AI for Medical Application: Current Trends, Challenges, and Future Directions

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Abstract: The integration of Artificial Intelligence (AI) into healthcare has significantly enhanced diagnostic precision, treatment strategies, pharmaceutical advancements, and hospital management. This review examines the role of AI in medical imaging, drug discovery, robotic surgery, epidemiology, and clinical decision-making. Techniques such as deep learning and natural language processing (NLP) have exhibited exceptional proficiency in interpreting medical images, forecasting disease trajectories, and optimizing healthcare infrastructure. Furthermore, the incorporation of AI into electronic health records (EHRs) and wearable health monitoring technologies has strengthened patient management and facilitated early disease identification. Despite these technological strides, several challenges remain, including concerns about data security, interpretability of AI models, biases in algorithms, and ethical dilemmas. Adherence to regulations such as HIPAA and GDPR is essential to maintaining patient data confidentiality. Additionally, efforts to improve AI fairness and transparency are crucial in fostering confidence among medical practitioners and patients. Future developments in medical AI are anticipated to be driven by advancements in multimodal AI, federated learning, and generative AI. Rather than displacing human expertise, AI will act as a complementary tool, equipping healthcare professionals with data-driven insights to refine clinical decision-making. Ensuring sustainable AI deployment and fostering international collaboration will be pivotal in making AI-driven medical solutions accessible and equitable. This paper provides an extensive review of AI's present applications, challenges, and future potential in medicine, highlighting its contributions to precision healthcare and improved patient outcomes.

Keywords: Medical AI, Healthcare Technology, Medical Imaging, Drug Discovery, AI in Surgery, Public Health, Explainable AI, Personalized Medicine

1. Introduction

Artificial Intelligence (AI) has become a pivotal technology in healthcare, significantly reshaping patient management, diagnostic procedures, and therapeutic planning. Utilizing extensive datasets, AI models recognize trends and generate predictions, improving both clinical judgments and workflow efficiency [1]. The expanding role of AI in medicine is fueled by innovations in machine learning, deep learning, and natural language processing, facilitating the automated interpretation of intricate medical information, such as imaging data, genomic sequences, and electronic health records.

AI has been widely adopted in medical imaging and diagnostics, with deep learning models enhancing disease detection and classification accuracy across radiology, pathology, and dermatology [2]. In drug discovery, AI expedites the identification of promising drug candidates by predicting molecular interactions and refining drug formulations, significantly cutting development time and costs compared to traditional methods [3]. Personalized medicine also benefits from AI-driven analysis of patient-specific data, including genetic profiles and clinical history, to recommend customized treatment strategies, improving therapeutic outcomes while minimizing side effects [4]. Furthermore, AI plays a crucial role in healthcare management by optimizing hospital workflows, forecasting patient admissions, and automating administrative processes, leading to greater efficiency and cost reduction [5].

Despite these advancements, AI implementation in medicine encounters challenges such as data privacy risks, ethical dilemmas, and the necessity for regulatory frameworks to ensure safety and reliability. Its integration into clinical settings demands rigorous validation and improved model interpretability to establish trust among healthcare providers and patients. This review examines the current landscape of AI applications in medicine, addresses key obstacles in its deployment, and explores prospective advancements in AI-driven healthcare innovations.

2. AI in Medical Imaging and Diagnostics

Artificial Intelligence (AI), particularly deep learning, has revolutionized medical imaging and diagnostics. Convolutional neural networks (CNNs) have been extensively employed across imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), X-rays, and ultrasound. These models demonstrate exceptional performance in image classification, anomaly detection, organ segmentation, and disease progression assessment, thereby enhancing diagnostic precision and efficiency [6].

Computer-aided diagnosis (CAD) systems have been developed to support radiologists by improving image interpretation, minimizing diagnostic errors, and reducing workload. AI-driven systems have proven particularly effective in early disease detection, especially in oncology, cardiology, and neurology [7]. In pathology, deep learning algorithms process digitized histopathological slides to detect malignant tissues with high accuracy. Automated histopathological analysis has shown remarkable effectiveness in identifying cancers such as breast and prostate cancer, sometimes surpassing human pathologists in diagnostic accuracy [8].

