Surgery in Practice and Science 22 (2025) 100290

Contents lists available at ScienceDirect

Surgery in Practice and Science

journal homepage: www.sciencedirect.com/journal/surgery-in-practice-and-science

Letter to the Editor

Artificial intelligence in surgical care for low- and middle-income countries: Challenges, opportunities, and the path forward

ARTICLE INFO

Keywords:
Artificial intelligence
Machine learning
Augmented reality
Surgery
LMICs
Africa
Healthcare innovation
Digital health

ABSTRACT

The application of Artificial Intelligence (AI) and Machine Learning (ML) in surgical care has significantly advanced healthcare delivery in high-income countries (HICs), yet remains underutilized in lower- and middle-income countries (LMICs). With a growing burden of surgical diseases, limited surgical expertise, and constrained healthcare resources, AI and ML offer transformative potential in optimizing surgical workflows, improving patient outcomes, and expanding access to specialized care. This manuscript explores the current status, challenges, and future prospects of AI and ML in surgical care for LMICs, emphasizing the critical need for investment, capacity building, and policy development to bridge the healthcare gap.

Introduction

Surgical diseases account for a significant proportion of global morbidity and mortality, with LMICs bearing the highest burden due to limited access to timely and quality surgical care [1]. An estimated 5 billion people worldwide lack access to safe and affordable surgical care, with LMICs facing 143 million additional surgical procedures needed annually to meet global demands [2]. Conditions such as traumatic injuries, obstetric complications, and cancer-related surgeries contribute to a growing disease burden, exacerbated by shortages of trained surgeons and inadequate healthcare infrastructure [3].

AI and ML have revolutionized surgical practice in HICs, enhancing decision-making, precision, and efficiency [4]. Robotic-assisted surgery, AI-guided imaging, and predictive analytics have significantly reduced surgical errors and improved patient outcomes [5]. However, their adoption in LMICs remains slow, hindered by infrastructural deficiencies, lack of expertise, and financial constraints. As healthcare systems in LMICs evolve, integrating AI-driven innovations into surgical care presents an opportunity to overcome traditional barriers and improve surgical outcomes [6].

Current landscape of AI and ML in surgical care

AI and ML applications in surgery span various domains, including preoperative assessment, intraoperative guidance, and postoperative monitoring [7]. Predictive analytics can assess patient risk factors and optimize surgical planning, while AI-driven imaging technologies such as augmented reality (AR) and computer vision enhance surgical precision [8]. Robotics-assisted surgery, though still in its infancy in LMICs, holds promise for improving surgical accuracy and accessibility [9]. Moreover, AI-powered telemedicine and remote surgical mentoring can address the shortage of specialized surgeons in rural and underserved areas [10].

Augmented reality (AR) is another rapidly emerging technology that enhances intraoperative visualization, allowing surgeons to overlay digital images onto real-time surgical fields [11]. AI-integrated AR can provide real-time guidance, reducing intraoperative complications and improving surgical efficiency [12]. Such technologies have already been widely adopted in HICs and have the potential to be scaled for use in LMICs with appropriate investment and policy support.

Challenges to AI adoption in LMICs

Despite the promise of AI in surgery, several barriers hinder its widespread adoption in LMICs [13]. Limited infrastructure remains a significant challenge, as many LMICs lack the necessary digital infrastructure, including high-speed internet, cloud computing, and AI-compatible surgical equipment [14]. Without these foundational technologies, AI implementation in surgical care remains difficult. Additionally, data gaps and the need for local context adaptation pose another major barrier. AI models require high-quality, diverse datasets for training, yet the scarcity of locally relevant surgical data limits the accuracy and applicability of these models in LMIC settings [15].

Another key obstacle is the lack of AI expertise. The shortage of AI-literate healthcare professionals slows down the adoption and implementation of AI-driven surgical interventions, further delaying technological integration [16]. Financial and policy constraints also play a crucial role, as AI implementation demands significant investment in technology and training. The absence of regulatory frameworks for AI in healthcare further hinders structured integration into surgical practice, creating uncertainty around the adoption of AI-based solutions. Moreover, ethical and equity concerns must be addressed, as AI-driven surgical care risks exacerbating health disparities if not properly regulated. Without strategic planning, AI advancements may disproportionately benefit urban centers while neglecting rural and underserved populations, ultimately widening the healthcare gap in LMICs

https://doi.org/10.1016/j.sipas.2025.100290
Received 23 March 2025; Accepted 6 June 2025
Available online 6 June 2025
2666-2620/© 2025 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

The future of AI and ML in surgical care for LMICs

The future of AI-driven surgery in LMICs is promising, provided that strategic investments and collaborative efforts are made to overcome existing barriers. Key recommendations include:

- **Capacity Building:** Training healthcare professionals in AI and ML through interdisciplinary collaborations with academic institutions and technology firms.
- **Public-Private Partnerships:** Encouraging partnerships between governments, private sector players, and international organizations to finance AI-based surgical initiatives.
- **Developing Local AI Solutions:** Creating AI models trained on LMIC-specific data to improve diagnostic accuracy and relevance.
- **Enhancing Infrastructure:** Strengthening digital health infrastructure to support AI-powered surgical tools and remote surgical care.
- **Policy and Ethical Considerations:** Establishing regulatory frameworks to ensure ethical, equitable, and sustainable AI adoption in surgical care.
- **Affordable AI Surgical Solutions:** Developing cost-effective AI-assisted surgical tools that align with LMIC healthcare budgets and capabilities.

