



## Robotics in Medicine

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### Abstract

Robotics has been adopted more rapidly in medicine due to technological advances. What was considered the future is now a reality in most hospitals across the globe.

The introduction of robotics into medical care is a current phenomenon transforming patient care and management. Robotics in medicine entails designing, building, and using robots to perform tasks that human medical practitioners have long performed. These include procedures such as surgery and patient rehabilitation, as well as administrative duties. Robots are increasingly being adopted in healthcare to carry out various tasks that enhance patient care. Examples include exoskeletons that assist stroke patients with mobilization and surgical robots that enable surgeons to perform operations remotely. Advanced robots continue to be designed for an ever-expanding range of medical applications. In a variety of settings and applications, robotic technology has demonstrated clear advantages in surgical outcomes, rehabilitation efficacy, and operating efficiency. This paper covers the impact of robotics on all aspects of medical delivery.

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### 1. Introduction

There has been an explosion of publications about the use of robots in healthcare in the past few years. Technological advancements have enabled robots to conduct increasingly varied and complex roles in healthcare. Robots are increasingly being adopted in healthcare to carry out various tasks that enhance patient care. Although robots were mainly studied in the surgical theatre and the rehabilitation unit, they were also studied in other settings, ranging from the hospital ward to the inpatient pharmacy<sup>[1]</sup>. Robots assist in delicate surgeries, support patients during rehabilitation, disinfect hospital spaces, and even help doctors consult remotely.

Medical robotics is the use of intelligent, AI-controlled machines to assist medical specialists in diagnostics, treatment, rehabilitation, and hospital work. It is transforming medical practices into safer, faster, and more efficient medical practices. The use of sophisticated robotics, e.g., teleoperated surgery platforms, improves accuracy and access to specialized care, eliminating geographical limitations. The innovations transform healthcare by enabling remote collaboration and by providing surgical skills worldwide. Over the past decade, commercial and research interest in medical robotics has grown significantly. Technological advances in robotics can lead to the development of new therapies to address a broad range of diseases and disorders, increase the quality and availability of care, and improve patients' health outcomes.

### 2. Objectives

The primary goal of the paper is to provide information and discuss different medical robot technologies and their impact on medicine. Additionally, it covers their applications regarding safety, precision, and the efficiencies associated with their use. The paper also discusses various applications that assist medical professionals, enhance patient outcomes, and develop medical

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technologies through automation and intelligent systems. It then describes the major benefits, real-world uses, challenges, and opportunities of their adoption in healthcare.

### 3. Significance of the Study

This study is important because it highlights the potential of medical robots to enhance healthcare productivity and simplify medical workers' duties. Another valuable factor is the improvement in hospital efficiency, which reduces staff workload and simplifies other medical processes. Also, medical robots help reduce the risks of human error and delays, ultimately leading to better patient outcomes. It is important to note that this development opens the way for subsequent technological advances in medicine.

### 4. Methodology

This study adopted a qualitative literature review methodology to examine the applications, benefits, and challenges of robotics in medicine. A literature review allows researchers to systematically evaluate and synthesize existing scholarly research to provide a comprehensive understanding of a specific topic [2]. This method was appropriate because extensive peer-reviewed research, clinical studies, and technological developments support the use of robotics in medicine.

#### 4.1. Research Design

The research used a descriptive-analytical design based on secondary data sources. The descriptive component focused on identifying and explaining the major applications of robotics in medicine, including robot-assisted surgery, rehabilitation robotics, and hospital automation. The analytical component evaluated the effectiveness, advantages, and limitations of robotic systems in healthcare environments. This approach allows researchers to examine technological trends and evaluate their impact on patient care and healthcare efficiency [3].

#### 4.2. Data Sources

The data used in this article were collected from reputable academic databases, peer-reviewed journal articles, conference papers, and other academic books, focused on robotics applications in medicine. PubMed, ScienceDirect, National Library of Medicine, SpringerLink, and Google Scholar. These databases provide access to high-quality peer-reviewed journal articles, conference papers, and academic publications relevant to robotics and healthcare [4]. The publications reviewed were validated to ensure their current relevance, reliability, and credibility.