The fusion of multi-modal data, integrating imaging, genetic, and clinical information, has further refined patient diagnostics and treatment planning. AI models trained on diverse datasets facilitate personalized medicine by offering comprehensive assessments of disease states and predicting individual patient prognoses [9]. For instance, AI-driven analysis of MRI scans and genomic data has successfully classified glioblastoma subtypes, crucial for tailoring patient-specific treatments.

Recently, transformer architectures, initially developed for natural language processing, have been adapted for medical imaging tasks. These models excel in segmentation, classification, detection, and clinical report generation by capturing long-range dependencies and contextual information within medical images [10]. Vision Transformers (ViTs), in particular, have demonstrated superior performance in radiology, often surpassing conventional CNNs in specific imaging applications, underscoring their potential for advancing medical diagnostics.

Despite these breakthroughs, AI-driven medical imaging still faces hurdles, including concerns about data privacy, the necessity for large annotated datasets, and ensuring model generalizability across varied populations. Future research should emphasize enhancing AI interpretability, refining federated learning for privacy-preserving data sharing, and establishing standardized evaluation metrics to facilitate broader clinical adoption.

3. AI in Drug Discovery and Personalized Medicine

Artificial Intelligence (AI) has significantly transformed drug discovery and personalized medicine by improving protein structure prediction, facilitating molecular design, and enabling individualized treatment strategies.

3.1. AI in Drug Discovery

3.1.1. Protein Structure Prediction and Molecular Design

Understanding protein structures is fundamental to drug development, yet conventional experimental techniques are often labor-intensive and costly. AI has revolutionized this domain, with models like AlphaFold by DeepMind demonstrating exceptional accuracy in predicting three-dimensional protein configurations from amino acid sequences [11]. This advancement accelerates drug target identification and the design of therapeutic compounds.

Beyond structural insights, AI-driven generative models, such as variational autoencoders and generative adversarial networks, contribute to the rapid design of novel drug candidates with optimized properties, streamlining the development pipeline [12].

3.1.2. Computational Pharmacology and AI-Enhanced Drug Screening

AI supports computational pharmacology by modeling drug-target interactions, evaluating potential adverse effects, and optimizing lead compounds. By leveraging extensive chemical and biological datasets, machine learning algorithms can pinpoint promising drug candidates, reducing reliance on traditional in vitro and in vivo screening processes [13].

3.2. AI in Personalized Medicine

3.2.1. Genomic Analysis and Precision Healthcare

In the realm of personalized medicine, AI examines genomic data to detect genetic variations linked to specific diseases, enabling the formulation of targeted therapies. Integrating genetic information with clinical records allows AI to support precision medicine initiatives, ensuring treatments are tailored to individual patient profiles, enhancing efficacy, and mitigating adverse reactions [14].

3.2.2. AI-Guided Treatment Optimization

AI systems assist clinicians by generating evidence-based treatment recommendations. By analyzing patient history, genetic markers, and lifestyle data, AI predicts individual therapeutic responses and suggests optimal treatment plans, contributing to improved healthcare outcomes [15].

3.3. Recent Developments

Recent progress includes the emergence of AlphaFold3, which extends beyond structure prediction to model protein-ligand interactions, further advancing drug discovery methodologies [16]. Additionally, AI-generated personalized therapy regimens, leveraging genetic and clinical data, are being deployed to offer tailored treatments, improving patient-specific medical interventions [17].

4. AI in Medical Robotics and Surgery

The incorporation of Artificial Intelligence (AI) into medical robotics and surgical interventions has substantially improved surgical accuracy, efficiency, and patient outcomes. This section examines advancements in AI-powered robotic surgery, computer vision applications in surgical navigation, AI-assisted minimally invasive and remote procedures, and emerging trends such as autonomous robotic surgeries.

4.1. AI-Enhanced Robotic Surgery Systems

AI has played a crucial role in evolving robotic-assisted surgery, extending capabilities beyond traditional manual techniques. The da Vinci Surgical System exemplifies this progress, leveraging AI to enhance dexterity and precision in minimally invasive operations [18]. AI algorithms facilitate automation in various surgical tasks, including suturing and knot tying, thereby alleviating cognitive demands on surgeons and reducing the likelihood of human errors [19].

4.2. Computer Vision for Surgical Navigation

Computer vision, an essential AI component, enables real-time image-guided navigation during surgeries. By accurately tracking surgical instruments and recognizing anatomical structures, these systems support intraoperative decision-making [20]. Vision-based tracking presents an efficient alternative to conventional external tracking mechanisms, fostering a more intuitive and precise surgical workflow [21].

