Artificial intelligence in healthcare: a focus on the best practices

Intissar Haddiya [1,2], *Sara* Ramdani[2]
[1] Department of Nephrology, Mohammed VI University Hospital, Oujda, Morocco.
[2] Laboratory of Epidemiology, Clinical Research and Public Health, Faculty of Medicine and Pharmacy of Oujda, University Mohammed First, Oujda – Morocco.

Abstract. The healthcare sector is undergoing a significant transformation driven by Artificial Intelligence (AI). AI applications in clinical practice offer a multitude of benefits for patient care, including earlier and more accurate diagnoses, personalized treatment planning, and improved access to information through virtual assistants. However, alongside this potential, challenges and ethical considerations remain. Data privacy, algorithmic bias, transparency of AI decision-making, and responsible use are crucial areas that require careful attention. Our presentation emphasizes the importance of establishing robust best practices within healthcare institutions and fostering collaboration among clinicians, data scientists, patients, and policymakers. Through careful consideration and ongoing refinement of AI technologies, we can leverage its potential to improve patient outcomes while upholding ethical standards and public health priorities.

1 Introduction

Artificial Intelligence (AI) is remarkably evolving in healthcare with diverse applications, including drug discovery, clinical trials, disease diagnosis, and patient care [1]. AI technologies, such as machine learning (ML), natural language processing (NLP), and robotics, are transforming healthcare by improving patient outcomes, reducing costs, and enhancing operational efficiency [2]. These systems analyze vast datasets, support clinical decision-making, and enable treatment personalization [3]. The integration of AI has also advanced predictive analytics, early disease detection, and workflow optimization, making significant contributions to healthcare delivery [3,4].

Despite these benefits, challenges persist, including data privacy concerns, ethical issues and the need for robust regulatory frameworks [3]. Interoperability difficulties, algorithmic bias, and lack of transparency in AI systems further complicate its adoption [5,6]. Ethical questions, such as those related to informed consent, certification, and liability, highlight the need for clear guidelines to address these barriers [7]. Additionally, biases in training datasets and the opacity of decision-making processes raise concerns about equitable care and trust in AI-driven solutions [8,9].

To overcome these challenges, researchers emphasize the importance of adopting harmonized standards under WHO guidance and value-sensitive AI development that accounts for human values and societal context [9,10]. Successful AI implementation requires robust cybersecurity measures, ethical frameworks, and legal guidelines [5]. Furthermore, fostering interdisciplinary collaboration, enhancing healthcare professional education, and addressing operational issues such as fragmented electronic health records systems are essential steps for integration [6,11].

Corresponding Author : intissarhaddiya@yahoo.fr

The ethical implications of AI span multiple levels, including individual, organizational, and societal concerns, and can be categorized into epistemic, normative, or overarching challenges [12]. Key principles such as justice, privacy, bias mitigation, and interpretability should guide the responsible deployment of AI in healthcare [13,14]. By addressing these issues, the healthcare sector can leverage AI to enhance diagnostic accuracy, improve treatment planning, and optimize clinical workflows, ultimately reshaping healthcare delivery and patient outcomes [4,14].

2 Key entities and primary actors in healthcare systems

AI's adoption in healthcare is a multifaceted process influenced by various stakeholders, barriers, facilitators, and ethical considerations. Key entities include healthcare providers, organizations, and technology developers. Barriers to adoption encompass inadequate IT infrastructure, unclear terminology, task complexity, and resource limitations in specific contexts [15,16]. Facilitators such as performance expectancy, effort expectancy, initial trust, and personal innovativeness play crucial roles [16]. Frameworks like the Technology, Organization, People, and Environment (TOPE) model emphasize the importance of technology and people in driving AI acceptance [17]. Specialty-specific barriers, the role of IT infrastructure, and cultural differences between high-income and low- and middle-income countries (LMICs) also warrant further exploration [15,18].
The integration of AI involves healthcare professionals, administrators, and patients, each playing distinct roles. Healthcare professionals' acceptance is shaped by perceived usefulness, ease of use, potential threats to autonomy, and concerns about privacy and clinical skills degradation [19,20]. Administrators address structural factors, including organizational size, workflow, and security, while patients' psychosocial factors and

medical conditions also impact AI adoption [19]. Collaborative initiatives, education programs, and interprofessional collaboration are essential for successful AI integration [21,22]. For instance, education programs like the Clinician Champions Program enhance AI knowledge and confidence among healthcare professionals [23]. Despite these efforts, many healthcare workers still lack a comprehensive understanding of AI principles, highlighting the need for standardized curricula and multidisciplinary approaches [24,25].

Ethical considerations are paramount in AI implementation, particularly in addressing disparities and ensuring equitable healthcare access. Strategies include mitigating bias throughout the AI lifecycle, integrating ethical standards into deployment, and adopting a rights-based approach to protect vulnerable populations [26-28]. These measures are especially critical in LMICs, where resource limitations and unique local requirements necessitate context-sensitive solutions and robust evaluations [29,30]. Collaborative efforts to improve data availability, build trust, and demonstrate cost-effectiveness are vital for responsible AI adoption in such settings [18].

Research plays a critical role in evaluating AI's long-term impacts on patient safety, healthcare costs, and clinical outcomes. A phased research framework, akin to clinical trials, includes in silico testing and real-world evaluations to assess effectiveness and address unintended consequences [31,32]. Longitudinal mixed-method studies and the development of "AI delivery science" are necessary to optimize AI implementation while addressing safety, ethical concerns, and medico-legal impacts [33,34]. Moreover, interprofessional collaboration and education for all stakeholders remain essential to understanding AI's implications and ensuring its responsible integration into healthcare systems [22].

In conclusion, AI has the potential to transform healthcare by enhancing clinical decision-making and patient interactions, particularly in under-resourced settings. However, addressing barriers, fostering collaboration, and emphasizing ethical principles are critical to achieving equitable and sustainable AI adoption [30,35]. Future research should focus on specialty-specific barriers, IT infrastructure improvements, and the creation of robust frameworks for evaluating AI's real-world applications [15,18]. By balancing technological innovation with human-centric care, AI can bridge gaps in healthcare delivery and improve outcomes for diverse populations.

