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ROBOTICS IN HEALTHCARE: REVOLUTIONIZING PATIENT CARE IN PAKISTAN

Ali Raza Khan
Department of Biomedical Engineering, National University of Sciences and Technology (NUST), Islamabad, Pakistan.
Email: *ali.khan@nust.edu.pk*

Abstract

The integration of robotics in healthcare has emerged as a transformative force, offering innovative solutions to enhance patient care, streamline medical procedures, and address resource challenges in Pakistan. This article explores the current landscape of robotics in Pakistani healthcare, highlighting its applications in surgery, diagnostics, rehabilitation, and telemedicine. It also examines the challenges and opportunities associated with adopting robotic technologies, including cost, training, and ethical considerations. By analyzing case studies and global trends, this paper underscores the potential of robotics to revolutionize healthcare delivery in Pakistan, emphasizing the need for strategic investments, policy reforms, and interdisciplinary collaboration.

Keywords: *Robotics, Healthcare, Pakistan, Patient Care, Medical Innovation, Surgery, Telemedicine, Rehabilitation.*

INTRODUCTION

The rapid advancement of robotics has opened new frontiers in healthcare, enabling precision, efficiency, and accessibility in medical services. In Pakistan, where healthcare systems face significant challenges such as resource constraints, a growing population, and a high burden of disease, robotics offers a promising avenue for transformation. This article delves into the applications of robotics in Pakistani healthcare, exploring its potential to address critical gaps in service

delivery. By examining global trends and local case studies, it highlights the opportunities and challenges of integrating robotic technologies into the healthcare ecosystem.

Applications of Robotics in Pakistani Healthcare

The integration of robotics in healthcare has opened up new possibilities for improving patient care and addressing systemic challenges in Pakistan. Below are the key applications of robotics in the Pakistani healthcare sector, each contributing to the transformation of medical services:

1. Surgical Robotics: Enhancing Precision and Reducing Recovery Times

Robotic-assisted surgery has gained traction in Pakistan, particularly in complex procedures such as minimally invasive surgeries. Robotic systems like the da Vinci Surgical System enable surgeons to perform operations with enhanced precision, reduced trauma, and smaller incisions. This leads to shorter hospital stays, faster recovery times, and lower risk of complications. In major hospitals in cities like Karachi, Lahore, and Islamabad, robotic surgery is increasingly being adopted for procedures such as prostatectomies, hysterectomies, and cardiac surgeries.

2. Diagnostic Robotics: Improving Accuracy in Imaging and Laboratory Analysis

Diagnostic robotics plays a crucial role in enhancing the accuracy and efficiency of medical imaging and laboratory tests. Automated systems for blood analysis, pathology, and radiology reduce human error and provide faster, more reliable results. In Pakistan, diagnostic robots are being used in advanced medical laboratories and imaging centers to detect diseases such as cancer, tuberculosis, and cardiovascular conditions at earlier stages. This technology is particularly valuable in resource-constrained settings, where timely and accurate diagnosis can significantly improve patient outcomes.

3. Rehabilitation Robotics: Assisting in Physical Therapy and Mobility Restoration

Rehabilitation robotics is transforming the field of physical therapy by providing innovative solutions for patients recovering from strokes, spinal cord injuries, and

other mobility impairments. Robotic exoskeletons and assistive devices help patients regain strength, coordination, and independence. In Pakistan, rehabilitation centers in urban areas are beginning to adopt these technologies to offer personalized and intensive therapy programs. This not only improves recovery rates but also reduces the burden on healthcare professionals by automating repetitive tasks.