4.3. AI-Assisted Minimally Invasive and Remote Procedures

AI has significantly advanced minimally invasive surgeries (MIS) and remote surgical capabilities. In MIS, AI supports tasks such as instrument segmentation and tissue differentiation, leading to smaller incisions and faster patient recovery [22]. In telesurgery, AI-driven robotic platforms allow specialists to conduct remote procedures, extending specialized surgical expertise to underserved areas [23].

4.4. Future Prospects: AI-Enabled Autonomous Surgeries

The development of AI-powered autonomous surgical systems represents a key area of future innovation. These systems aim to independently execute specific surgical procedures under human supervision. Research in imitation learning, where robots are trained through surgical video demonstrations, suggests that AI-assisted systems may achieve competency levels comparable to human surgeons [24]. Such advancements could lead to standardized surgical techniques and improved patient outcomes.

4.5. Recent Advances

Recent innovations in AI and medical robotics include the integration of augmented reality (AR) to enhance surgical accuracy. Companies such as Medivis employ AR and computer vision to provide real-time, three-dimensional visualizations of patient anatomy during operations [25]. Additionally, AI-driven analytics are being used to assess surgical performance, contributing to improved training methodologies and patient safety [26].

5. AI in Healthcare Management and Clinical Decision Support

Artificial Intelligence (AI) has revolutionized healthcare management and clinical decision support systems (CDSS), increasing efficiency, accuracy, and personalized care.

5.1. Healthcare Resource Optimization and Administrative Automation

AI-driven solutions optimize healthcare resources, streamline patient management, and enhance hospital operations. By analyzing extensive datasets, AI predicts patient admissions, refines staff allocation, and manages inventory, leading to cost reductions and improved service delivery. AI-powered automation also alleviates administrative burdens, including medical documentation and scheduling, thereby reducing physician workload [27].

5.2. Natural Language Processing in Electronic Health Records

Natural Language Processing (NLP), a subset of AI, enables the extraction of meaningful insights from unstructured data in Electronic Health Records (EHRs). NLP-based algorithms detect patient symptoms, track medical histories, and assess treatment responses, facilitating disease diagnosis, treatment planning, and clinical research. However, challenges remain, including privacy concerns, inconsistencies in data quality, and the need for large annotated datasets [28].

5.3. Predictive Analytics for Disease Risk Assessment

AI-driven predictive modeling allows for early detection of high-risk patients by analyzing demographic information, medical records, and lifestyle factors. These models enable proactive intervention strategies for chronic conditions such as cardiovascular diseases and diabetes, thus improving patient care and treatment outcomes [29].

5.4. AI-Powered Medical Assistants and Dialogue Systems

AI-driven medical dialogue systems, including ChatGPT, function as intelligent health assistants by offering patients medical information, addressing health-related queries, and aiding clinicians in decision-making. Utilizing advanced NLP techniques, these systems generate human-like responses, improving patient engagement and accessibility to healthcare services [30].

5.5. Recent Innovations

Recent advancements include AI-driven agents designed to assist with clinical trial enrollment, post-hospitalization patient care, and physician briefings. These AI applications aim to alleviate physician burnout by handling administrative responsibilities, allowing healthcare professionals to dedicate more time to direct patient care [31].

6. AI in Epidemiology and Public Health

Artificial Intelligence (AI) has emerged as a crucial asset in epidemiology and public health, enabling sophisticated approaches to disease forecasting, outbreak detection, policy development, and remote health surveillance.

6.1. Infectious Disease Prediction and Epidemic Monitoring

AI's capability to analyze extensive datasets has significantly improved the prediction and monitoring of infectious disease outbreaks. Machine learning models process real-time patient data, environmental variables, and epidemiological patterns to forecast disease spread and identify vulnerable regions. The Canadian AI system BlueDot, for instance, employs natural language processing and machine learning techniques to synthesize diverse data sources, effectively anticipating the dissemination of infectious diseases [32]. During the COVID-19 pandemic, AI models played a pivotal role in outbreak prediction and disease progression tracking, facilitating timely public health interventions [25].