3 Understanding AI in healthcare

AI technologies, including ML, NLP, and deep learning (DL), have transformative applications in areas such as disease diagnosis, personalized treatment planning, medical imaging analysis, and predictive analytics [36-38]. ML algorithms analyze vast datasets to identify patterns, predict disease outcomes, and optimize treatment plans, enabling early disease detection and improved care delivery [37,39]. Similarly, NLP extracts valuable insights from electronic medical records, clinical notes, and medical texts, enhancing workflow efficiency and supporting informed clinical decision-making [39,40].

DL, a subset of AI, has demonstrated significant advancements in healthcare, particularly in medical imaging, genomics, and molecular diagnostics, enabling precise and personalized treatment approaches [41,42]. It has also been applied to protein structure prediction and experimental data interpretation, underscoring its potential to address complex healthcare challenges [42]. In emergency medicine, AI technologies streamline processes by identifying clinically significant conditions and improving documentation efficiency [43]. Moreover, AI-driven predictive analytics further support clinical decision-making and resource allocation, contributing to better patient outcomes and reduced costs [2,44].

Robotic Process Automation (RPA) complements these AI applications by automating rule-based tasks such as patient registration and radiology imaging requisitions, significantly reducing processing times and operational costs [45,46]. RPA enhances staff efficiency, minimizes burnout, and allows for more patient interaction, ultimately improving care quality and access [47]. In private healthcare, RPA further digitalizes workflows, enhancing performance and customer satisfaction [48] (Table 1).

Despite its promise, the integration of AI in healthcare faces significant challenges, including data privacy and security concerns, ethical issues, and regulatory compliance [5,38]. Ensuring data security, minimizing bias, and addressing ethical implications require robust cybersecurity measures, interdisciplinary collaboration, and clear ethical frameworks to guide the responsible and transparent use of AI in healthcare [5,44,49]. Additionally, cost considerations and the need for standardized implementation practices underscore the importance of further research to establish best practices for AI integration [50].

Technology	Applications	Examples
ML	Pattern recognition, treatment plans	Predictive modeling, risk assessment
NLP	EMR analysis, clinical notes interpretation	Chatbots, decision support tools
DL	Medical imaging, genomics, drug discovery	Tumor detection, protein folding
RPA	Workflow automation	Patient registration, billing

By strategically addressing these challenges and leveraging ethical frameworks and interdisciplinary collaboration, AI technologies will continue to advance healthcare systems, offering solutions that are more efficient, personalized, and effective for patients and providers alike [49,51].

4 Healthcare data

AI in healthcare leverages diverse data sources to enhance patient care and outcomes across a wide range of applications. Key inputs for AI include structured, unstructured, and genomic data from sources such as electronic health records, medical imaging, clinical notes, and multi-omics datasets [52,53]. Structured data is often analyzed using ML techniques, including support vector machines and neural networks, while unstructured data, which comprises approximately 80% of medical information, requires specialized approaches like NLP to extract valuable insights [54]. Genomic data, encompassing DNA/RNA sequencing and single-cell genomics, is processed using advanced DL architectures to uncover biological patterns and inform treatment strategies [55]. These AI-driven methods have transformative applications in fields such as oncology, neurology, and cardiology, enabling improvements in disease detection, diagnosis, treatment planning, and outcome prediction [52].

Recent advancements have expanded AI's scope by integrating multi-omics, clinical, behavioral, and environmental data, providing comprehensive insights into complex biological systems [56]. For instance, in oncology, AI models now integrate multimodal data, improving diagnostic and prognostic accuracy while identifying novel patterns across modalities [57]. These innovations extend to other areas such as cardiology and neurology, where AI supports the development of personalized medicine by combining clinical and multi-omics data [52,58].

However, significant challenges persist, including issues with data integration, model interpretability, security, and bias mitigation [56]. To address these obstacles, researchers have proposed strategies such as targeted sampling methods, AI-powered health indices, digital twin models for personalized simulations, and blockchain technology to enhance data security [59]. Additionally, developing AI systems capable of data-driven knowledge discovery and causal inference is critical to overcoming integration barriers and ensuring actionable insights [60].

Despite the potential of AI to transform healthcare, ethical considerations and seamless integration into existing healthcare infrastructures remain vital. Rigorous validation, real-world applications, and the adherence to FAIR (Findable, Accessible, Interoperable, and Reusable) principles for data management are essential for maximizing the benefits of AI while addressing challenges related to transparency and equitable implementation (Assefa, 2022; Mohr et al., 2024). By tackling these issues, AI can pave the way for omics-informed personalized medicine and a new era of precision healthcare.

5 Applications of AI in healthcare

AI algorithms analyze extensive datasets, including genomics and proteomics, to develop tailored treatment approaches. ML algorithms interpret medical images for early disease detection and characterization. AI-driven predictive modeling enables proactive health management and timely interventions [61]. Various AI algorithms, such as artificial neural networks, support vector machines, and fuzzy logic, have shown promising results in disease detection, diagnosis, and treatment optimization [62]. AI systems can rapidly analyze large volumes of imaging data, leading to more accurate diagnoses with fewer errors [63]. While AI offers significant potential in healthcare, challenges related to data privacy, ethics, and regulation must be addressed [64]. Coordinated efforts are necessary to realize the benefits of AI in healthcare and ensure its ethical integration into healthcare systems [63].

AI applications in workflow optimization and telemedicine offer significant operational benefits. In radiology, AI enhances workflow efficiency, supports interpretation tasks, and improves quality and safety [65]. Telemedicine integrated with AI enables faster and more accurate diagnoses, reduces in-person visits, and improves patient experiences [66]. AI-powered telemedicine systems analyze patient data to suggest appropriate care options, optimizing healthcare efficiency and patient satisfaction (Figure1). These technologies are particularly beneficial in rural areas, overcoming geographical and resource barriers [67]. AI assists in decision-making, automates administrative tasks, and enhances healthcare delivery. However, successful implementation requires physician guidance, compliance with existing clinical practices, and proper education and training for healthcare providers [68].

Despite challenges, AI in telemedicine holds great promise for improving patient outcomes, healthcare accessibility, and overall delivery of medical care globally [66].

