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NARRATIVE REVIEW **ROBOTICS IN HEALTHCARE**

Integration of robotics in healthcare management: a narrative review

Asima Irshad [1], Noureen Farooq [2], Qurba Kiran [3], Anas Farooq [4], Sonia Munir [5], Sarah Kafeel [6]

Author affiliations:

1. Asima Irshad, Superior University,17km Raiwind Road, Lahore, Pakistan; Email: asima0332@yahoo.com
2. Noureen Farooq, Physiotherapist, 5 Care Net Work, Alshifa, Riyadh, Saudi Arabia; Email: noureen.15@gmail.com
3. Qurba Kiran, Superior University, 17km Raiwind Road, Lahore, Pakistan; Email: qurbabutt8@gmail.com; {ORCID: 0000-0002-8354-9247}
4. Anas Farooq, MBBS, Al-Faisal University, Riyadh, Saudi Arabia; Email: anasfarooq20@gmail.com
5. Sonia Munir, Assistant Professor, Isra university, Islamabad, Pakistan; Email: Docsonia@ymail.com
6. Sarah Kafeel, Assistant Professor, Isra university, Islamabad, Pakistan; Email: Sarahkafeel@hotmail.com

Correspondence: Qurba Kiran, **Email:** qurbabutt8@gmail.com

ABSTRACT

Background: Rapid advancements in robotics have addressed concerns including a dwindling workforce and the need for technological integration, resulting in major advances in patient care. Combining concepts from engineering, physics, and mathematics, robotics has developed from industrial applications in the 1960s to medical applications in the 1980s. These days, robots assist with a variety of medical tasks, such as surgery, patient monitoring, and rehabilitation. Notwithstanding their revolutionary potential, particularly in domains such as pharmacy automation and telepresence, the assimilation of robotics into nursing care has not received enough attention. The numerous uses and effects of robotics in patient care are reviewed in this study, with a focus on how they might improve productivity, lower error rates, and enable independent living for the old and disabled.

Objective: To provide a narrative review of integration of Robotics in health care management to provide individualized and effective healthcare solutions.

Method: A systematic search of MEDLINE/PubMed and Google Scholar databases, then thoroughly reviewed the articles, focusing on those published in the last 5 years.

Conclusion: Robotics integration in healthcare is revolutionizing minimally invasive procedures, medicine administration, and improved mobility for patients. Robotics-assisted rehabilitation enhances the results of physical and cognitive treatment while helping the aged and disabled. While robotic process automation (RPA) boosts productivity and lowers errors in administrative work and pharmacy operations, telepresence robots enable remote patient connection. As robots' technology develops, more individualized and effective healthcare solutions could be possible.

Abbreviations: ASD: autism spectrum disorder, EMR: Electronic Medical Record, AI: artificial intelligence, IoMT: Internet of Medical Things. RPA: robotic process automation, UN: United Nations, UV-C: ultraviolet-C lighting, WHO: World Health Organization

Keywords: Robotics; Health Care Management; Patient Care; Robotic-Assisted Surgery; Robotics-assisted rehabilitation; Pharmacy Automation

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1. INTRODUCTION

Robots are physically embodied systems that can interact with their environment to sense and react to it. Their degree of autonomy, sensory ability and aesthetic appearance can all differ. They are resistant to psychological damage, can perform repetitive tasks with extreme precision, and can handle materials that pose a risk to humans.[1]Nowadays,well-defined functions like productivity, pharmacy automation, and hospital logistics are handled by robotic systems.[2,3] We predict that future developments in technology will further enhance robot capabilities, enabling them to function more independently and collaborate closely with people. Actually, automation and robotics are becoming more and more necessary in the healthcare industry every day.[3,4] This manuscript also attempts to educate a broader readership on the use of robotic technology in healthcare.

The most well-known robots are extensively utilized in manufacturing, healthcare, agriculture, logistics, and transportation.[5,6] Robots are employed in a variety of production processes because of their accuracy, consistency, and speed, including welding, assembling, and packaging. Another industry where robots can be extremely helpful to medical personnel in diagnosing, operating and recovering from injuries is healthcare. Robots can be used in agriculture for a variety of tasks, such as planting, harvesting, and fertilizing crops.