6.2. AI in Public Health Policy Development

AI aids policymakers by analyzing complex health data, revealing trends in disease transmission, and informing the development of targeted public health strategies. These models evaluate intervention efficacy, optimize healthcare resource distribution, and enhance the overall responsiveness of public health initiatives [23]. By integrating AI-driven insights, decision-makers can improve epidemic control measures and design proactive policies to mitigate future health crises.

6.3. Wearable Technology and Remote Health Surveillance

The fusion of AI with wearable technology has revolutionized remote health monitoring, enabling continuous assessment of physiological metrics such as heart rate, physical activity, and biochemical markers. AI algorithms detect anomalies in these datasets, facilitating early diagnosis and personalized medical interventions. Studies indicate that AI-powered wearable devices can reliably capture and analyze health signals, offering new prospects for preemptive disease detection and real-time therapeutic responses [33]. Additionally, AI-driven remote monitoring platforms have been deployed to track vital signs and predict disease trajectories, improving patient outcomes while alleviating strain on healthcare systems [34].

7. Challenges and Ethical Considerations

The implementation of Artificial Intelligence (AI) in healthcare introduces several challenges and ethical concerns that must be addressed to ensure safe, effective, and equitable medical applications.

7.1. Data Privacy and Security

AI-driven healthcare solutions depend on vast amounts of patient data, necessitating strict adherence to privacy and security regulations. Legal frameworks such as HIPAA in the U.S. and GDPR in the EU outline protocols for protecting medical records, restricting unauthorized access, and fortifying cybersecurity to prevent data breaches [35].

7.2. Explainability and Trust in AI

The opacity of AI models, particularly deep learning systems, creates a ”black box” issue, where the reasoning behind predictions remains unclear. In medical contexts, this lack of transparency can reduce trust and hinder adoption by healthcare professionals and patients. Enhancing AI interpretability is essential to ensure clinical decisions remain comprehensible and justifiable [36].

7.3. Bias and Equity in AI

AI models trained on non-representative datasets risk perpetuating biases, potentially leading to disparities in healthcare outcomes among different demographic groups. Mitigating these biases requires diverse and inclusive training data, continuous auditing, and algorithmic adjustments to ensure fairness and equitable treatment across populations [21].

7.4. Regulatory and Ethical Complexities

The integration of AI in healthcare raises critical legal and ethical issues, including accountability, informed consent, and unintended consequences. Developing comprehensive regulatory policies and ethical guidelines is crucial to governing AI deployment responsibly and ensuring its alignment with medical standards and patient rights [22].

8. Challenges and Ethical Considerations

The adoption of Artificial Intelligence (AI) in healthcare presents various challenges and ethical concerns that must be addressed to ensure safe, effective, and equitable implementation.

8.1. Data Privacy and Security

AI-driven healthcare systems handle vast amounts of sensitive patient information, necessitating strict adherence to privacy and security regulations. Policies such as HIPAA in the U.S. and GDPR in the EU outline protocols for protecting medical data, controlling access, and enhancing cybersecurity to mitigate risks associated with data breaches [35]. As AI applications continue to expand, ensuring compliance with these legal frameworks remains a fundamental requirement for maintaining patient confidentiality and trust [33].

8.2. Explainability and Trust in AI

The complexity of AI models, particularly deep learning architectures, often results in a lack of transparency, commonly referred to as the ”black box” issue. In healthcare, the inability to interpret AI-driven decisions can reduce trust and hinder acceptance among medical professionals and patients. Enhancing AI interpretability is crucial for ensuring that clinical decisions remain transparent, comprehensible, and justifiable [32].

8.3. Bias and Fairness

AI models trained on non-representative datasets risk perpetuating biases, leading to disparities in healthcare outcomes across different demographic groups. Addressing these biases requires diverse and inclusive training data, rigorous auditing processes, and algorithmic refinements to ensure fairness and equitable healthcare delivery [36].

8.4. Regulatory and Ethical Considerations

The deployment of AI in healthcare raises complex legal and ethical concerns, including questions of accountability, informed consent, and potential unintended consequences. Developing robust regulatory frameworks and ethical guidelines is essential to ensure AI adoption aligns with medical standards and upholds patient rights [32]. Establishing clear accountability structures for AI-driven clinical decisions is crucial for fostering responsible and transparent AI implementation in medicine.