AI has helped drug discovery and development progress and enhance decision-making across various disciplines. AI applications in clinical trials are improving success rates through enhanced trial design, patient selection, and stratification [69]. The integration of AI has led to more efficient and cost-effective drug development processes, addressing the inverse relationship between development costs and market success [70]. AI is particularly promising for dementia drug discovery and clinical trials, where challenges include patient heterogeneity and disease course length. ML tools and big data analytics are being applied at multiple stages of the therapy pipeline, offering opportunities to overcome historical obstacles in dementia research [71]. The growing relevance of AI in this field is evidenced by the increasing number of specialized start-ups and

collaborations between pharmaceutical companies and AI platforms [69].

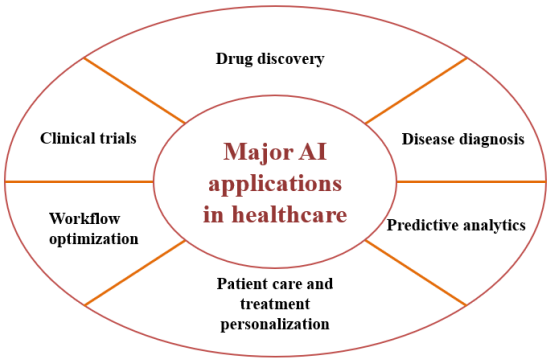

Fig. 1. Key applications of AI in healthcare.

6 Benefits of AI in healthcare

In diagnostics, AI-powered algorithms enhance image quality, automate measurements, and assist in identifying conditions such as cardiovascular diseases and cancer [72,73]. These technologies match or even outperform human experts in medical image interpretation, reducing errors, increasing consistency, and enabling early detection and intervention [72,74]. Additionally, AI facilitates faster triage and personalized treatment plans, contributing to improved patient outcomes and more efficient healthcare workflows [73,75]. By providing real-time remote analyses and continuous monitoring, AI also enhances accessibility, particularly for underserved rural and remote areas [72,74].

Beyond diagnostics, AI's ability to analyze complex medical data improves clinical decision-making, optimizes hospital operations, and accelerates medical discoveries [76,77]. In medical imaging, AI-powered DL algorithms and neural networks have significantly advanced disease detection, organ segmentation, and 3D reconstruction, leading to more accurate diagnoses and better treatment planning [78,79]. These innovations are transforming fields such as radiology, pathology, and cardiology, while also enabling breakthroughs in identifying genetic markers for diseases like Alzheimer's [80].

Despite its transformative potential, integrating AI into healthcare presents challenges. Issues such as data privacy, ethical concerns, and interoperability remain significant hurdles. To address these challenges, interdisciplinary collaboration, regulatory oversight, and ongoing research are essential for ensuring responsible and effective AI implementation [5]. Overcoming these barriers can lead to a more accessible and efficient global healthcare system, enabling data-driven decisions, real-time processing, and continuous learning to optimize care delivery and administrative efficiency [76].

As AI continues to evolve, its integration into medical practice offers the potential to fundamentally transform healthcare. From improving diagnostic accuracy to personalizing treatment plans and streamlining operations, AI promises to enable better patient outcomes, advance medical research, and redefine the future of healthcare delivery [79,81].

7 Challenges of AI in healthcare

The implementation of AI in healthcare is fraught with challenges spanning data privacy, ethical considerations, integration difficulties, and social equity concerns. Ensuring robust cybersecurity measures and clear legal frameworks is essential to address data privacy and security issues [5,82]. Moreover, ethical concerns, such as algorithmic bias and the need for representative data, must be prioritized to avoid perpetuating disparities and ensuring equitable healthcare delivery [5,83]. Addressing these issues requires the development of algorithmic auditing frameworks, open science practices, and rigorous validation processes to enhance transparency and trust [84,85].

Interoperability remains a significant barrier to seamless AI integration in healthcare, with universal standards and enhanced data governance critical to overcoming this challenge [5,82]. The governance of healthcare AI systems extends beyond technical issues to include equity in benefit distribution and oversight of complex systems. Additionally, the interpretability of AI-generated insights remains a critical challenge, requiring explainable AI (XAI) frameworks to enhance trust and usability for healthcare professionals. These frameworks aim to make AI systems more transparent by providing clear, interpretable explanations of how predictions or decisions are made [86]. In many cases, AI models, particularly complex ones like DL, operate as "black boxes," where the internal decision-making processes are opaque. This lack of transparency can make it difficult for clinicians to understand or justify the recommendations or predictions made by the AI, especially in high-stakes situations such as diagnosing critical illnesses or determining treatment plans [86-90].

To address this issue, the development and implementation of XAI frameworks are essential. These frameworks aim to make AI systems more transparent by providing clear, interpretable explanations of how predictions or decisions are made. For instance, XAI can highlight which variables or features were most influential in a decision, such as patient history, imaging data, or laboratory results. This level of transparency not only builds trust among healthcare professionals but also allows them to validate and critically assess the AI's recommendations, ensuring they align with clinical knowledge and ethical considerations [86-90].

AI also has the potential to impact social equity in healthcare systems. Depending on its implementation, AI can either bridge or widen the healthcare inequity divide [91]. Distributed widely, AI can expand access to

underserved communities; however, limited deployment in resource-rich settings risks exacerbating existing disparities. Ensuring equity in AI applications necessitates the use of diverse training datasets, inclusive development approaches, and transparent frameworks to address systemic biases and prioritize underserved populations [92].

In clinical practice, AI has shown promise in improving efficiency and diagnostic accuracy. For example, models like Doctor AI have demonstrated strong performance in predicting diagnoses and treatments using historical electronic health record data [93]. Similarly, AI's role in analyzing pre-pandemic data has enhanced predictive capabilities during the COVID-19 crisis [94]. Despite these advancements, challenges remain in translating these models into clinical workflows. Open datasets and explainable AI solutions are necessary to ensure transparency, facilitate validation, and address ethical concerns in real-world applications [86].

