LETTER TO EDITOR

TRANSFORMING MEDICINE: HOW ROBOTICS, AI, AND IMMERSIVE TECHNOLOGIES ARE REVOLUTIONIZING HEALTHCARE

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Cite this article as: Eman A. Transforming medicine: how robotics, AI, and immersive technologies are revolutionizing healthcare. Baqai J Health Sci. 2025;26(2): 1 - 2

Date of Submission: Jan 27, 2025
Date of Acceptance: Aug 22, 2025
Date of Online Publication: Dec 30, 2025
DOI: https://doi.org/10.63735/baqa.v26i2.01-02
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Robots have evolved from autonomous mechanisms in the 1960s to sophisticated systems supporting patients, nurses, and surgeons in controlled environments. Pakistani research has shown the growing importance of artificial intelligence and machine learning in healthcare delivery through neural network algorithms and cognitive simulation capabilities. Healthcare robotics integration follows a systematic three-phase approach: assessment and planning, implementation and training, and evaluation and optimization.

AI-powered diagnostic tools have shown success in early detection of conditions like cancer, cardiovascular diseases, and neurological disorders, while robotic surgical systems have enhanced precision and reduced recovery times for patients undergoing complex procedures. Pakistan's healthcare landscape presents unique opportunities and challenges for implementing robotic technologies and telemedicine solutions. Case studies from the Civil Hospital in Karachi and the Sindh Institute of Urology and Transplantation demonstrate successful implementation of robotic surgery programs, with the Sindh government funding 150 robotic cases annually. Telemedicine initiatives in Pakistan have shown promising results in addressing healthcare access challenges in remote areas [1,2].

AI-driven algorithms enable large-scale dataset analysis, enabling more precise diagnosis and individualized treatment plans. Remote patient monitoring reduces readmission rates and enhances long-term treatment standards. Robotic-assisted operations improve surgical precision, expedite recuperation, and reduce complications. AI-powered virtual assistants and chatbots simplify administrative tasks [2]. Over the past ten years, robotic laparoscopy has advanced significantly in the clinical, commercial, and academic domains. Intuitive Surgical's da Vinci robot enables semi-automated arm and patient cart placement, enhanced instrument coupling, and the capacity to mount endoscopic and laparoscopic instruments on any arm. 2019 saw the completion of almost 1.2 million surgeries, with improvements in single-port laparoscopic robots resulting in more precise and effective surgical operations. Prototypes of detached surgical robots that remove the trocar-pivot limitation have also been investigated. With over 5 million patients treated, the most advanced medical robots are those that facilitate laparoscopic surgery, indicating strong momentum into the next ten years. Endoluminal and natural orifice interventions, as well as robots for microsurgery, are examples of non-laparoscopic procedure-specific robots. Assistive wearable robotics focuses on the design and control of wearable robotic devices intended to improve the mobility or functionality of individuals with musculoskeletal or neuromuscular impairment. Rehabilitation robots are designed to deliver repetitive movement therapy to the limbs following neurological injuries. More seriously disabled people can now benefit from robotic therapy because to advancements in control

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techniques for rehabilitation robots that have made it easier for the patient and robot to cooperate, encouraging neuroplasticity [3].

In catastrophe situations and outside of populated regions, tele-operated robots provide remote medical care, including tele-surgery. Operation Lindbergh, the first successful tele-surgery, was performed in 2000 with the Zeus surgery robot and France Telecom's multiservice transmission network. Immersion interfaces are used in telepresence, a branch of tele-robotics, to shorten emergency response times and hospital stays. Autonomous robots in healthcare are being made possible by the fascinating field of tele-robotics [4]. Personalized treatments, unstructured settings, and the integration of cutting-edge technology like artificial intelligence (AI), robotics, quantum computing, the Internet of Things (IoT), and multi-robot systems are all made possible by the growing usage of robotic systems in healthcare. While sophisticated surgical robotic systems like VisAR use VR and AR for simulated reality, the meta verse, which combines these technologies, has the potential to revolutionize services [5].

Healthcare robotics represents a transformative force in modern medicine, bridging geographical barriers and democratizing access to advanced care. From Pakistan's pioneering telemedicine initiatives to da Vinci surgical systems worldwide, these technologies offer genuine hope for reducing health disparities. Success stories from Karachi's Civil Hospital demonstrate how thoughtful implementation can benefit underserved populations. As we embrace this digital revolution, ensuring equitable access and affordability remains paramount for creating a healthier, more connected global community where quality healthcare transcends borders.

Conflict of Interest: The authors declared no conflict of interest.

Acknowledgment: None

Funding Source: None

Author's Contribution:

AE: Concept & design, writing, final approval of manuscript and responsible for accuracy and integrity of research

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