modal data, such as medical images and genomics, opens avenues for precise diagnostics and treatment personalization. In the Georgian healthcare landscape, where certain diseases are more prevalent due to regional factors, AI-driven clinical practices can offer tailored interventions. This approach can significantly impact disease management, reduce treatment costs, and improve patient outcomes. The implementation of AI and ML in healthcare is not without challenges. Ethical concerns, data privacy, algorithm bias, and the need for healthcare professional engagement require careful consideration. Striking a balance between human expertise and AI's capabilities is essential. In the global context, including Georgia, fostering interdisciplinary collaboration between technologists, medical professionals, and policymakers will be crucial in harnessing the full potential of AI in healthcare.

Methodology

The purpose of this study was to specify the most important implications of AI in healthcare for developing countries and to assess perspectives and challenges of implementation. At the first stage, desk research was performed. Fifty relevant scientific articles and reports were identified, by key words, with utilization of various scientific bases and analyzed.

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Moreover, the major findings of the desk research, regarding implications of AI in healthcare in developing countries and challenges were used for the qualitative research. More specifically, in-depth interviews (overall 10) were conducted with various stakeholders of Georgia's healthcare system and two focus-group discussions (FGD) were moderated with medical professionals and specialists. The purpose of in-depth interviews and FDGs was assessment of attitudes and perceptions of major stakeholders regarding AI implementation and utilization. According to the reviewed literature perceptions and attitudes of stakeholders are very important for the successful implementation. Nevertheless, this issue is not evaluated sufficiently, especially in developing countries. Furthermore, the FDGs were conducted online using Zoom platform, led by an experienced moderator using appropriate „Discussion guide“ and supported by a research assistant. The assistant was pre-trained in FGD method and specific aspects of transcript preparation.

A total of ten in-depth interviews were conducted, six interviews were face-to-face and four by video calls. The average duration of an interview was 50 minutes. Based upon informed consent all discussions and in-depth interviews were audio/video recorded and transcripts prepared based on them. Transcript data were analyzed using ‘content-analysis’ methodology. Analysis started immediately after the FDGs were conducted and in-depth interviews ceased, respectively. Consequently, ‘main ideas’ or ‘themes’ were summarized and highlighted using ‘concept map’ approach.

Results

In the specific context of healthcare research in Georgia, a burgeoning landscape is emerging as the country embarks on its initial forays into exploring the applications of artificial intelligence (AI). This research trajectory represents a pioneering effort, marking Georgia's first exploration of the multifaceted possibilities of AI within the healthcare domain. It highlights the country's dedication to leveraging technological advancements to enhance its healthcare infrastructure and services. Within this research landscape, Georgia seeks to comprehensively evaluate the potential and implications of AI technologies in healthcare, a venture that is characterized by its novelty and forward-looking orientation. As the country takes these initial steps, the aim is to discern how AI can be effectively integrated to not only augment healthcare delivery but also to address the unique healthcare challenges that are intrinsic to developing nations. This pioneering research signifies a promising journey for Georgia as it seeks to harness the transformative power of AI to optimize healthcare practices within its specific national context. This exploration is poised to lay the foundation for a deeper understanding of the applications, benefits, and potential limitations of AI in healthcare, fostering a rich research landscape within the country and contributing to the global discourse on AI in healthcare.

The utilization of AI in developing nations carries substantial potential to enhance the quality of healthcare services and broaden healthcare access. Nevertheless, this endeavor is currently grappling with fundamental challenges. These obstacles include a deficiency in public health infrastructure, a shortage of adequately trained healthcare professionals, and a prevalent

apprehension of job displacement, as underscored in Joshi et al.'s recent study (2022) (Joshi et al., 2022). The fear of potential job loss among healthcare professionals engenders skepticism and mistrust towards AI and related technologies, thereby impeding their effective integration into healthcare practices, as noted in de Abreu et al.'s research (2021), as cited by Joshi et al. (2022).