The integration of AI in healthcare also raises concerns about its impact on human-centered values, such as empathy, compassion, and trust in doctor-patient relationships. While AI promises increased efficiency, it must be implemented in a way that supports, rather than replaces, these core values [95,96]. Medical education should evolve to prepare practitioners to work alongside AI, emphasizing its assistive role in promoting person-centered care [97]. Ultimately, as AI becomes more prevalent, healthcare systems must critically assess how to balance technological efficiency with the preservation of human connection and empathy [96].

To fully harness AI's potential, interdisciplinary collaboration, enhanced education for healthcare professionals, and ongoing research are imperative. Addressing challenges in ethical oversight, data governance, and model transparency will be essential to ensure AI's transformative benefits are equitably distributed, advancing healthcare delivery and patient outcomes on a global scale [5].

8 Best practices for AI implementation

Standardizing and securing healthcare data for AI requires a comprehensive, collaborative approach that prioritizes privacy, equity, and transparency while adhering to ethical principles. Ensuring data privacy and combating algorithmic bias are critical, with robust governance frameworks guiding data sharing and ML methodologies (Polevikov, 2023; Mooney, 2023). Addressing algorithmic bias involves developing diverse datasets and inclusive practices to promote health equity (Arora et al., 2023). Innovative AI methods, such as KNN, Bayesian Networks, and Decision Trees, can enhance healthcare staff security practices by analyzing electronic health records and network logs, further safeguarding sensitive data (Yeng et al., 2020).

Implementing these best practices requires the active collaboration of data scientists, clinicians, patient advocates, ethicists, and policymakers to ensure responsible and ethical AI integration [98]. Continuous reassessment and refinement of these approaches are necessary to maximize AI's potential in enhancing patient care and public health.

Ethical and transparent AI frameworks are essential for ensuring accountability throughout the AI lifecycle. Solanki et al. propose actionable steps for developers to uphold ethical practices, while Kiseleva et al. conceptualize transparency as a multilayered accountability system, emphasizing interpretability, explainability, and thorough documentation [27,99]. Fehr et al. contribute a survey-based framework for assessing AI transparency in data processes and ethical considerations [100]. Crossnohere et al. identify five central pillars for ethical AI—transparency, reproducibility, ethics, effectiveness, and engagement—highlighting the need for transparency in model development and validation [101]. These frameworks collectively emphasize that contextualizing transparency within healthcare settings is vital to building trust and ensuring ethical AI practices [27,99].

Interdisciplinary collaboration is crucial for addressing barriers to AI adoption in healthcare. Specialized conferences foster cross-disciplinary exchange, driving innovation and advancing explainable AI research [102]. Collaboration among healthcare professionals, administrators, insurers, legislators, and patients is necessary to tackle issues such as biases in clinical decision-making, trust deficits, and interoperability challenges [21,103]. Strategies to overcome these barriers include promoting interdisciplinary partnerships, enhancing AI literacy among healthcare professionals, and supporting research and development initiatives [5].

9 Future directions

AI is poised to revolutionize healthcare by enhancing diagnostics, treatment, and operational efficiency across a variety of fields. In mental health, AI applications include early detection of disorders, personalized treatment plans, and AI-driven virtual therapists, offering innovative approaches to patient care [104]. Techniques such as ML and NLP are being applied to diverse healthcare data types, with significant advancements in cancer, neurology, and cardiology [52]. Beyond treatment, AI is transforming healthcare research by optimizing electronic medical record (EMR) data utilization, standardizing protocols, and improving clinical decision-making [105]. However, these advancements come with ethical concerns, such as privacy risks, algorithmic bias, and the need to preserve the human element in patient care [104].

AI also holds the potential to address global health inequities and advance precision medicine. In resource-

limited settings, AI offers tools for optimizing healthcare delivery, predicting disease outbreaks, and enhancing diagnostics [106]. However, automated decision systems risk exacerbating existing social, economic, and health disparities if biases are not addressed, and their decision-making processes remain opaque [107]. While current AI developments often prioritize high-income countries, tailored AI solutions can significantly improve access to quality care in low- and middle-income countries [108]. For these systems to be effective, strategies must focus on careful design, ongoing monitoring, and sustainable implementation, particularly in resource-poor settings [106,107].

A sustainable and inclusive approach to AI in healthcare requires addressing key challenges and implementing strategic measures. Improving data quality and diversity, assessing disparities, enhancing transparency, and involving local communities in AI development are essential steps [109]. A human rights-based framework aligned with the UN's Sustainable Development Goals is critical for ensuring equity in AI strategies [110]. In LMICs, five building blocks for responsible AI implementation have been proposed, including addressing operational barriers, fostering cultural shifts, investing in human capital, and advancing AI literacy [6,29]. Additionally, clear regulatory frameworks are vital for building trust, ensuring ethical use, and safeguarding patient interests.

10 Conclusion

The adoption of AI in healthcare marks a transformative milestone in the evolution of medical practice, offering unprecedented opportunities to enhance diagnostics, treatment, and operational efficiency. From personalized treatment plans to AI-driven virtual therapists, AI is reshaping patient care, particularly in fields such as mental health, oncology, neurology, and cardiology. By leveraging advanced technologies like ML and NLP, AI systems analyze diverse datasets—structured, unstructured, and genomic—to improve decision-making, facilitate early detection, and support tailored treatment approaches. Furthermore, advancements in medical imaging, predictive analytics, and multi-omics integration underscore AI's potential to revolutionize healthcare delivery and research.

Despite its promise, the journey toward effective AI integration in healthcare is fraught with challenges. Data privacy, security concerns, algorithmic bias, and interoperability barriers are critical issues that need to be addressed. These challenges are particularly pronounced in LMICs, where limited resources and infrastructure complicate AI adoption. Ensuring equity in AI applications requires the development of inclusive datasets, robust governance frameworks, and targeted strategies that prioritize underserved populations. A human rights-based approach, aligned with global sustainability goals, is essential to ensure that AI narrows, rather than widens, healthcare disparities.

Ethical considerations are paramount in the development and deployment of AI systems. Transparent model validation, explainable AI (XAI) frameworks, and rigorous algorithmic auditing are necessary to build trust among healthcare professionals and patients alike. Additionally, fostering interdisciplinary collaboration among clinicians, data scientists, patient advocates, and policymakers is critical to navigating the complex ethical and technical landscape of AI in healthcare. Conferences and specialized training programs play a vital role in advancing explainable AI research and promoting cross-disciplinary exchange, addressing biases, and enhancing AI literacy among healthcare stakeholders.