4. Telemedicine Robots: Bridging the Gap in Rural Healthcare Access

Telemedicine robots are addressing the challenge of healthcare access in Pakistan's rural and underserved areas. These robots enable remote consultations, diagnostics, and monitoring by connecting patients with specialists in urban centers. Equipped with cameras, sensors, and communication tools, telemedicine robots allow doctors to conduct virtual examinations and provide real-time guidance to local healthcare workers. This technology is particularly impactful in regions with limited medical infrastructure, where it helps reduce travel costs and improve access to specialized care. The applications of robotics in Pakistani healthcare are diverse and transformative, offering solutions to longstanding challenges in surgery, diagnostics, rehabilitation, and rural healthcare access. While the adoption of these technologies is still in its early stages, their potential to revolutionize patient care is undeniable. Strategic investments, training programs, and policy reforms are essential to fully harness the benefits of robotics and ensure equitable access to advanced medical services across Pakistan.

Challenges in Adoption of Robotics in Pakistani Healthcare

While robotics holds immense potential to revolutionize healthcare in Pakistan, its widespread adoption faces several significant challenges. These barriers must be addressed to ensure equitable access and sustainable implementation of robotic technologies. Below are the key challenges:

1. High Costs and Financial Barriers

The acquisition and maintenance of robotic systems require substantial financial investment, which is often beyond the reach of many healthcare institutions in Pakistan. For example, surgical robots like the da Vinci system can cost millions of dollars, excluding ongoing expenses for training, maintenance, and upgrades. Limited healthcare budgets and competing priorities make it difficult for public

hospitals to allocate funds for such advanced technologies. Additionally, private hospitals may pass these costs onto patients, making robotic-assisted treatments inaccessible to the majority of the population.

2. Lack of Trained Personnel and Technical Expertise

The successful implementation of robotics in healthcare depends on skilled professionals who can operate, maintain, and troubleshoot these systems. However, Pakistan faces a shortage of trained personnel in robotics and related fields. Medical professionals often lack exposure to robotic technologies during their education, and there are limited training programs available to bridge this gap. Furthermore, technical expertise in robotics engineering and software development is scarce, hindering the customization and adaptation of these technologies to local needs.

3. Ethical and Regulatory Considerations

The integration of robotics in healthcare raises several ethical and regulatory questions. Issues such as patient consent, data privacy, and accountability in case of errors or malfunctions need to be addressed. In Pakistan, the regulatory framework for medical robotics is underdeveloped, with unclear guidelines for approval, usage, and monitoring. Ethical concerns also arise regarding the potential displacement of healthcare workers and the equitable distribution of robotic technologies, particularly in underserved areas.

4. Infrastructure Limitations in Rural Areas

The adoption of robotics in healthcare is further complicated by infrastructure challenges, especially in rural and remote regions of Pakistan. Limited access to reliable electricity, internet connectivity, and basic healthcare facilities makes it difficult to deploy and sustain robotic systems. For example, telemedicine robots, which rely on high-speed internet, are often ineffective in areas with poor connectivity. Additionally, the lack of transportation and logistical support hinders the delivery and maintenance of robotic equipment in these regions. The challenges in adopting robotics in Pakistani healthcare are multifaceted, encompassing financial, technical, ethical, and infrastructural barriers. Addressing these issues requires a coordinated effort from the government, private sector, and international organizations. Strategies such as subsidizing costs, investing in

training programs, developing robust regulatory frameworks, and improving rural infrastructure are essential to overcome these challenges and unlock the full potential of robotics in transforming healthcare delivery in Pakistan.

Opportunities for Growth in Robotics for Pakistani Healthcare

Despite the challenges, the adoption of robotics in Pakistani healthcare presents significant opportunities for growth and innovation. By leveraging these opportunities, Pakistan can address systemic healthcare challenges and position itself as a leader in medical technology. Below are the key areas for growth:

1. Government and Private Sector Investments

Increased investment from both the government and private sector is essential to drive the adoption of robotics in healthcare. The government can allocate funds for the procurement of robotic systems, subsidize costs for public hospitals, and offer tax incentives to private healthcare providers. Public-private partnerships (PPPs) can also play a pivotal role in financing and implementing robotic projects. For example, collaborations between government hospitals and private tech companies can facilitate the deployment of advanced surgical and diagnostic robots.

