MEDICAL ROBOTS

Equalizing access: How robotics and AI can transform surgical care worldwide

Marta Weber[1]*, Kee B. Park[2]†, Salim Afshar[2,3]†

The integration of robotics and artificial intelligence holds promise for improving access to surgical care worldwide.

Nine of 10 people in low- and middle-income countries (LMICs) lack safe and affordable surgical and anesthesia services when needed (*1*). Of the 313 million surgical procedures performed annually, only 6% occur in these areas, and this lack of access contributes to an estimated 17 million deaths annually (*1*). The need for affordable, timely medical care in LMICs is more critical than ever given that morbidity and mortality continue to rise.

Meanwhile, in high-income regions, the use of robotic surgery increased from 20 to 49% between 2012 and 2024 (*2*), shifting from traditional open procedures to less invasive laparoscopic methods, resulting in reduced pain, bleeding, shorter hospital stays, and faster recovery times while improving surgical precision.

Similarly, artificial intelligence (AI) continues to revolutionize the medical field by optimizing patient care through predictive analytics, improving diagnostic accuracy, personalizing treatment, and identifying high-risk patients. In addition, the ongoing advancements in large language models and multimodal large-scale AI can streamline health care delivery by optimizing resource allocations, automating appointments, processing billing, and managing medical records (*3*). At the Mayo Clinic, AI tools have been integrated into neurology and cardiovascular specialties to analyze computerized tomography (CT) data after strokes and interpret electrocardiograms (ECGs) to predict heart failure or detect atrial fibrillation (*4*).

Despite advancements, access to surgical care in LMICs continues to worsen, and these technologies remain limited. Implementing robotics and AI in underserved regions could help bridge the health care gap by reducing workforce shortages, automating administrative tasks, and enhancing surgical education through simulation-based training. In addition, AI-augmented tools such as digital image processing on mobile devices can offer cost-effective, rapid, and accurate diagnoses while also predicting complications and tailoring care plans through preventive measures (*5*, *6*). Moreover, AI-powered telemedicine platforms facilitate remote consultations, allowing distant specialists to assist local surgeons in real time (*5*). Meanwhile, robotic telesurgery allows experienced surgeons to operate remotely, giving LMICs access to expert care without requiring full on-site infrastructure. Minimally invasive robotic surgery can also reduce infection risk, discomfort, hospitalization time, and costs (*7*).

Some initiatives have shown promising results, although they remain limited in scale, and widespread adoption in LMICs has yet to materialize. Proximie, a telepresence surgical platform, has facilitated remote guidance during surgical procedures in Tanzania, a potential game changer for educational and training purposes. However, broader implementation is still lacking. Similarly, transcontinental robotic telestenting for cardiac procedures has been successfully demonstrated (*8*), and the use of robots for telesurgery, even over 5G networks, is currently being validated (*9*). In addition, projects such as the SAVE (Surgery: Assess/Validate/Expand) Initiative, which focuses on AI-driven surgical innovations for global health, highlight the importance of addressing the gap in essential surgery services through scalable, technology-driven solutions (*10*).

We believe it is only a matter of time before telesurgery becomes an acceptable mode of providing surgical care. The critical question remains: Who will benefit?

CHALLENGES

The fundamental challenges to implementing robotics and AI in LMICs are well known: high costs, insufficient infrastructure, limited technical expertise, and ethical concerns. The initial investment for a new surgical system can exceed $1 million, with additional costs per procedure and ongoing maintenance expenses (*7*). Moreover, training gaps and infrastructure constraints, including unreliable electricity, network issues, and inadequate operating rooms, further limit the adoption of these technologies. Telesurgery, in particular, relies on stable high-speed internet, which is often inconsistent in underserved areas. In addition, the lack of professionals trained in maintaining complex robotic systems further hinders implementation. Addressing AI bias and ethical concerns is equally critical, given that algorithms may underrepresent minority populations and overlook ethnic variations in disease predisposition, potentially resulting in disparities in decision-making and outcomes. Furthermore, language barriers and mistrust in foreign-led technologies may impede acceptance, underscoring the need for clear guidelines on responsibility, liability, and informed consent, along with robust measures to ensure data privacy and security. Overcoming these barriers is essential for the successful integration of AI and robotics in LMICs.

FROM BARRIERS TO SOLUTIONS

Bridging the gap between AI/robotics and global surgery communities through a collaborative and multifaceted approach is key. Expert leaders from both fields can accelerate knowledge exchange by collaborating at events ranging from major conferences to webinars, as exemplified by the 2024 Hamlyn Symposium on Medical Robotics, which aims to strengthen interdisciplinary collaboration. Establishing research partnerships between AI and surgical experts is vital for driving meaningful innovation, and academic journals can

[1]University of Geneva, Geneva, Switzerland. [2]Harvard Medical School, Boston, MA, USA. [3]Harvard School of Dental Medicine, Boston, MA, USA.
*Corresponding author. Email: marta.weber.mdt@gmail.com
†These authors contributed equally to this work.

actively support these efforts by dedicating sections to the intersection of AI, robotics, and global surgery. Moreover, creating joint educational programs between universities from high-income countries and medical schools in LMICs can substantially enhance global knowledge sharing through structured exchange opportunities. International collaborative clinical trials between hospitals in high-income countries and LMICs can effectively evaluate the performance of AI-driven technologies in diverse populations, ensuring their global applicability. Funders play a pivotal role by providing grants for projects aimed at promoting surgical equity in LMICs. Accelerating the implementation of telesurgery in LMICs requires forming international partnerships focused on capacity building, creating scalable training programs, and integrating low-cost robotic alternatives. Strengthening telemedicine and telerobotics through investments in network infrastructure, especially by enhancing 5G access and piloting telerobotic programs in LMIC hospitals, is essential. In addition, implementing fail-safe protocols and ensuring the presence of on-site medical personnel can help manage unexpected complications and system failures. Last, increasing industry investment in research and development (R&D) for innovative AI and robotic solutions tailored to LMICs' unique challenges, such as affordable robotic alternatives and subsidized equipment, can help bridge the gap between advanced technology and underserved populations.

The integration of robotics and AI into global surgery offers promising opportunities to improve health care, particularly in LMICs, by making surgical care more accessible, efficient, and safe. However, to realize this promise, the two communities need to be intentional in collaborating. The future of global surgery relies on our ability to harness these technologies for the benefit of all. As we move forward, one key guiding question should be how technology can be used to better deliver surgical care to those in need.

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