The integration of AI in clinical workflows also raises important questions about the human-centered values of empathy, compassion, and trust. While AI offers efficiency and accuracy, it must complement rather than replace the interpersonal aspects of medical care. Medical education must evolve to prepare practitioners for collaborative roles with AI, emphasizing its assistive capabilities in supporting person-centered care.

AI's transformative potential extends beyond individual patient care to broader healthcare systems, improving operational efficiencies, enhancing resource allocation, and accelerating medical discoveries. In radiology and pathology, AI-powered DL models are advancing disease detection and treatment planning, while in resource-limited settings, AI tools are enabling timely diagnostics and care delivery. Innovations like digital twin models, blockchain technology for data security, and AI-powered health indices illustrate the scope of AI's impact on modern healthcare.

However, the success of AI in healthcare hinges on sustained efforts to address its limitations. Data quality, standardization, and ethical oversight remain critical challenges. Regulatory frameworks must be established to guide the ethical and transparent use of AI, ensuring compliance with privacy laws and addressing liability concerns. Collaborative efforts between governments, healthcare organizations, and technology developers are essential to develop sustainable and scalable AI solutions.

Looking ahead, the future of AI in healthcare depends on rigorous research, robust governance, and inclusive implementation strategies. Investments in human capital, cultural shifts within healthcare organizations, and continuous innovation are needed to maximize AI's benefits while mitigating its risks. By balancing technological advancements with ethical and equitable practices, AI has the potential to redefine healthcare delivery, improve patient outcomes, and advance global health equity. Through strategic planning and collective commitment, AI can unlock a

new era of precision medicine and transformative healthcare solutions.

References

[1] M. Y. Shaheen, Applications of Artificial Intelligence (AI) in healthcare: A review. ScienceOpen Preprints (2021)
[2] A. Ramalingam, A. Karunamurthy, T. A. Victoire, and B. Pavithra, Impact of Artificial Intelligence on Healthcare: A Review of Current Applications and Future Possibilities [J]. Artificial Intelligence (AI) **12**, 06 (2023)
[3] D. Talati, AI in healthcare domain. Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online) **2**, 256 (2023)
[4] C. S. Stafie, I.-G. Sufaru, C. M. Ghiciuc, I.-I. Stafie, E.-C. Sufaru, S. M. Solomon, and M. Hancianu, Exploring the intersection of artificial intelligence and clinical healthcare: a multidisciplinary review. Diagnostics **13**, 1995 (2023)
[5] F. C. Udegbe, O. R. Ebulue, C. C. Ebulue, and C. S. Ekesiobi, The role of artificial intelligence in healthcare: A systematic review of applications and challenges. International Medical Science Research Journal **4**, 500 (2024)
[6] P. Esmaeilzadeh, Challenges and strategies for wide-scale artificial intelligence (AI) deployment in healthcare practices: A perspective for healthcare organizations. Artificial Intelligence in Medicine **151**, 102861 (2024)
[7] J. Amann, A. Blasimme, E. Vayena, D. Frey, V. I. Madai, and P. Q. Consortium, Explainability for artificial intelligence in healthcare: a multidisciplinary perspective. BMC medical informatics and decision making **20**, 1 (2020)
[8] A. T. Hui, S. S. Ahn, C. T. Lye, and J. Deng, Ethical challenges of artificial intelligence in health care: a narrative review. Ethics in Biology, Engineering and Medicine: An International Journal **12** (2021)
[9] E. A. Karpova, AI Health Ethical Review: A Value Design Methodology. Človek **34**, 129 (2023)
[10] R. Bouderhem, Shaping the future of AI in healthcare through ethics and governance. Humanities and Social Sciences Communications **11**, 1 (2024)
[11] J. Benjamins, J. G. Duinkerken, G. den Hamer-Jordaan, R. Canfijn, R. Koster, E. de Vet, and A. Haveman-Nies, Implementation of EPR-Youth, a Client-Accessible and Multidisciplinary Health Record; A Mixed-Methods Process Evaluation. International journal of integrated care **23**, 26 (2023).10.5334/ijic.6905
[12] J. Morley, C. C. V. Machado, C. Burr, J. Cowls, I. Joshi, M. Taddeo, and L. Floridi, The ethics of AI in health care: A mapping review. Social Science & Medicine **260**, 113172 (2020).https://doi.org/10.1016/j.socscimed.2020.113172
[13] F. B. Emdad, S. M. Ho, B. Ravuri, and S. Hussain, Towards a unified utilitarian ethics framework for healthcare artificial intelligence. arXiv preprint arXiv:2309.14617 (2023)
[14] W. Vinu, P. K. Patra, M. K. N. Lakshman, R. Bhattacharjee, D. K. Baruah, and B. J. Chutia, Ethical Implications Of Artificial Intelligence In Healthcare Decision-Making A Crossroads Of Social Values, Computer Algorithms, And Medical Practice. Journal of Namibian Studies: History Politics Culture **35**, 2371 (2023)
[15] K. Morrison, Artificial intelligence and the NHS: a qualitative exploration of the factors influencing adoption. Future Healthcare Journal **8**, e648 (2021)
[16] B. Z. Hameed *et al.*, Breaking barriers: Unveiling factors influencing the adoption of artificial intelligence by healthcare providers. Big Data and Cognitive Computing **7**, 105 (2023)
[17] G. B. Anugerah and A. N. Hidayanto, in *2023 3rd International Conference on Intelligent Cybernetics Technology & Applications (ICICyTA)* (IEEE, 2023), pp. 477.
[18] T. Ciecierski-Holmes, R. Singh, M. Axt, S. Brenner, and S. Barteit, Artificial intelligence for strengthening healthcare systems in low- and middle-income countries: a systematic scoping review. NPJ Digit Med **5**, 162 (2022).10.1038/s41746-022-00700-y
[19] A. Khanijahani, S. Iezadi, S. Dudley, M. Goettler, P. Kroetsch, and J. Wise, Organizational, professional, and patient characteristics associated with artificial intelligence adoption in healthcare: A systematic review. Health Policy and Technology **11**, 100602 (2022).https://doi.org/10.1016/j.hlpt.2022.100602
[20] S. Castagno and M. Khalifa, Perceptions of Artificial Intelligence Among Healthcare Staff: A Qualitative Survey Study. Front Artif Intell **3**, 578983 (2020).10.3389/frai.2020.578983
[21] C. A. Bobak, M. Svoboda, K. A. Giffin, D. P. Wall, and J. Moore, in *BIOCOMPUTING 2021: Proceedings of the Pacific Symposium* (World Scientific, 2020), pp. 351.
[22] A. Mucci, W. M. Green, and L. H. Hill, Incorporation of artificial intelligence in healthcare professions and patient education for fostering effective patient care. New Directions for Adult and Continuing Education **2024**, 51 (2024)
[23] B. Teferi *et al.*, Accelerating the Appropriate Adoption of Artificial Intelligence in Health Care: Prioritizing IDEA to Champion a Collaborative Educational Approach in a Stressed System. Education Sciences **14**, 39 (2023)
[24] D. Wiljer and Z. Hakim, Developing an artificial intelligence–enabled health care practice: rewiring health care professions for better care. Journal of medical imaging and radiation sciences **50**, S8 (2019)
[25] R. Charow *et al.*, Artificial intelligence education programs for health care professionals: scoping review. JMIR Medical Education **7**, e31043 (2021)
[26] M. D. Abràmoff *et al.*, Considerations for addressing bias in artificial intelligence for health equity. NPJ Digit Med **6**, 170 (2023)
[27] P. Solanki, J. Grundy, and W. Hussain, Operationalising ethics in artificial intelligence for healthcare: A framework for AI developers. AI and Ethics **3**, 223 (2023)
[28] S. Johnson, Racing into the fourth industrial revolution: exploring the ethical dimensions of medical