They offer benefits like cost-effectiveness, efficiency, and precision. Robots can be employed in automated warehouses and distribution centers in the transportation and logistics sector to process orders more quickly and accurately.[7] This narrative review aims to shed light on how robots are changing the management of healthcare, with a focus on how it can increase overall quality, safety and efficiency.

2. ROBOTICS IN PATIENTCARE

Healthcare-related issues such a shrinking workforce and technological advancements have made it possible to investigate robotics in healthcare settings. The multidisciplinary field of robotics draws on concepts from physics, mathematics and engineering including computer, electrical, and mechanical engineering. Robots have been used in American enterprises since the 1960s, and in the 1980s, they were initially applied in the medical field. Numerous robotic technology applications support patient care, such as mobility support, medicine administration, evaluations, physiologic parameter monitoring, and companionship. Furthermore, there is a well-established history of using robots in surgery to do less invasive procedures. In actuality, during the previous 20 years, the surgical robot sector has grown rapidly. Robotics hasn't gotten much attention in the nursing literature, despite the fact that these technologies have the potential to completely transform nursing care.[8]

The phrase "mobile robots in healthcare" describes the use of robotic technology for purposes such as patient interaction, autonomous or semi-autonomous navigation of healthcare environments, and other duties.

2.1. Types of Mobile Robots

Some examples of common types of mobile robots used in healthcare, along with their functionality and applications;

1. Disinfection Robots
2. Delivery Robots
3. Telepresence Robots
4. Patient Monitoring Robots,
5. Rehabilitation Robots,
6. Surgical Robots,
7. Service Robots,
8. Autonomous Mobile Robots,
9. Collaborative Robots,
10. Exoskeleton Robots,
11. Pharmacy Robots,
12. Emergency Response Robots,
13. Vital Sign Monitoring Robots, and
14. Mobile Ultrasound Robots.

Mobile robots have been used in the healthcare sector for a number of purposes, such as patient monitoring, drug delivery, supply and specimen delivery, and disinfection. To lower the risk of illnesses linked to healthcare, mobile robots with ultraviolet-C (UV-C) lighting can disinfect operating rooms, patient rooms, and other places. These robots are able to target surfaces that a human cleaner could miss while navigating a space. The potential of mobile robots to provide individualized care, company, and 24-hour monitoring makes them important in the assisted care space. They can help with mobility assistance, medicine reminders, and even simple housekeeping duties, which lessens the load on carers and encourages independence for the people they support. Additionally, mobile robots can enhance the safety and security of individuals receiving care.
Furthermore, mobile robots can be employed for patient monitoring tasks like routine check-ins with patients or

the monitoring of vital signs. They are a desirable option for healthcare companies trying to enhance their operations since they can save expenses, boost productivity, and enhance patient outcomes.[9]

2.2. Robotics Assisted Rehabilitation

The United Nations (UN) reports that the global population is ageing. By 2050, that percentage is expected to increase to 16%, meaning that one in six individuals on the planet would be 65 or older.[10] Individuals in this age range are more likely to experience chronic illness and struggle to live independently. In addition, there are established causes of death that affect the elderly, include prescription errors, drug forgetfulness, and unintentional falls. Furthermore, according to the World Health Organization (WHO), over a billion people worldwide live with impairments. In addition, the WHO reports that certain disorders like diabetes, obesity, and depression have become more common in recent years and call for further surveillance. Because of the advancements in artificial intelligence, particularly in machine learning algorithms, which have facilitated the development of intelligent and automated services, these individuals can receive specialized support.

The primary application of psychotherapy is to assist individuals with mental health conditions like depression, ASD (autism spectrum disorder), and cognitive impairment. The majority of works used robot cognitive rehabilitation tests and analysis to simulate a psychotherapist for patients with deficient cognitive care. Children with ASD benefited from cognitive and behavioral therapy, as well as interactive games and music with the carer robot. Furthermore, since higher-grade depression requires more care from a human therapist, the robots are utilized as conversation partners to assist those who are lonely or experiencing low-grade melancholy. Second, carer robots offer interactive workouts to support physiotherapy rehabilitation. As carers, robots not only offer physical support to those with mobility issues but also offer monitoring features such as activities, pathways, vital signs monitoring, and hazards.