Conclusion

AI and ML have the potential to revolutionize surgical care in LMICs by addressing critical healthcare gaps and improving patient outcomes. With 5 billion people lacking access to safe surgery and 143 million additional surgical procedures needed annually, investing in AI-driven healthcare solutions is not just an option but an imperative. However, to fully realize this potential, concerted efforts are needed to invest in AI-driven healthcare solutions, build local capacity, and develop policies that facilitate the seamless integration of AI into surgical practice. The time to act is now—embracing AI in surgical care will not only bridge the healthcare divide but also pave the way for a more equitable and efficient global healthcare system.

Ethical approval

This is a letter to editor, Ethical approval not applicable.

Source of funding

No funding for this study was received.

CRediT authorship contribution statement

William Nkenguye: Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Bickler SN, Weiser TG, Kassebaum N, Higashi H, Chang DC, Barendregt JJ, et al. Global burden of surgical conditions. editors. In: Debas HT, Donkor P, Gawande A, Jamison DT, Kruk ME, Mock CN, editors. Essential surgery: disease control priorities. Essential surgery: disease control priorities. 3rd Edition, Volume 1. WashingtonDC: The International Bank for Reconstruction and Development /The World Bank; 2015 [Internet][cited 2025 Mar 20]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK333518/.

[2] Mukhopadhyay S, Ojomo K, Nyberger K, Meara JG. Lancet commission on global surgery. Iran J Pediatr 2017;27(4) [Internet][cited 2025 Mar 20]Available from, https://brieflands.com/articles/ijp-11273#abstract.

[3] Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. Lancet 2015 Aug 8;386(9993):569–624 [Internet][cited 2025 Mar 20]Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60160-X/fulltext?dgcid=recommender_referral_trendmd.

[4] Wah JNK. Revolutionizing surgery: ai and robotics for precision, risk reduction, and innovation. J Robot Surg 2025 Jan 7;19(1):47.

[5] Knudsen JE, Ghaffar U, Ma R, Hung AJ. Clinical applications of artificial intelligence in robotic surgery. J Robot Surg 2024;18(1):102 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10907451/.

[6] Alowais SA, Alghamdi SS, Alsuhebany N, Alqahtani T, Alshaya AI, Almohareb SN, et al. Revolutionizing healthcare: the role of artificial intelligence in clinical practice. BMC Med Educ 2023 Sep 22;23(1):689. https://doi.org/10.1186/s12909-023-04698-z [Internet][cited 2025 Mar 20]Available from:.

[7] Solanki SL, Pandrowala S, Nayak A, Bhandare M, Ambulkar RP, Shrikhande SV. Artificial intelligence in perioperative management of major gastrointestinal surgeries. World J Gastroenterol 2021 Jun 7;27(21):2758–70 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8173379/.

[8] Dixon D., Sattar H., Moros N., Kesireddy S.R., Ahsan H., Lakkimsetti M., et al. Unveiling the influence of AI predictive analytics on patient outcomes: a comprehensive narrative review. Cureus [Internet]. [cited 2025 Mar 20];16(5):e59954. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11161909/.

[9] Mehta A, Cheng Ng J, Andrew Awuah W, Huang H, Kalmanovich J, Agrawal A, et al. Embracing robotic surgery in low- and middle-income countries: potential benefits, challenges, and scope in the future. Ann Med Surg 2022 Nov 1;84:104803 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9793116/.

[10] Anawade P.A., Sharma D., Gahane S. A comprehensive review on exploring the impact of telemedicine on healthcare accessibility. Cureus [Internet]. [cited 2025 Mar 20];16(3):e55996. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11009553/.

[11] Chang YZ, Wu CT. Application of extended reality in pediatric neurosurgery: a comprehensive review. Biomed J 2024 Dec 8;100822 [Internet][cited 2025 Mar 20]Available from: https://www.sciencedirect.com/science/article/pii/S2319417024001252.

[12] Takeuchi M, Kitagawa Y. Artificial intelligence and surgery. Ann Gastroenterol Surg 2023 Dec 18;8(1):4–5 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10797843/.

[13] Zuhair V, Babar A, Ali R, Oduoye MO, Noor Z, Chris K, et al. Exploring the impact of artificial intelligence on global health and enhancing healthcare in developing nations. J Prim Care Community Health 2024 Apr 12;15:21501319241245847 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11010755/.

[14] (PDF) Infrastructure and data readiness for AI implementation in healthcare systems of low-and middle-income countries [Internet]. [cited 2025 Mar 20]. Available from: https://www.researchgate.net/publication/389327074_Infrastructure_and_Data_Readiness_for_AI_Implementation_in_Healthcare_Systems_of_Low-and_Middle-Income_Countries.

[15] Yang J, Dung NT, Thach PN, Phong NT, Phu VD, Phu KD, et al. Generalizability assessment of AI models across hospitals in a low-middle and high income country. Nat Commun 2024 Sep 27;15:8270 [Internet][cited 2025 Mar 20]Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11436917/.

[16] Esmaeilzadeh P. Challenges and strategies for wide-scale artificial intelligence (AI) deployment in healthcare practices: a perspective for healthcare organizations. Artif Intell Med 2024 May 1;151:102861 [Internet][cited 2025 Mar 20]Available from: https://www.sciencedirect.com/science/article/pii/S0933365724001039.

William Nkenguye[a,b]

[a] *School of Public Health, Department of Epidemiology and Applied Biostatistics, KCMC University, P O Box 2240, Moshi, Tanzania*

[b] *Kilimanjaro Clinical Research Institute, Kilimanjaro Christian Medical Centre, P O Box 3010, Moshi, Tanzania*

E-mail address: williamnkenguye@gmail.com.