These challenges collectively constitute the primary impediments to the successful adoption of AI in developing countries. Nevertheless, there is potential for a more harmonious alignment of expectations between healthcare professionals and AI technologies. Moreover, fostering collaborative co-creation in the design and implementation of AI systems holds promise in mitigating these hurdles. This notion is consistent with findings in a systematic literature review by Hogg et al. (2023) which addressed AI's role in healthcare (Hogg, 2023). It is important to highlight that a notable gap exists in research pertaining to AI in healthcare within the context of developing countries, as indicated by Hogg et al.'s review. Further exploration of this subject may yield valuable insights to overcome these challenges and enhance the integration of AI in healthcare within developing nations.

Also, Healthcare systems in developing nations frequently grapple with a chronic shortage of medical personnel. AI applications hold promise in addressing this persistent workforce deficit. The World Health Organization (WHO) acknowledges that the rapid integration of AI technology in healthcare comes with a set of notable challenges. One significant concern lies in the potential lack of comprehension regarding the intricate workings of AI technologies, often referred to as the 'black box' problem. This lack of understanding can lead to the risk of patient harm. Additionally, AI technologies, especially those reliant on machine learning processes, are susceptible to biases inherent in the model itself and the data used for training.

Furthermore, AI applications in healthcare frequently involve access to sensitive personal information. Consequently, there is a pressing need to establish effective measures for safeguarding and responsibly managing this data, as well as overseeing the purposes for which AI is deployed in the healthcare sector.

The primary highlights revolve around three substantial challenges in the integration of AI in healthcare: a deficiency in transparency, regulatory and governance complexities, and a fundamental lack of comprehension among healthcare practitioners and patients.

Developing countries, including Georgia, often encounter challenges related to the geographical distribution of healthcare professionals and the adoption of modern technologies and AI in healthcare. According to the opinions of the respondents, in the Georgian context, AI empowered digital health platforms have the potential to bridge healthcare disparities between urban and rural regions. Like many other developing countries, Georgia's healthcare system faces a challenge of medical professional asymmetry. More specifically, 70% of healthcare professionals work in the capital city and only 30% of the medical personnel serve the rest 70% of the country's population in the regions. Telemedicine empowered by AI can connect patients (even in the most distant areas of the country) with medical experts, overcoming geographical barriers and improving access to specialized care. Moreover, interdisciplinary approach and value-based healthcare are the most accentuated aspects of the healthcare systems, that should be met for

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patient-centered care, better outcomes, and higher quality of treatment. In Georgia, as in most developing countries, many regions and rural areas do not have specialists such as endocrinologists, ophthalmologists etc. This results in fragmented care and lack of care continuity. However, telemedicine provides a platform to offer multidisciplinary team approach to the patients living in rural areas. Even more, shortage of specialists in certain areas represents significant challenge in Georgia's healthcare system, as well as in other developing countries. "Brain drain", migration of talents to developed countries leaves developing countries scarce of highly qualified specialists. With the application of AI optimization of resources becomes available. For instance, in telemedicine settings with AI involvement preliminary diagnosis can be made with analysis of various images, scans and recordings of lung and heart sounds. And human intelligence should be used only for special cases. This frees time for specialists for more significant cases and decreases time for diagnosis for the patients.

Rather interesting topic emerged in the Focus Group discussions. According to the opinions of some respondents, there can be a trend observed in the displaced population – forced to leave their places of residence after the wars in August of 2008 and in 1990s. Healthcare specialists from the Samegrelo region (where large number of displaced citizens is concentrated) shared findings of several charity check-ups conducted in this population. According to their observations, there is a trend of increased oncological disease prevalence among these individuals compared to other citizens in the same region. One of the suggestions is that increased levels of stress these individuals underwent through, could contribute to greater exposure to oncological conditions. Nevertheless, this fact needs further in-depth research and implementation of AI can support trend identification, disease prediction and prevention. With a diverse population and a wide spectrum of health conditions, AI-driven analytics can aid in tailoring treatment approaches to the country's unique demographic and epidemiological landscape.