For the past 15 years, researchers have been actively studying robot-assisted neurorehabilitation. Numerous robotic upper limb devices have been created and tested on stroke survivors who have experienced acute and chronic strokes. Early research in this area concentrated on the proximal regions of the upper extremities, using equipment made expressly to help and teach reaching motions that involved the elbow and shoulder joints. A variety of gadgets that help and teach distal upper extremity movements, like wrist and/or finger movements, has been steadily rising since 2003. Furthermore, research needs to be done on the potential applications of robot-assisted hand rehabilitation for other neurological conditions such as cerebral palsy and spinal cord injuries. The fact that almost 75% of the gadgets that have been published have not been tested on actual users could be due to the fact that these robots are too complicated for patients to utilize. In order to make sure that the development meets the patient's demands, designers should consider the motor abilities of the patients they wish to assist, incorporate therapists' feedback at every level of the design process, and conduct regular design evaluations.[11]

2.3. Telepresence Robots in Patient Interaction

With the ongoing advancements in robotic technology, robotic telepresence is now partially realized. By mapping the operator's visual, tactile, motor, and cognitive functions to a remote robot, it makes it possible to put the operator efficiently "on-the-scene." One important area of application is social robotic telepresence, which facilitates social interaction over distance. The potential of telerobots to support individuals with special needs—such as remote patient communication, dementia support for older adults, remote learning for students confined to their homes, care for children with cognitive disabilities, and independent living for seniors—has been the subject of several studies.[12,13]

Elderly people who experience social isolation and loneliness are more likely to have poor physical, mental, or emotional health, which can increase their reliance on medical care. Certain mobile robotic devices are intended to provide elderly individuals with social interaction support and companionship. Together with its features, the developed robot allows for a variety of interactions in a distant setting, including navigation, the ability to collect and carry small goods, the ability to measure an elderly person's vital signs, the use of a calendar and reminder, and interpersonal communication. The elderly and professional careers are not the only groups of people who could employ the robot system. The robot can be operated remotely by someone who is far away like a professional carer.[14]

Children who are bedridden or in hospitals may be especially affected by telepresence robots since they have less access to schooling and worse health. Similarly, compared to children without disabilities, children with disabilities face more inequality, worse health, and less educational possibilities. Therefore, telepresence robots have the potential to enhance people's quality of life by facilitating social interactions and creating social networks.[15]

3. DA VINCI SURGICAL SYSTEM

When robots first entered in the surgical field more than 20 years ago, it was applied to disciplines like neurosurgery and orthopedics that already had established anatomical markers. The concept of telepresence was developed by virtual reality pioneer Scott Fisher at the NASA Ames Research Center, and it provided a foundation for the development of robotic surgery.

This idea would eventually be used by the US Army in an effort to create a system that could do remote surgical treatments in a hazardous location, like a battlefield. The potential application of this technology for minimally invasive surgery became apparent following Jacques Périssat's April 1989 Atlanta presentation on his laparoscopic cholecystectomy experience.

Later on, the technology was used for vascular anastomoses, proving that tele manipulators could be used for delicate surgical procedures.

In January 1999, the first iteration of the da Vinci® surgical system with three arms was made accessible in Europe, and in July 2000, it received FDA certification. It was primarily utilized in heart surgery, cholecystectomy, and fundoplication. Gradually, it was also utilized in colorectal and bariatric surgery, kidney harvesting from living donors, and other specialties like urology and gynecology. The FDA authorized the version with a fourth robotic arm—which was the same as the arms of the instrument holder—for clinical use in December 2002. By acting as a retractor that is frequently moved, this arm allows the surgeon to better control and expose anatomical tissues, hence decreasing the need for surgical assistance. The primary benefit of the da Vinci S® system model, which was unveiled by Intuitive Surgical in 2006, is that it is easier to handle and has larger arm and instrument movements, which enable surgery involving multiple abdominal quadrants and aid in colorectal resections. The newest model, the da Vinci Si®, was introduced in April 2009 and features a high definition (HD) vision system in addition to enhancements to the manipulators and pedal unit. Additionally, it permits the addition of a second console to the surgeon console—an innovation that enhances safety during the learning curve by enabling a novice surgeon to receive mentorship during the process.