9. Future Directions and Conclusion

The integration of Artificial Intelligence (AI) in healthcare has driven significant advancements, with its future trajectory poised to introduce even more transformative changes. This section examines anticipated developments, the collaborative relationship between AI and medical professionals, the importance of sustainable AI deployment, and the need for global cooperation.

9.1. Emerging Trends in Medical AI

9.1.1. Multimodal AI

Next-generation AI systems will integrate diverse medical data sources—such as imaging, genomics, electronic health records, and real-time physiological monitoring—to generate comprehensive insights into patient health. This multimodal approach aims to enhance diagnostic accuracy and facilitate more personalized treatment strategies by incorporating a holistic view of patient information [37].

9.1.2. Federated Learning

Federated learning enables AI models to be trained on decentralized datasets while maintaining local data privacy. In healthcare, this technique allows institutions to collaboratively develop AI models without compromising patient confidentiality, leading to more robust and generalizable AI applications across medical settings [23].

9.1.3. Generative AI

Generative AI, including models such as ChatGPT, has the potential to reshape medical education, patient engagement, and clinical decision support by synthesizing vast medical literature and generating contextually relevant text. These AI systems can assist in medical documentation, provide patient-friendly explanations, and summarize clinical guidelines, contributing to enhanced healthcare service delivery [33].

9.2. Collaboration Between AI and Healthcare Professionals

AI is designed to augment rather than replace healthcare practitioners. By automating administrative tasks and offering data-driven insights, AI enhances clinical workflows, allowing medical professionals to devote more time to direct patient care. This collaboration is expected to improve diagnostic precision and therapeutic decision-making, ultimately leading to better patient outcomes [38].

9.3. Sustainable Development and International Cooperation

The continued evolution of AI in medicine must address challenges such as data security, algorithmic bias, and disparities in access to technology. Establishing clear ethical guidelines and regulatory policies will be crucial in ensuring equitable AI deployment. Additionally, fostering global collaboration among researchers, policymakers, and industry leaders will aid in standardizing AI integration and promoting responsible innovation in healthcare [39].

9.4. Conclusion

AI has already begun revolutionizing healthcare, improving diagnostics, treatment planning, and patient management. Future advancements in multimodal AI, federated learning, and generative AI are expected to drive further progress. The synergy between AI and healthcare professionals, alongside sustainable AI practices and international cooperation, will be key to unlocking AI's full potential in medicine.

References

[1] M. Alloghani, D. Al-Jumeily, A. J. Aljaaf, M. Khalaf, and S. Y. Tan, "The application of artificial intelligence technology in healthcare: A systematic review," 2020.

[2] K. Moulaei, A. Yadegari, M. Baharestani, S. Farzanbakhsh, B. Sabet, and M. R. Afrash, "Generative artificial intelligence in healthcare: A scoping review on benefits, challenges and applications," *International Journal of Medical Informatics*, vol. 188, 2024.

[3] E. Gómez-González, E. Gomez, J. Márquez-Rivas, M. Guerrero-Claro, I. Fernández-Lizaranzu, M. I. Relimpio-López, M. E. Dorado, M. J. Mayorga-Buiza, G. Izquierdo-Ayuso, and L. Capitán-Morales, "Artificial intelligence in medicine and healthcare: a review and classification of current and near-future applications and their ethical and social impact," 2020.

[4] M. Nasr, . M. Islam, S. Shehata, F. Karray, and Y. Quintana, "Smart healthcare in the age of ai: Recent advances, challenges, and future prospects," 2021.

[5] B. S. Ingole, V. Ramineni, N. K. Pulipeta, M. J. Kathiriya, M. S. Krishnappa, and V. Jayaram, "The dual impact of artificial intelligence in healthcare: Balancing advancements with ethical and operational challenges," 2024.

[6] G. Litjens, T. Kooi, B. E. Bejnordi, A. A. A. Setio, and C. I. Sánchez, "A survey on deep learning in medical image analysis," *Medical Image Analysis*, vol. 42, no. 9, pp. 60–88, 2017.

[7] H. Greenspan, B. V. Ginneken, and R. M. Summers, "Guest editorial deep learning in medical imaging: Overview and future promise of an exciting new technique," *IEEE Transactions on Medical Imaging*, vol. 35, no. 5, pp. 1153–1159, 2016.