Another area for AI's potential is enhancement of healthcare quality in the provider sector. Government of Georgia envisions to position the country on the global medical tourism market, as a destination country. However, to realize this vision one of the central requirements is to offer adequate healthcare quality to medical tourists. Currently, Georgia's provider sector faces many challenges regarding healthcare quality, like many other developing country contexts. Therefore, respondents accentuated the role of AI as a solution to the number of problems in this regard. To illustrate, utilization of AI for the early prognosis of infections in hospitalized patients could significantly decrease costs of the treatment of complications and save more lives. Even though electronic medical records are not fully implemented in all clinics, this process will be completed soon. Georgia's nascent electronic health records system can benefit immensely from AI-driven data management solutions. By effectively organizing and analyzing health data, the country can identify emerging health trends, improve clinical research, and facilitate evidence-based policy formulation. The greater problem, in this scope, is a lack of data analytics. Respondents extended this topic further on the national level. According to the representatives of non-governmental organizations, working with the ministry of healthcare and involved in various projects, data from different registries (birth, oncological etc.) and digital platforms in the country are not processed

and analyzed adequately, thus living serious potential for evidence-based decisions unrealized. Consequently, implementation of AI is sought as a solution to this problem on a provider, as well as on a state level.

Another area of concern in Georgia's healthcare system is polypharmacy and excessive instrumental or laboratory investigation – “overmedicalization over-investigation”. According to the respondents this problem also could be solved, and patients could benefit from AI utilization. To cite one of the respondents – “currently, the ministry of healthcare cannot control this problem as more than 90% of clinics are private, for-profit. The only way to correct this problem is to leverage control and regulatory capacity. And this can be achieved only by creation of evidence pool and data analytics. To identify trends in medicine prescription and “treatment behavior””. Moreover, through the identification of mentioned trends and data analytics with AI total healthcare expenditures can be decreased and quality of treatment enhanced. Still another direction in healthcare quality for the prevention of infections and complications is hand hygiene. Respondents weren't familiar with AI empowered solutions for hand hygiene compliance (mentioned above, in the literature review findings). During interviews and FGDs this information was shared with them by researchers. Most of the respondents found this technology very useful for Georgia's context.

One of the significant challenges in Georgia's healthcare system is a lack of therapeutic education and self-management among chronic patients and parents of the children with chronic diseases. Among the respondents were two experts with several years' experience in diabetes research. To illustrate their opinion regarding AI's role in patient education – “we conducted several studies to assess the needs and problems of the patients with diabetes, adults, and children. One of the biggest problems in this regard is lack of education among parents of children having diabetes and adult diabetic patients. Diabetes is a disease which heavily depends on self-management and behavior change. Lack of knowledge hinders serious behavior change and outcomes are much worse. If we could use AI, to increase access to the newest information for them results could be much better”. According to the discussion, with utilization of generative AI tools access to up-to-date information can be increased and digital libraries (video library as well) can be created. This concerns other chronic conditions as well, where modification of risks is possible with self-management and behavior change. Once personalized health content generation becomes possible patients can easily get information tailored to their specific condition. To continue the topic of chronic diseases, which represents a significant burden for the country's budget, introduction of AI empowered chronic disease assistance platforms can also improve health condition of patients and quality of life. To illustrate, one of such digital applications, on a global market, is Dario, where AI can assess/recognize mental and physical state of the patient based on voice recognition and text comprehension technologies, directs patient accordingly to the relevant specialist and offers additional assistance. This kind of applications customized to Georgian patients can decrease healthcare expenditures on top of the benefits mentioned above. Among the participants of FGDs were two professionals working on mental wellness issues (one psychiatrist and another- representative of NGO working on mental health). During discussions,