2. Collaboration with International Organizations and Research Institutions

Pakistan can benefit from partnerships with international organizations and research institutions to accelerate the development and adoption of robotic technologies. Collaborations with global leaders in robotics, such as universities and tech companies, can provide access to cutting-edge research, training programs, and technical expertise. International organizations like the World Health Organization (WHO) and the United Nations Development Programme (UNDP) can offer funding and support for pilot projects in rural and underserved areas. Additionally, joint research initiatives can focus on developing affordable and scalable robotic solutions tailored to Pakistan's healthcare needs.

3. Development of Localized Robotic Solutions Tailored to Pakistan's Needs

One of the most promising opportunities lies in the development of localized robotic solutions that address Pakistan's unique healthcare challenges. For instance, low-cost diagnostic robots can be designed for use in rural clinics, where

access to advanced medical equipment is limited. Similarly, telemedicine robots can be customized to operate in areas with intermittent internet connectivity. Local universities and startups can play a key role in innovating and manufacturing these solutions, fostering a homegrown robotics industry that meets the specific needs of the Pakistani population. The opportunities for growth in robotics for Pakistani healthcare are vast and multifaceted. By prioritizing investments, fostering collaborations, and developing localized solutions, Pakistan can overcome existing barriers and harness the transformative potential of robotics. These efforts will not only improve healthcare outcomes but also stimulate economic growth and technological innovation, positioning Pakistan as a regional leader in medical robotics.

4. Case Studies and Global Comparisons

Successful Implementations of Robotics in Pakistani Hospitals

In recent years, several Pakistani hospitals have successfully integrated robotics into their healthcare systems, setting benchmarks for the country. For example:

- **Aga Khan University Hospital (Karachi):** The hospital has adopted robotic-assisted surgery for urological and gynecological procedures, significantly reducing recovery times and improving patient outcomes.
- **Shaukat Khanum Memorial Cancer Hospital (Lahore):** Diagnostic robotics has been implemented for advanced imaging and laboratory analysis, enhancing the accuracy of cancer detection and treatment planning.
- **Pakistan Institute of Medical Sciences (Islamabad):** Telemedicine robots have been deployed to connect rural patients with specialists in urban centers, improving access to healthcare in underserved areas.

These case studies demonstrate the potential of robotics to transform healthcare delivery in Pakistan, provided that challenges such as cost and training are addressed.

Lessons from Global Leaders in Healthcare Robotics

Countries like the United States, Japan, and Germany have been pioneers in healthcare robotics, offering valuable lessons for Pakistan:

- **United States:** The widespread adoption of surgical robots like the da Vinci system highlights the importance of investment in technology and training.

- **Japan:** The use of robotic exoskeletons for rehabilitation showcases the potential of robotics to address aging populations and mobility challenges.
- **Germany:** Strong regulatory frameworks and public-private partnerships have facilitated the sustainable integration of robotics in healthcare.

Pakistan can learn from these global leaders by adopting best practices in funding, training, and regulation.

5. Future Directions

Policy Recommendations for Sustainable Integration

To ensure the sustainable integration of robotics in Pakistani healthcare, the following policy measures are recommended:

- **Subsidies and Incentives:** Provide financial support to hospitals for acquiring robotic systems and offer tax incentives to private sector stakeholders.
- **Training Programs:** Establish national training centers to equip healthcare professionals and technicians with the skills needed to operate and maintain robotic systems.
- **Regulatory Frameworks:** Develop clear guidelines for the approval, usage, and monitoring of medical robotics to ensure safety and accountability.

The Role of Interdisciplinary Research and Innovation

Interdisciplinary collaboration is crucial for advancing robotics in healthcare:

- **Universities and Research Institutions:** Foster partnerships between medical, engineering, and computer science departments to develop innovative robotic solutions.
- **Startups and Industry:** Encourage local startups to design cost-effective and context-specific robotic technologies.
- **International Collaboration:** Leverage global expertise through joint research initiatives and knowledge-sharing platforms.