[8] B. Allison, X. Ye, and F. Janan, "Mixr: A standard architecture for medical image analysis in augmented and mixed reality," *IEEE*, 2020.

[9] V. Guarrasi, F. Aksu, C. M. Caruso, F. Di Feola, A. Rofena, F. Ruffini, and P. Soda, "A systematic review of intermediate fusion in multimodal deep learning for biomedical applications," 2024.

[10] K. He, C. Gan, Z. Li, I. Rekik, Z. Yin, W. Ji, Y. Gao, Q. Wang, J. Zhang, and D. Shen, "Transformers in medical image analysis: A review," 2022.

[11] Z. Yang, X. Zeng, Y. Zhao, and R. Chen, "Alphafold2 and its applications in the fields of biology and medicine," *Signal Transduction and Targeted Therapy*, vol. 8, no. 1, p. 115, 2023.

[12] X. Tang, H. Dai, E. Knight, F. Wu, Y. Li, T. Li, and M. Gerstein, “A survey of generative ai for de novo drug design: new frontiers in molecule and protein generation,” *Briefings in Bioinformatics*, vol. 25, no. 4, p. bbae338, 2024.

[13] Q. Liao, Y. Zhang, Y. Chu, Y. Ding, Z. Liu, X. Zhao, Y. Wang, J. Wan, Y. Ding, P. Tiwari *et al.*, “Application of artificial intelligence in drug-target interactions prediction: A review,” *npj Biomedical Innovations*, vol. 2, no. 1, p. 1, 2025.

[14] K. B. Johnson, W.-Q. Wei, D. Weeraratne, M. E. Frisse, K. Misulis, K. Rhee, J. Zhao, and J. L. Snowdon, “Precision medicine, ai, and the future of personalized health care,” *Clinical and translational science*, vol. 14, no. 1, pp. 86–93, 2021.

[15] A.-D. E. Parekh, O. A. Shaikh, S. Manan, M. Al Hasibuzzaman *et al.*, “Artificial intelligence (ai) in personalized medicine: Ai-generated personalized therapy regimens based on genetic and medical history,” *Annals of Medicine and Surgery*, vol. 85, no. 11, pp. 5831–5833, 2023.

[16] B. Stuart, T. Danaher, R. Awdish, and L. Berry, “Finding hope and healing when cure is not possible,” in *Mayo Clinic Proceedings*, vol. 94, no. 4. Elsevier, 2019, pp. 677–685.

[17] N. Schopow, G. Osterhoff, and D. Baur, “Applications of the natural language processing tool chatgpt in clinical practice: comparative study and augmented systematic review,” *JMIR Medical Informatics*, vol. 11, p. e48933, 2023.

[18] J. E. Knudsen, U. Ghaffar, R. Ma, and A. J. Hung, “Clinical applications of artificial intelligence in robotic surgery,” *Journal of robotic surgery*, vol. 18, no. 1, p. 102, 2024.

[19] M. Iftikhar, M. Saqib, M. Zareen, and H. Mumtaz, “Artificial intelligence: revolutionizing robotic surgery,” *Annals of Medicine and Surgery*, vol. 86, no. 9, pp. 5401–5409, 2024.

[20] P. Mascagni, D. Alapatt, L. Sestini, M. S. Altieri, A. Madani, Y. Watanabe, A. Alseidi, J. A. Redan, S. Alfieri, G. Costamagna *et al.*, “Computer vision in surgery: from potential to clinical value,” *npj Digital Medicine*, vol. 5, no. 1, p. 163, 2022.

[21] L. Yang and K. Etsuko, “Review on vision-based tracking in surgical navigation,” *IET Cyber-Systems and Robotics*, vol. 2, no. 3, pp. 107–121, 2020.

[22] E. Siddig, H. F. Eltigani, and A. Ahmed, “The rise of ai: How artificial intelligence is revolutionizing infectious disease control.” *Annals of biomedical engineering*, 2023.

[23] I. Andras, E. Mazzone, F. W. van Leeuwen, G. De Naeyer, M. N. van Oosterom, S. Beato, T. Buckle, S. O’Sullivan, P. J. van Leeuwen, A. Beulens *et al.*, “Artificial intelligence and robotics: a combination that is changing the operating room,” *World journal of urology*, vol. 38, pp. 2359–2366, 2020.