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the significance of deteriorating mental health of the population was discussed and alarming rate of emerging problems such as anxiety disorders and panic attacks were mentioned. It should be noted that prevalence of mental problems dramatically increased after COVID-19 and after the war in Ukraine. As Georgian population underwent two wars in 1990s and in 2008, war in Ukraine caused significant re-traumatization among citizens. Official statistics do not illustrate the real situation in this regard, as due to stigma and cultural issues the number of individuals suffering mental problems is much greater. According to the respondents, implementation of solutions, such as AI coupled with Virtual Reality Goggles and Biofeedback devices can bring substantial results for the treatment of patients with different phobias, post-traumatic-stress disorders (PTSD) and anxieties. It should be noted that neurofeedback devices empowered with AI diagnostics is newly introduced on Georgia's market and has attracted attention of patients and specialists in very short period of time. It should be outlined that none of the respondents of interviews and FGDs mentioned robotic surgeries among listed significant AI implications in healthcare.

In developing countries, the adoption of AI in healthcare is often driven by the need to address resource constraints, access issues, and the delivery of cost-effective care. The specific technologies used may vary, but the common goal is to leverage AI to improve healthcare access, quality, and efficiency. AI can help these countries maximize their limited healthcare resources and enhance the overall health outcomes of their populations. It's worth noting that while these technologies offer significant promise, their successful implementation in developing countries may also face challenges related to infrastructure, affordability, and regulatory frameworks. Nevertheless, the potential benefits in terms of improving healthcare access and quality make AI an important focus for healthcare development in these regions.

However, despite all the benefits and potential implications of AI in healthcare that were discussed during the study, challenges and skepticism among the respondents should also be mentioned. During the FGDs, healthcare specialists expressed concerns regarding replacement of doctors with AI and machine learning. Moreover, skepticism and fear of change were evident in the discussion process and in the concerns that were expressed. It is well known and researched how this kind of attitudes and resistance to change, as well as fears hinder innovations, especially in regard with implementation of new technologies. Another challenge named by the respondents was lack of flexibility and coordination of efforts on a system's level in the country. More specifically, many processes in scope of digitalization of healthcare are hindered by a lack of collaboration among different ministries and state units. Still another challenge named in FGDs and interviews is deficiency of specific and clear vision of government concerning digitalization of healthcare and AI. Moreover, absence of the relevant technological infrastructure, weak regulatory system and loose monitoring from the government's side were named as substantial hindering barriers for effective implementation and utilization of AI in healthcare.

To summarize, despite these challenges, there is growing recognition of the potential benefits of AI in healthcare for developing countries, including improving healthcare access, quality, and efficiency. Efforts are underway to overcome these obstacles through international partnerships, capacity-building initiatives, and the development of AI solutions tailored to the

specific needs and resources of these regions. For the effective realization of AI's potential in healthcare the following requirements should be met – clear and specific vision and strategy should be developed by the government. Furthermore, Government in a flagmanship role should coordinate collaboration and integration of efforts among various ministries and institutions in order to develop technological infrastructure and framework in the country. Provider sector and all the stakeholders should be involved from the very initial stage of AI implementation - vision and strategy development etc. Even more, encouragement and stimulation of the provider sector should be thought to enhance AI adoption by the private clinics and hospitals. As for the provider sector, management of clinics need to consider and utilize change management principles for the effective transformation. To illustrate, so called “champions” – specialists supporting and enthusiastic about AI implementation should be engaged actively in the groundwork processes to change attitudes and perceptions of the personnel in favor of technological progress.

CONCLUSIONS

AI and machine learning have brought about transformative changes in healthcare quality, data management, and clinical practices on a global scale. In Georgia, these advancements hold immense promise in overcoming healthcare disparities and optimizing healthcare delivery. As AI continues to evolve, a harmonious integration with human expertise will pave the way for a future where healthcare is not only technologically advanced but also empathetic and patient centric.

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