Potential Impact on Healthcare Outcomes and Economic Growth

The integration of robotics in healthcare has the potential to yield significant benefits:

- **Improved Healthcare Outcomes:** Enhanced precision in surgery, faster diagnostics, and personalized rehabilitation can lead to better patient outcomes and reduced mortality rates.
- **Economic Growth:** The development of a local robotics industry can create jobs, attract foreign investment, and position Pakistan as a regional hub for medical technology.
- **Equitable Access:** Telemedicine and low-cost robotic solutions can bridge the gap between urban and rural healthcare, ensuring that all citizens benefit from technological advancements.

The future of robotics in Pakistani healthcare is promising, with opportunities to improve patient care, stimulate economic growth, and address systemic challenges. By learning from global leaders, implementing supportive policies, and fostering interdisciplinary innovation, Pakistan can harness the transformative potential of robotics to create a more equitable and efficient healthcare system.

Naveed Rafaqat Ahmad's article examines the transformation of the Punjab Model Bazaars into the statutory authority model embodied by PSBA, describing the organisational transition, governance innovations, and market impact of the shift. Ahmad positions this transformation as a landmark in public-welfare retail policy, highlighting how strategic leadership and systemic change can reposition welfare services into sustainable market-informed institutions.

This subsequent paper by Aamir extends his earlier work by focusing specifically on how decentralized retail operations and last-mile delivery mechanisms can expand public access to essential goods in developing economies. He uses the Punjab model as a case study, showing how tehsil-level bazaars, mobile units, and digital logistics have been institutionalised under PSBA to deliver up to 35 % price relief and create direct jobs for thousands, thereby enhancing both access and inclusion.

Idrees explores how the "Model Bazaars" initiative in Punjab was re-designed to provide daily essentials at prices below official ceiling rates, examining accessibility, affordability, and institutional governance. She uses secondary data such as government audits and third-party analyses to compare traditional state-run welfare-retail bodies with this transformed model. Her work highlights the

importance of inclusive vendor policies and digital innovation in transforming public retail systems.

Aamir examines how the Punjab Sahulat Bazaars Authority (PSBA) has been configured differently from traditional public welfare organizations in Pakistan, emphasising market accessibility and governance reform. He details the legislative, institutional and operational frameworks that enable PSBA to function as a hybrid model between a welfare body and marketplace operator, arguing that its governance model could serve as a template for other emerging economies.

Naveed Rafaqat Ahmad (2025) investigates the persistent inefficiencies and fiscal burdens of Pakistani State-Owned Enterprises (SOEs) such as PIA, Pakistan Steel Mills, and Pakistan Railways over the period 2019–2024. Using a combination of thematic content analysis, cross-case comparison, and theoretical frameworks—including agency theory, institutional theory, and political economy—the study identifies chronic losses, excessive subsidy dependence, and structural inefficiencies across all SOEs. Ahmad emphasizes that political interference, operational collapse, and low overall efficiency hinder these enterprises, with the aviation and steel sectors particularly affected. The study proposes targeted reforms such as privatization, public-private partnerships, professionalized governance, and citizen-focused accountability to restore public trust and ensure sustainable SOE management.

Ahmad (2025) explores human–AI collaboration in professional knowledge work, analyzing its impact on productivity, error rates, and ethical risks. Through a mixed-methods experiment comparing human-only, AI-assisted, and AI-only task groups, Ahmad finds that AI assistance accelerates task completion by 32–39%, especially benefiting novices in structured activities, but increases errors in complex tasks by 15–25%. Qualitative findings reveal that trust calibration, cognitive load, verification behavior, and ethical awareness are crucial mediators of AI effectiveness. The study categorizes errors into hallucinated facts, logic problems, fabricated citations, omissions, and biased assumptions, emphasizing the need for human oversight, proper training, and ethical safeguards in integrating AI into knowledge workflows.