AI and rights-based regulatory framework. AI and Ethics **2**, 227 (2022)
[29] H. Alami *et al.*, Artificial intelligence in health care: laying the Foundation for Responsible, sustainable, and inclusive innovation in low-and middle-income countries. Globalization and Health **16**, 1 (2020)
[30] A. Urman, C.-K. Wang, I. Dankwa-Mullan, E. Scheinberg, and M. J. Young, (American Society of Clinical Oncology, 2018).
[31] Y. Park, G. P. Jackson, M. A. Foreman, D. Gruen, J. Hu, and A. K. Das, Evaluating artificial intelligence in medicine: phases of clinical research. JAMIA open **3**, 326 (2020)
[32] C. McInerney, C. McCrorie, J. Benn, I. Habli, T. Lawton, T. F. Mebrahtu, R. Randell, N. Sheikh, and O. Johnson, Evaluating the safety and patient impacts of an artificial intelligence command centre in acute hospital care: a mixed-methods protocol. BMJ open **12**, e054090 (2022)
[33] R. C. Li, S. M. Asch, and N. H. Shah, Developing a delivery science for artificial intelligence in healthcare. NPJ Digit Med **3**, 107 (2020)
[34] R. Challen, J. Denny, M. Pitt, L. Gompels, T. Edwards, and K. Tsaneva-Atanasova, Artificial intelligence, bias and clinical safety. BMJ quality & safety **28**, 231 (2019)
[35] A. Shuaib, Transforming Healthcare with AI: Promises, Pitfalls, and Pathways Forward. International Journal of General Medicine, 1765 (2024)
[36] A. O. Abdullh A *et al.*, THE USE OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE DECISION-MAKING. Journal of Population and Therapeutics and Clinical Pharmacology (2022)
[37] I. Chatterjee, R. Ghosh, S. Sarkar, M. Kundu, and K. Das, Revolutionizing Inovations and Impact of Artificial Intelligence in Healthcare.
[38] Divya, Dr. N. Sree, AI ASSISTANCE FOR HEALTHCARE USING NLP. INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (2024)
[39] F. A. Rathore and M. A. Rathore, The emerging role of artificial intelligence in healthcare. J Pak Med Assoc **73**, 1368 (2023)
[40] M. Chen and M. Decary, in *Healthcare management forum* (SAGE Publications Sage CA: Los Angeles, CA, 2020), pp. 10.
[41] K. L B, V. S, E. Kotei, A. Gadde, G. A. Kothamasu, S. C. Nallabantu, and G. J, AI and the next medical revolution: deep learning's uncharted healthcare promise. Engineering Research Express **6**, 022202 (2024).10.1088/2631-8695/ad56fc
[42] S. Mittal and Y. Hasija, 2020), pp. 57.
[43] S. Lee, N. M. Mohr, W. N. Street, and P. Nadkarni, Machine learning in relation to emergency medicine clinical and operational scenarios: an overview. Western Journal of Emergency Medicine **20**, 219 (2019)
[44] I.-A. Almasri, The Power of Artificial Intelligence for Improved Patient Outcomes, Ethical Practices and Overcoming Challenges. MEDICINE **2** (2024)
[45] N. Sumathi and A. Jeyalakshmi, Implementing robotic process automation to improve operational efficiency in the health-care sector. International Journal of Health Sciences, 9666 (2022)
[46] Z. Zhou, Y. Chen, F. Huang, Y. Feng, and M. Aibin, in *2023 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE)* (IEEE, 2023), pp. 192.
[47] E. Thaler, University of Pennsylvania, 2022.
[48] M. Ratia, J. Myllärniemi, and N. Helander, in *Proceedings of the 22nd International Academic Mindtrek Conference*2018), pp. 222.
[49] A. Ahmad, A. Tariq, H. K. Hussain, and A. Y. Gill, Revolutionizing Healthcare: How Deep Learning is poised to Change the Landscape of Medical Diagnosis and Treatment. Journal of Computer Networks, Architecture and High Performance Computing **5**, 458 (2023)
[50] M. Khosravi, Z. Zare, S. M. Mojtabaeian, and R. Izadi, Artificial intelligence and decision-making in healthcare: a thematic analysis of a systematic review of reviews. Health services research and managerial epidemiology **11**, 23333928241234863 (2024)
[51] B. Chander, Advanced deep learning techniques and applications in healthcare services. Deep Learning for Personalized Healthcare Services **7**, 37 (2021)
[52] F. Jiang *et al.*, Artificial intelligence in healthcare: past, present and future. Stroke and vascular neurology **2** (2017)
[53] K. Srikanth, S. Das, and M. Deb, Relevance Of Artificial Intelligence In Healthcare: An Exhaustive Review. Educational Administration: Theory and Practice **30**, 9094 (2024)
[54] H.-J. Kong, Managing unstructured big data in healthcare system. Healthcare informatics research **25**, 1 (2019)
[55] R. A. A. Rahem and F. Al-Akayleh, in *2024 2nd International Conference on Cyber Resilience (ICCR)* (IEEE, 2024), pp. 1.
[56] F. Wang and A. Preininger, AI in health: state of the art, challenges, and future directions. Yearbook of medical informatics **28**, 016 (2019)
[57] J. Lipkova *et al.*, Artificial intelligence for multimodal data integration in oncology. Cancer cell **40**, 1095 (2022)
[58] W. Lotter, M. J. Hassett, N. Schultz, K. L. Kehl, E. M. Van Allen, and E. Cerami, Artificial Intelligence in Oncology: Current Landscape, Challenges, and Future Directions. Cancer Discovery **14**, 711 (2024)
[59] A. E. Mohr, C. P. Ortega-Santos, C. M. Whisner, J. Klein-Seetharaman, and P. Jasbi, Navigating challenges and opportunities in multi-omics integration for personalized healthcare. Biomedicines **12**, 1496 (2024)
[60] L. Tong *et al.*, Integrating multi-omics data with EHR for precision medicine using advanced artificial intelligence. IEEE Reviews in Biomedical Engineering (2023)
[61] N. Rane, S. Choudhary, and J. Rane, Towards Autonomous Healthcare: Integrating Artificial Intelligence (AI) for Personalized Medicine and Disease Prediction. Available at SSRN 4637894 (2023)
[62] J. Awwalu, A. G. Garba, A. Ghazvini, and R. Atuah, Artificial intelligence in personalized medicine application of AI algorithms in solving personalized