Lastly, the incorporation of augmented reality, made possible by 3D reconstructions that are updated in real time, is opening up new possibilities for robotic surgery. This includes the automation of some surgical duties, which was previously thought to be an idealistic future.[16]

4. LOGISTIC AND AUTOMATION

Software robotics, or robotic process automation (RPA),[17] is a technology that automates business processes with fewer human intervention. It is based on the idea of software robots. By creating software robots that can do the duties of medical professionals or health workers, RPA can be a successful way for supporting the health care industry during COVID-19. To further provide advanced governance services, RPA guarantees increased operational effectiveness and flexibility while lowering operating costs and error occurrences.

RPA has been widely applied to diagnosis and testing. The testing facilities face massive demand due to the quick spread of diseases, which causes a large wait list of patients awaiting testing.[18] Using attended bots to gather patient data, enter it into the hospital's Electronic Medical Record (EMR), record test results, and forward these records to other departments, RPA can speed up COVID-19 testing by up to 90% while reducing human error and minimizing down on wait times.[19] Hospitals do a mobile patient survey in order to get an initial diagnosis.

The diagnosis time was greatly reduced by having RPA handle these data automatically without the need for data input experts. Testing can be done more quickly and efficiently when RPA and AI are integrated, without relying on radiological results, saving patients' wait times by up to 70%. By autonomously scheduling patient requests, RPA bots guarantee that appointment services for video consultations are available 24/7.[20]

5. ROBOTIC PHARMACY AUTOMATION

Automation is increasing pharmacies' efficiency. Increased effectiveness is giving pharmacies a chance to offer additional services and to provide greater medication safety. The issue facing pharmacy is: Getting prescription drugs to patients is one of the traditional basic responsibilities of most pharmacists. There is a chance for direct interventions that enhance patient outcomes when the appropriate medication is given to the correct patient at the right time. However, the processes involved in distributing medication are incredibly laborious, repetitive, and practically impossible to execute correctly.

Automation offers a solution for pharmacy as well. Dispensing robots are significantly making less mistakes than human counterparts and never get tired or distracted. Furthermore, dispensing robots permitted pharmacists and technicians for more profitable clinical services which for human judgment in this age of steadily declining prescription margins.

A number of hospitals and many medical clinics use robotics to administer medication because of the potential hazards and massive quantity. Robotic pharmacy is becoming more and more common in clinics and hospitals. Robotic pharmacy is becoming more and more common in clinics and hospitals. Robotic pharmacy will spread more rapidly due to regulations than because of accessible technology. At the UCSF Medical Center in California, a similar technology is now in use, and it is greatly increasing overall efficiencies. The largest benefit would be the elimination of inaccurate medication dosages and other errors that are mostly the result of human mistake.

Hospital pharmacies were once based on a centralized operations approach. Larger hospitals are more complicated, with hundreds of beds dispersed among several divisions, making it difficult to keep track of the transfer of drugs from pharmacy to patient. This kind of tracking can be completed with significantly higher efficiency. One problem is that smaller hospitals now lack the funding necessary to pay for the large upfront costs involved in putting such automated systems into place. However, there is a significant trend in that direction, so costs will eventually go down.[21]

Some clues of how human variables may interact—or not interact—with robotics throughout the dispensing process can also be found in the literature currently under publication. The average time to fill a prescription was lowered by 40 seconds during a transitional period before robots was used at a community hospital.[22] However, the workflow stages for technicians needed to be rearranged, and this resulted in an increase in time from 17 to 38 seconds. The percentage of workarounds went from 10% to 36% is a more concerning aspect

Robotics is often seen favorably in pharmacy automation studies, although it should be noted that unit-dose dispensing may not always produce the same level of speed as original pack dispensing via robotic picking. The assessments of robotic prescription filling and barcode-based drug dispensing are encouraging in terms of overall automation throughout the dispensing process; they provide indications of decreased error rates, faster prescription filling times, and more complete prescriptions.