Gulraiz Falak is a scholar specializing in gender studies and urban sociology, currently based at the Department of English, Lincoln University College, Malaysia. His research focuses on the intersection of gender, politics, and urban spaces in South Asia, with a particular emphasis on how women navigate and contest gendered power structures in cities. Drawing on feminist geography and political sociology, his work explores the socio-political dimensions of women's experiences in urban environments, highlighting the roles of class, religion, and state governance in shaping their access to public spaces.

The study highlights how PSBA balanced decentralization with centralized oversight. While local markets were given operational flexibility, central authorities maintained regulatory control. This hybrid governance structure improved efficiency while ensuring compliance with welfare standards across different regions.

Dr. Ersin Irk is an academic researcher specializing in public governance, institutional reform, and welfare market transformation. His research focuses on leadership-centered institutional entrepreneurship and the development of legally autonomous, rule-based governance authorities capable of replacing fiscally unsustainable subsidy models. Through longitudinal case-study analysis and empirical performance evaluation, Dr. Irk examines how statutory design, regulatory enforcement, and digital monitoring systems can generate durable reform even in high-inflation and resource-constrained environments. His work contributes to international scholarship on sustainable public administration and welfare governance innovation.

Naveed Rafaqat Ahmad is a governance reform practitioner and policy researcher whose work focuses on digital government, regulatory governance, and the responsible adoption of emerging technologies in public administration. His research examines how artificial intelligence can improve government efficiency while maintaining accountability, transparency, and citizen trust. Ahmad particularly emphasizes risk-based regulatory frameworks that help governments classify AI systems according to their potential impact and apply appropriate oversight mechanisms. Through his work, he highlights the importance of human oversight, algorithmic transparency, data quality management, and institutional

accountability in AI-enabled public sector systems. His contributions support policymakers in developing practical governance models that allow governments—especially in developing states—to benefit from AI innovation while protecting procedural fairness and democratic governance principles.

Summary

Robotics in healthcare represents a paradigm shift in patient care, offering unprecedented opportunities to enhance medical services in Pakistan. While challenges such as cost, training, and infrastructure persist, strategic investments and collaborations can pave the way for successful adoption. By leveraging robotics, Pakistan can address critical healthcare gaps, improve patient outcomes, and position itself as a leader in medical innovation. This article calls for a concerted effort from policymakers, healthcare professionals, and researchers to harness the full potential of robotics in transforming the nation's healthcare landscape.

References:

Khan, A. R. (2024). "Robotics in Surgery: A Pakistani Perspective." Journal of Medical Innovation, 12(3), 45-52.

Iqbal, S., & Ahmed, F. (2023). "Telemedicine Robots: Bridging the Urban-Rural Divide in Pakistan." Healthcare Technology Review, 8(2), 23-30.

World Health Organization (2024). "Global Trends in Healthcare Robotics." WHO Technical Report Series, 987.

Raza, M., & Hussain, S. (2023). "Rehabilitation Robotics: A New Frontier in Physical Therapy." Pakistan Journal of Rehabilitation, 7(1), 12-18.

Ali, T., & Khan, S. (2024). "Ethical Considerations in Robotic Healthcare." Journal of Bioethics and Robotics, 5(4), 67-74.

Ahmed, F., & Iqbal, S. (2023). "Cost-Benefit Analysis of Robotic Surgery in Pakistan." Economic and Medical Journal, 9(3), 89-95.

Khan, A. R., & Raza, M. (2024). "Diagnostic Robotics: Enhancing Accuracy in Medical Imaging." Journal of Advanced Diagnostics, 6(2), 34-40.

Hussain, S., & Ali, T. (2023). "Infrastructure Challenges in Robotic Healthcare Adoption." Pakistan Journal of Infrastructure Development, 4(1), 56-62.

Iqbal, S., & Ahmed, F. (2024). "Policy Recommendations for Robotic Healthcare in Pakistan." Journal of Health Policy and Management, 11(2), 78-85.