medicine problems. International Journal of Computer Theory and Engineering **7**, 439 (2015)
[63] K. J. Devi, W. Alghamdi, N. Divya, A. Alkhayyat, A. Sayyora, and T. Sathish, in *E3S Web of Conferences* (EDP Sciences, 2023), p. 04043.
[64] B. Rawat, Y. Joshi, and A. Kumar, in *2023 5th International Conference on Inventive Research in Computing Applications (ICIRCA)* (IEEE, 2023), pp. 374.
[65] L. Letourneau-Guillon, D. Camirand, F. Guilbert, and R. Forghani, Artificial intelligence applications for workflow, process optimization and predictive analytics. Neuroimaging Clinics **30**, e1 (2020)
[66] P. Patel, Role of Artificial Intelligence in Telemedicine. International Journal for Research in Applied Science and Engineering Technology **11**, 443 (2023).10.22214/ijraset.2023.55211
[67] A. M. Chavez-Cano, Artificial Intelligence Applied to Telemedicine: opportunities for healthcare delivery in rural areas. LatIA **1**, 3 (2023)
[68] S. Sharma, R. Rawal, and D. Shah, Addressing the challenges of AI-based telemedicine: Best practices and lessons learned. Journal of education and health promotion, 338 (2023)
[69] M. Liebman, The Role of Artificial Intelligence in Drug Discovery and Development. Chemistry International **44**, 16 (2022).10.1515/ci-2022-0105
[70] M. B. M. A. Rashid, Artificial intelligence effecting a paradigm shift in drug development. SLAS TECHNOLOGY: Translating Life Sciences Innovation **26**, 3 (2021)
[71] T. Doherty *et al.*, Artificial intelligence for dementia drug discovery and trials optimization. Alzheimer's & Dementia **19**, 5922 (2023)
[72] K. Kusunose, Transforming Echocardiography: The Role of Artificial Intelligence in Enhancing Diagnostic Accuracy and Accessibility. Internal Medicine, 4171 (2024)
[73] E. Zavaleta-Monestel, R. Quesada-Villaseñor, S. Arguedas-Chacón, J. García-Montero, M. Barrantes-López, J. Salas-Segura, A. Anchía-Alfaro, D. Nieto-Bernal, and D. E. Diaz-Juan, Revolutionizing Healthcare: Qure. AI's Innovations in Medical Diagnosis and Treatment. Cureus **16** (2024)
[74] S. C. C. Chan, A. L. Neves, A. Majeed, and A. Faisal, (British Medical Journal Publishing Group, 2024).
[75] O. Adelaja and H. Alkattan, Operating Artificial Intelligence to Assist Physicians Diagnose Medical Images: A Narrative Review. Mesopotamian Journal of Artificial Intelligence in Healthcare **2023**, 45 (2023)
[76] M. I. A. Bhagat, M. K. G. Wankhede, M. N. A. Kopawar, and P. D. A. Sananse, Artificial Intelligence in Healthcare : A Review. International Journal of Scientific Research in Science, Engineering and Technology (2024)
[77] H. Devianto, The Advantages of Artificial Intelligence in Operational Decision Making. Hasanuddin Economics and Business Review **6**, 24 (2022)
[78] A. S. Panayides *et al.*, AI in Medical Imaging Informatics: Current Challenges and Future Directions. IEEE J Biomed Health Inform **24**, 1837 (2020).10.1109/jbhi.2020.2991043
[79] L. Pinto-Coelho, How Artificial Intelligence Is Shaping Medical Imaging Technology: A Survey of Innovations and Applications. Bioengineering (Basel) **10** (2023).10.3390/bioengineering10121435
[80] N. Naeem, Artificial Intelligence and Research: Innovation or Intrusion? Esculapio **19**, 378 (2023).10.51273/esc23.251319427
[81] J. Bajwa, U. Munir, A. Nori, and B. Williams, Artificial intelligence in healthcare: transforming the practice of medicine. Future Healthc J **8**, e188 (2021).10.7861/fhj.2021-0095
[82] J. S. Winter, AI in healthcare: data governance challenges. Journal of hospital management and health policy **5** (2021)
[83] K. Paranjape, Implementing Artificial Intelligence in Health Care: Data and Algorithm Challenges and Policy Considerations. American Journal of Biomedical Science & Research **11**, 280 (2021).10.34297/ajbsr.2021.11.001645
[84] N. Norori, Q. Hu, F. M. Aellen, F. D. Faraci, and A. Tzovara, Addressing bias in big data and AI for health care: A call for open science. Patterns **2** (2021)
[85] L. H. Nazer *et al.*, Bias in artificial intelligence algorithms and recommendations for mitigation. PLOS Digital Health **2**, e0000278 (2023)
[86] G. Alam, I. McChesney, P. Nicholl, and J. Rafferty, in *2023 3rd International Conference on Computing and Information Technology (ICCIT)* (IEEE, 2023), pp. 486.
[87] R. Tiwari, Explainable AI (XAI) and its Applications in Building Trust and Understanding in AI Decision Making. INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT **07** (2023).10.55041/IJSREM17592
[88] D. Praveenraj, M. Victor, C. Vennila, A. Alawadi, P. Diyora, N. Vasudevan, and T. Avudaiappan, Exploring Explainable Artificial Intelligence for Transparent Decision Making. E3S Web of Conferences **399** (2023).10.1051/e3sconf/202339904030
[89] E. Rajabi and S. Kafaie, Knowledge Graphs and Explainable AI in Healthcare. Information **13**, 459 (2022).10.3390/info13100459
[90] U. Pawar, D. O'Shea, S. Rea, and R. O'Reilly, *Explainable AI in Healthcare* 2020).
[91] G. Currie and E. Rohren, in *Seminars in Nuclear Medicine* (Elsevier, 2022), pp. 498.
[92] N.-J. Iloanusi and S. A. Chun, in *Proceedings of the 25th Annual International Conference on Digital Government Research*2024), pp. 841.
[93] E. Choi, M. T. Bahadori, A. Schuetz, W. F. Stewart, and J. Sun, in *Machine learning for healthcare conference* (PMLR, 2016), pp. 301.
[94] W. Sun, S. V. Kalmady, N. Sepehrvand, L. M. Chu, Z. Wang, A. Salimi, A. Hindle, R. Greiner, and P. Kaul, Improving ECG-based COVID-19 diagnosis and mortality predictions using pre-pandemic medical records at population-scale. arXiv preprint arXiv:2211.10431 (2022)
[95] A. B. Kocaballi, K. Ijaz, L. Laranjo, J. C. Quiroz, D. Rezazadegan, H. L. Tong, S. Willcock, S. Berkovsky, and E. Coiera, Envisioning an artificial