#### 4.3. Data Analysis

The collected data was analyzed using thematic analysis, a widely used qualitative research method that identifies and analyzes patterns across studies. This approach allowed the researcher to categorize the data into four key areas: surgical robotics, rehabilitation robotics, diagnostic robotics, and hospital automation. Such analysis helps researchers understand intricate findings and identify common trends and technological advancements in medical robotics [5].

### 5. Literature Review

#### 5.1. Robotics in Medicine

In the following section, we provide a comprehensive analysis of the existing literature on robotics in medicine.

The word "robot" was coined by Czech writer Karel Čapek in his play in 1920. Isaac Asimov coined the term "robotics" in 1942 and came up with three rules to guide the behavior of robots and later added the zeroth law [2]:

1. **Law 0:** A robot may not injure humanity or through inaction, allow humanity to come to harm.
2. **Law 1:** Robots must never harm human beings,
3. **Law 2:** Robots must follow instructions from humans without violating rule 1,
4. **Law 3:** Robots must protect themselves without violating the other rules.

According to the definition, medical robotics includes several devices used for surgery, medical training, rehabilitation therapy, prosthetics, and assisting people with disabilities [7]. Robots are becoming increasingly prevalent in almost every industry, from healthcare to According to the definition, medical robotics includes several devices used for surgery, medical training, rehabilitation therapy, prosthetics, and assisting people with disabilities [7].

Although there are many types of robots designed for different environments and for different purposes/applications, they all share four basic similarities [3]:

1. All robots have some form of mechanical construction designed to achieve a particular task.
2. They have electrical components that power and control the machinery.
3. All robots must be able to sense their surroundings; a robot may have light sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing and sonar sensors (ears), etc.
4. All robots contain some level of computer programming code.

Programs are the essence of a robot since they provide intelligence. There are three different types of robotic programs: remote control, artificial intelligence, and hybrid. Some robots are programmed to faithfully carry out specific actions repeatedly (repetitive actions) without variation, with a high degree of accuracy.

Robotics is an interdisciplinary field that involves design, construction, operation, and use of robots. It is a branch of engineering and computer science that includes the design and use of machines capable of performing programmed tasks without human involvement. The field develops machines that can efficiently perform various tasks, automate tasks, and handle jobs that a human might not be able to do. Robots could someday be our drivers, companions, collaborators, teachers, specialists, and exploration pioneers [4].

#### 5.2. Medical Robots

Recent technological advancements have led to the development of various medical robots. These robots have emerged in several categories, including neurosurgery robots, orthopedic robots, endoscopic surgery robots, instructional robots, rehabilitation-assisted robots, and capsule robots, among others [10]. Medical robots are designed to assist healthcare professionals in performing complex and delicate tasks with greater accuracy and consistency than traditional methods. The application of artificial intelligence technology has emerged across many fields and continues to evolve, improving healthcare [11]. Robotics in medicine is a rapidly advancing field that integrates engineering, computer

science, and healthcare to improve the quality, precision, and efficiency of medical procedures and patient care<sup>[1]</sup>. Medical robots are designed to assist healthcare professionals in performing complex and delicate tasks with greater accuracy and consistency than traditional methods. These robotic systems utilize advanced technologies such as sensors, artificial intelligence (AI), and computer-assisted control systems to enhance human capabilities rather than replace healthcare professionals<sup>[2]</sup>.

The history of robotics in healthcare started in the late 1900s when robotic-assisted surgery was developed. In the 1990s, the launch of the da Vinci Surgical System transformed the concept of minimally invasive surgery by enabling surgeons to perform more complex procedures with greater precision and control. Telehealth and remote care robots have

transformed modern healthcare. Medical robotics encompasses a diverse set of technologies that can assist medical workers in providing more accurate, effective, and minimally invasive medical care. These systems facilitate automation of surgery, rehabilitation, patient assistance, and pharmacy. Robotics in healthcare is a revolutionary advancement in the engineering sector that combines innovative technology with medical practice to improve patient outcomes, enhance surgical precision, and optimize hospital processes. The general purposes of robots in healthcare are classified as surgical, rehabilitation and mobility, radiotherapy, socially assistive, telepresence, pharmacy, disinfection, delivery and transport, and interventional and imaging assistance. As demonstrated in Figure 1, robots are used in medical procedures<sup>[12]</sup>.



Fig 1: Use of robots in medical operation<sup>[5]</sup>.