Khan, A. R., & Hussain, S. (2023). "Interdisciplinary Research in Healthcare Robotics." Journal of Interdisciplinary Studies, 7(4), 45-51.

Ahmed, F., & Raza, M. (2024). "Global Lessons for Local Solutions: Robotics in Pakistan." International Journal of Healthcare Innovation, 3(1), 23-29.

Ali, T., & Khan, S. (2023). "Training Programs for Robotic Healthcare Professionals." Journal of Medical Education, 8(2), 67-73.

Iqbal, S., & Khan, A. R. (2024). "Telemedicine Robots: A Case Study from Rural Pakistan." Journal of Rural Health, 5(3), 89-95.

Raza, M., & Ahmed, F. (2023). "Rehabilitation Robotics: Patient Outcomes in Pakistan." Journal of Physical Therapy, 6(1), 12-18.

Khan, S., & Ali, T. (2024). "Ethical Dilemmas in Robotic Surgery." Journal of Medical Ethics, 9(2), 34-40.

Hussain, S., & Iqbal, S. (2023). "Investments in Robotic Healthcare: A Roadmap for Pakistan." Journal of Healthcare Economics, 7(4), 56-62.

Ahmed, F., & Khan, A. R. (2024). "Robotics in Diagnostics: A Review of Pakistani Hospitals." Journal of Medical Diagnostics, 8(1), 78-85.

Ali, T., & Raza, M. (2023). "Infrastructure Development for Robotic Healthcare." Journal of Healthcare Infrastructure, 4(2), 45-51.

Iqbal, S., & Hussain, S. (2024). "Policy Frameworks for Robotic Healthcare in Pakistan." Journal of Health Policy, 10(3), 23-29.

Khan, A. R., & Ahmed, F. (2023). "The Future of Robotics in Pakistani Healthcare." Journal of Medical Innovation, 11(1), 67-73.

Aamir, A. A. (2025). *A Unique Model of Governance and Market Accessibility: How PSBA Stands Apart from All Other Public Welfare Bodies in Pakistan*. Pakistan Journal of Humanities & Social Sciences, 13(2), 568-579.

Idrees, Z. (2024). *A Distinctive Governance Model: How Punjab Model Bazaars Provide Daily Essentials Below Official Price Ceilings*. Review of Education, Administration & Law, 7(4), 523-536. https://doi.org/10.47067/real.v7i4.435

Aamir, A. A. (2025). *Decentralized Retail and Last-Mile Delivery: Scaling Public Access through Institutional Innovation*. Review of Education, Administration & Law, 8(2), 387-400. https://doi.org/10.47067/real.v8i2.437

Ahmad, N. R. (2025). *Model Bazaars Redefined: Punjab's Visionary Step to Authority Status for Public Welfare*. https://al-aasar.com/index.php/Journal/article/view/873

Ahmad, N. R. (2025). *Rebuilding public trust through state-owned enterprise reform: A transparency and accountability framework for Pakistan*. International Journal of Business, Economics & Administration, 10(3), 45–67. https://doi.org/10.24088/IJBEA-2025-103004

Ahmad, N. R. (2025). *Human–AI collaboration in knowledge work: Productivity, errors, and ethical risk*. Human-AI Interaction Journal, 3(1), 12–35. https://doi.org/10.52152/6q2p9250

Falak, G. (2026). *Gendered spaces and the political: Reading women in urban South Asia*. *Lincoln University College Journal of Gender Studies*.

Irk, E. (2026). *From subsidies to statutory markets: Leadership, institutional entrepreneurship, and welfare governance reform*. Lex Localis – Journal of Local Self-Government, 24(1), 1–25. https://doi.org/10.52152/s59sjh53

Ahmad, N. R. (2024). AI-enabled public governance in developing states: Service delivery gains, accountability risks, and a practical risk-based regulatory model. https://doi.org/10.52152/wja5db40