[24] T. D. Lalitharatne, L. Costi, R. Hashem, I. Nisky, R. E. Jack, T. Nanayakkara, and F. Iida, “Face mediated human–robot interaction for remote medical examination,” *Scientific reports*, vol. 12, no. 1, p. 12592, 2022.

[25] B. Fida, F. Cutolo, G. di Franco, M. Ferrari, and V. Ferrari, “Augmented reality in open surgery,” *Updates in surgery*, vol. 70, no. 3, pp. 389–400, 2018.

[26] C. Y. Ko, B. L. Hall, A. J. Hart, M. E. Cohen, D. B. Hoyt *et al.*, “The american college of surgeons national surgical quality improvement program: achieving better and safer surgery,” *The Joint Commission Journal on Quality and Patient Safety*, vol. 41, no. 5, pp. 199–AP1, 2015.

[27] A. Sarkar, P. Singh, and M. Varkey, “Healthcare artificial intelligence in india and ethical aspects,” in *AI, consciousness and the New Humanism: Fundamental reflections on minds and machines*. Springer, 2024, pp. 107–150.

[28] E. Hossain, R. Rana, N. Higgins, J. Soar, P. D. Barua, A. R. Pisani, and K. Turner, “Natural language processing in electronic health records in relation to healthcare decision-making: a systematic review,” *Computers in biology and medicine*, vol. 155, p. 106649, 2023.

[29] S. A. Alowais, S. S. Alghamdi, N. Alsuhebany, T. Alqahtani, A. I. Alshaya, S. N. Almohareb, A. Aldairem, M. Alrashed, K. Bin Saleh, H. A. Badreldin *et al.*, “Revolutionizing healthcare: the role of artificial intelligence in clinical practice,” *BMC medical education*, vol. 23, no. 1, p. 689, 2023.

[30] L. Yang, S. Lu, and L. Zhou, “The implications of artificial intelligence on infection prevention and control: Current progress and future perspectives,” *China CDC weekly*, vol. 6, no. 35, p. 901, 2024.

[31] M. Chen and M. Decary, “Artificial intelligence in healthcare: An essential guide for health leaders,” in *Healthcare management forum*, vol. 33, no. 1. Sage Publications Sage CA: Los Angeles, CA, 2020, pp. 10–18.

[32] S. Gerke, T. Minssen, and G. Cohen, “Ethical and legal challenges of artificial intelligence-driven healthcare,” in *Artificial intelligence in healthcare*. Elsevier, 2020, pp. 295–336.

[33] S. Shajari, K. Kuruvinashetti, A. Komeili, and U. Sundararaj, “The emergence of ai-based wearable sensors for digital health technology: a review,” *Sensors*, vol. 23, no. 23, p. 9498, 2023.

[34] F. Tsvetanov, “Integrating ai technologies into remote monitoring patient systems,” *Engineering Proceedings*, vol. 70, no. 1, p. 54, 2024.

[35] N. Yadav, S. Pandey, A. Gupta, P. Dudani, S. Gupta, and K. Rangarajan, “Data privacy in healthcare: In the era of artificial intelligence,” *Indian Dermatology Online Journal*, vol. 14, no. 6, pp. 788–792, 2023.

[36] D. Ueda, T. Kakinuma, S. Fujita, K. Kamagata, Y. Fushimi, R. Ito, Y. Matsui, T. Nozaki, T. Nakaura, N. Fujima *et al.*, “Fairness of artificial intelligence in healthcare: review and recommendations,” *Japanese Journal of Radiology*, vol. 42, no. 1, pp. 3–15, 2024.

[37] T. Tu, S. Azizi, D. Driess, M. Schaekermann, M. Amin, P.-C. Chang, A. Carroll, C. Lau, R. Tanno, I. Ktena *et al.*, “Towards generalist biomedical ai,” *Nejm Ai*, vol. 1, no. 3, p. AIoa2300138, 2024.

[38] A. M. K. Sherani, M. Khan, M. U. Qayyum, and H. K. Hussain, “Synergizing ai and healthcare: Pioneering advances in cancer medicine for personalized treatment,” *International Journal of Multidisciplinary Sciences and Arts*, vol. 3, no. 2, pp. 270–277, 2024.

[39] S.-e. Sugawara, “The multistability of predictive technology in nuclear disasters,” *Social Studies of Science*, vol. 53, no. 4, pp. 495–521, 2023.