To work autonomously or semi-autonomously, any robot needs a plan to determine its path of action. Plans in medical and health robotics include: a plan to assist a patient out of bed and a plan to access a tumor in an organ. Medical and health robotics planning must account for new methods for operating in uncertain environments with human interaction<sup>[13]</sup>. The multimodal sensing method enables robots to work safely in dynamic healthcare settings and gather the information they need to perform specific tasks. As a patient's ability improves, therapy advances to reduce robotic

assistance and promote independence. Operational sustainability requires power sources such as batteries, hard-wired connections, or an integrated system that balances mobility needs with life cycles.

**5.3. Types of Medical Robots**

The development of a wide range of robots serves a variety of roles within the medical environment. Medical robots fall into several categories. The robots are grouped in this study by their predominant role and summarized in Table 1.

Table 1: Analysis of some Medical Robot Types, Functions, and Applications<sup>[14,15,16, 17, 18]</sup>:

Type of Medical Robot	Primary Function	Applications	Benefits	Reference
Surgical Robots	Assist surgeons in performing precise and minimally invasive procedures	Laparoscopic surgery, cardiac surgery, neurosurgery	High precision, reduced trauma, faster recovery	[14, 15]
Rehabilitation Robots	Assist patients in regaining motor function and mobility	Stroke rehabilitation, physical therapy, spinal cord injury recovery	Improved recovery, consistent therapy, patient monitoring	[16]
Diagnostic Robots	Assist in disease detection and diagnostic imaging	Capsule endoscopy, robotic imaging, biopsy procedures	Accurate diagnosis, early detection, reduced human error	[17]
Hospital Service Robots	Perform routine hospital tasks and logistics	Medication delivery, sample transport, hospital supply management	Increased efficiency, reduced staff workload	[18]
Telepresence Robots	Enable remote communication between doctors and patients	Telemedicine, remote monitoring, virtual consultations	Improved healthcare access, remote care capability	[14]
Disinfection Robots	Sterilize hospital environments and equipment	UV sterilization, infection control, hospital sanitation	Reduced infection rates, improved patient safety	[18]

Full details and the types of robots discussed in the paper include the following <sup>[1, 19, 20]</sup>:

1. **Surgical Robots:** The first robots introduced to the medical field in the 1980s, now as *Surgical Robots*, provided surgical assistance via robotic arm technologies. Surgical robots can assist in performing surgical procedures. Their specific roles within surgery are varied, ranging from instrument control to automated

surgical table movement. They enable minimally invasive procedures with unmatched precision. Surgical robots are unsurprisingly found predominantly in the hospital theatre setting. They use high-precision instruments guided by AI algorithms and controlled by surgeons for minimally invasive operations. Figure 2 shows some surgical robots <sup>[21]</sup>.

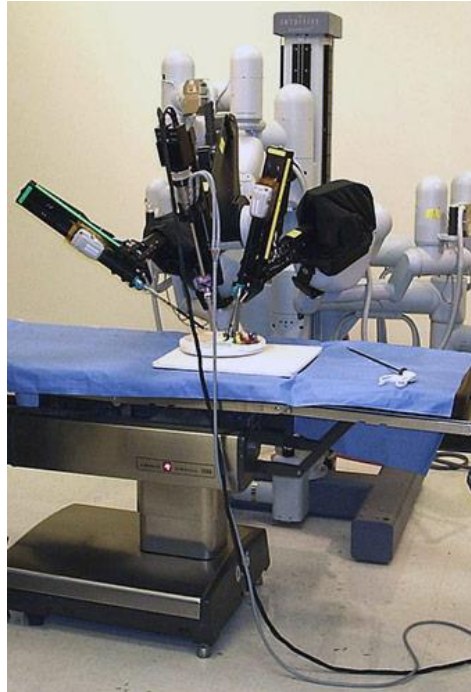


Fig 2: Some surgical robots <sup>[9]</sup>.

2. **Rehabilitation Robots:** Rehabilitation is one of the major roles of robots in healthcare. Rehabilitation robots are those that can physically assist or assess patients to help achieve goals. These robots assist patients recovering from strokes, injuries, or neurological conditions. They can improve dexterity, help achieve

rehabilitation targets, or aid mobilization. These robots may be used in the inpatient setting and in community rehabilitation centers. Current rehabilitation robots are large and relegated to the clinic. Figure 3 shows an upper limb rehabilitation <sup>[21]</sup>.