intelligence documentation assistant for future primary care consultations: a co-design study with general practitioners. Journal of the American Medical Informatics Association **27**, 1695 (2020)
[96] A. Kerasidou, Artificial intelligence and the ongoing need for empathy, compassion and trust in healthcare. Bulletin of the World Health Organization **98**, 245 (2020)
[97] A. Sauerbrei, A. Kerasidou, F. Lucivero, and N. Hallowell, The impact of artificial intelligence on the person-centred, doctor-patient relationship: some problems and solutions. BMC medical informatics and decision making **23**, 73 (2023)
[98] S. Polevikov, Advancing AI in healthcare: A comprehensive review of best practices. Clinica Chimica Acta **548**, 117519 (2023).https://doi.org/10.1016/j.cca.2023.117519
[99] A. Kiseleva, D. Kotzinos, and P. De Hert, Transparency of AI in healthcare as a multilayered system of accountabilities: between legal requirements and technical limitations. Front Artif Intell **5**, 879603 (2022)
[100]J. Fehr, G. Jaramillo-Gutierrez, L. Oala, M. I. Gröschel, M. Bierwirth, P. Balachandran, A. Werneck-Leite, and C. Lippert, in *Healthcare* (MDPI, 2022), p. 1923.
[101]N. L. Crossnohere, M. Elsaid, J. Paskett, S. Bose-Brill, and J. F. Bridges, Guidelines for artificial intelligence in medicine: literature review and content analysis of frameworks. Journal of Medical Internet Research **24**, e36823 (2022)
[102]A. U. Patel, Q. Gu, R. Esper, D. Maeser, and N. Maeser, The Crucial Role of Interdisciplinary Conferences in Advancing Explainable AI in Healthcare. BioMedInformatics **4**, 1363 (2024)
[103]Y. Lai, A. Kankanhalli, and D. Ong, Human-AI collaboration in healthcare: A review and research agenda. (2021)
[104]D. B. Olawade, O. Z. Wada, A. Odetayo, A. C. David-Olawade, F. Asaolu, and J. Eberhardt, Enhancing mental health with Artificial Intelligence: Current trends and future prospects. Journal of Medicine, Surgery, and Public Health **3**, 100099 (2024).https://doi.org/10.1016/j.glmedi.2024.100099
[105]L. Rubinger, A. Gazendam, S. Ekhtiari, and M. Bhandari, Machine learning and artificial intelligence in research and healthcare. Injury **54**, S69 (2023)
[106]T. D. Hadley, R. W. Pettit, T. Malik, A. A. Khoei, and H. M. Salihu, Artificial intelligence in global health—A framework and strategy for adoption and sustainability. International Journal of Maternal and Child Health and AIDS **9**, 121 (2020)
[107]M. Burger, The risk to population health equity posed by automated decision systems: A narrative review. arXiv preprint arXiv:2001.06615 (2020)
[108]A. Hosny and H. J. Aerts, Artificial intelligence for global health. Science **366**, 955 (2019)
[109]C. T. Berdahl, L. Baker, S. Mann, O. Osoba, and F. Girosi, Strategies to improve the impact of artificial intelligence on health equity: Scoping review. JMIR AI **2**, e42936 (2023)
[110]C. Fernández-Aller, A. F. de Velasco, Á. Manjarrés, D. Pastor-Escuredo, S. Pickin, J. S. Criado, and T. Ausín, An inclusive and sustainable artificial intelligence strategy for europe based on human rights. IEEE Technology and Society Magazine **40**, 46 (2021)