The Kingdom of Saudi Arabia has been actively involved in pharmacy automation for an extended time period. Nonetheless, traditional pharmacies continue to operate in the places where automated pharmacies are being introduced. This allowed us to compare the two systems against one another over an extended period of time and collect pre-implementation metrics, including the time it takes to fill a prescription from the time it is made or, in the event of repeat orders, from the patient's presentation. This addresses a significant gap in the existing research.[23]

6. ROBOTICS FOR ADMINISTRATIVE EFFICIENCY

The use of information technology, or IT, in every aspect of society has raised demand for these tools globally.[24] When using humans alone, it is very difficult to control the overloading process unless the organization hires more staff, which raises the cost of operations. Robotic Process Automation (RPA) can, however, be used to reproduce and control this operation in a way that is in line with the requirements for completion time, data gathering, and application complexity.[25,26] With requirements analysis, design, development, testing, and maintenance, robotics can be used to estimate and complete the Software Development Life Cycle (SDLC) complexity.[27]

In order to imitate human jobs and carry out repetitive and automated processes on a daily basis, the project focuses on digital-operation activity processes that are carried out by software robotics technology applying RPA application.[28] Reducing human error while increasing process effectiveness and efficiency is the goal. In order to ascertain the goal, the procedure will establish a connection with the RPA application and supply information. The process needs to be developed more effectively and efficiently and followed consistently if it is to be implemented successfully and achieve the desired outcome. Throughout the procedure, RPA needs to be able to recognize repetitive human tasks and be accurately and consistently automated to match the task. The procedure must accomplish the goal while reducing risk, time, and expense. Robotics is an innovative field.

RPA, in theory, refers to a software robot within a computer program that can operate and work 24 × 7 throughout the year, as opposed to interacting with staff members who work set hours and need breaks. In addition, compared to human performance, the bots' ability to handle a high volume of work and do repetitive tasks prevents lengthy responses and maintains the same level of execution quality. Furthermore, when carried out by humans, case-sensitive information, including employee private data like social security numbers, phone numbers, addresses, and others, may be exposed and compromised; however, this may be prevented by implementing RPA.[29,30]

7. Digital Health Technologies & IoMT Innovations

Digital healthcare puts automated detection technologies and integrated cloud goods in the hands of customers. POC devices that let consumers to monitor their health include glucometers, ECG readers, ultrasonography and thermometers. These gadgets can access the internet and store data in the cloud. The development of such innovations is necessary for providing makeshift healthcare, as it makes it possible to adjust insulin levels and have direct patient-clinician communication. Current hospitals are starting to implement the "smart-bed" concept, which enables the bed to adjust its angle and position in response to the patient's sleeping posture. Internet of Medical Things (IoMT)-enabled gadgets are also changing conventional home healthcare services. For example, the cloud-based intelligent home medicine distribution system automatically uploads patient medical history data. It reminds physicians and patients about the medication that has to be taken as well and alerts clinicians when a patient is not taking their prescribed prescription. The healthcare system is facing increasing pressures due to factors such as urbanization, industrial adaptation, and technology innovation, in addition to growing populations.[31]

8. CONCLUSION

The use of robotics in health care is simplifying medical procedures, enhancing effectiveness, promoting patient care and increase overall quality. Robotic technologies help automate pharmacy, surgery and rehabilitation, reducing errors and addressing shortages of workers. Robotic Process Automation (RPA) simplifies administrative duties, while telepresence robots enhance patient interaction.

Remote monitoring and personalized treatment are mad e possible by advances in digital health and the Internet of Medical Things (IoMT).
Global health could become safer, more effective, and more accessible as robotics develops.

9. LIMITATIONS

The study includes the absence of comprehensive information regarding long-term patient outcomes and the efficiency of different robotic applications in a range of healthcare settings. Moreover, there may be significant variations in how robots are incorporated across various institutions, which makes it difficult to generalize findings. Healthcare professionals' hesitation and ethical concerns about robotic technology adoption could also have an impact on acceptance and implementation. Lastly, the applicability of findings across various healthcare systems and populations might be limited by financial constraints and various levels of access to technology.
In-depth longitudinal studies should be carried out to assess the long-term effects of robotics on patient outcomes in a variety of healthcare environments.

10. RECOMMENDATIONS

In order to reduce implementation variation and assure standard robotic technology integration across institutions, standardized guidelines must be created. Furthermore, supplying healthcare personnel with ongoing education and training will assist in reducing hesitations and ethical issues, promoting increased acceptability.

11. Conflict of interest

None declared by the authors.

12. Author contribution

AA, NF: Concept or design

QK: Literature search, review

AF: drafting the manuscript

SM: Critical review, editing

SK: Supervision, final approval

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