Fig 3: An upper limb rehabilitation <sup>[9]</sup>.

3. **Radiotherapy Robot:** *These robots can be used to assist with the delivery of radiotherapy. They can assist with the application of radiotherapy and image guidance to manage conditions such as liver and orbital metastases. Robotic therapy devices have also been developed for rehabilitating the hand and fingers.*
4. **Telepresence Robots:** *A core feature of the telepresence robotic group is the ability to allow individuals to have a remote presence through means of robot. The robot may be used for activities such as remote ward rounds, remote surgical mentoring or remote assessment of histology slides. Physicians use robots to help them examine and treat patients in rural or remote locations, providing them with a “telepresence” in the room. During the COVID-19 pandemic, the role of telepresence robots became increasingly critical.*
5. **Assistive Robots:** *These robots can take multiple forms, such as humanoid or animal-like, and work to provide support in areas traditionally done by humans, such as companionship and service provision. Assistive robotics also includes mobility aids such as wheelchairs and walkers with intelligent navigation and control systems, for individuals with impaired lower-limb functions. Advancements in artificial intelligence may lead to socially assistive robots that can function more independently and perform more complex tasks. Robotics technology is being used to develop assistive robots to support older people and individuals with disabilities. These robots can assist with daily tasks, monitor health conditions, and provide companionship, promoting independence and improving quality of life.*
6. **Disinfection Robots:** *With the increase in antibiotic-resistant bacteria and outbreaks of deadly infections like Ebola, more healthcare facilities are using robots to clean and disinfect surfaces. Autonomous robots equipped with UV light or disinfectant sprays sterilize hospital environments. They help reduce infection risks, especially in intensive care units and high-traffic areas. Cleaning and disinfection of autonomous mobile robots (AMRs) simplifies routine AMR tasks, enabling hospital rooms to be sanitized and ready for incoming patients quickly, allowing workers to focus on patient-centric, value-driven work.*
7. **Pharmacy Robots:** *There is a group of robots with the specific role of assisting with the management and delivery of pharmacy services, which include drug storage, dispensing, and compounding. The pharmacy and socially assistive group of robots can be found in both inpatient and outpatient settings.*
8. **Modular Robots:** *Modular robots enhance other systems and can be configured to perform multiple functions. In healthcare, these include therapeutic exoskeleton robots and prosthetic robotic arms and legs. Therapeutic robots can help with rehabilitation after strokes, paralysis, or traumatic brain injuries or with impairments caused by multiple sclerosis.*
9. **Autonomous Mobile Robots (AMRs):** *Healthcare organizations often rely on AMRs because of their ability to assist with critical needs such as disinfection, telepresence, and delivery of medication and medical supplies. Other types of AMRs that are used in healthcare include service robots and social robots.*
10. **Service Robots:** *Service robots relieve the daily burden on healthcare workers by handling routine logistical tasks. Many of these robots operate autonomously and can send a report upon completing a task. These robots set up patient rooms, track supplies, file purchase orders, restock medical supply cabinets, and transport bed linens to or from laundry facilities.*
11. **Social Robots:** *Social robots interact directly with humans. These “friendly” AMRs can be used in long-term care environments to provide social interaction and monitoring. They can be used to offer directions to visitors and patients inside the hospital environment. In general, social robots help reduce caregiver workloads and improve patients’ emotional well-being.*
12. **Soft Robotics:** *Soft robotics is an emerging field that focuses on creating robots with flexible, adaptable structures. These robots are particularly useful in healthcare due to their ability to interact safely with human tissues. Applications include soft exoskeletons, which are wearable devices that assist patients with mobility impairments.*
13. **Nanorobotics:** *Nanorobotics involves the use of microscopic robots to perform tasks at the cellular or molecular level. In healthcare, nanorobots hold the potential to revolutionize drug delivery, cancer treatment, and precision medicine. These tiny nanoscale robots have the potential to navigate through the human body, deliver targeted treatments, perform minimally invasive surgeries, and repair tissues at the cellular level. Nanorobots can revolutionize drug delivery by precisely targeting specific cells or organs, increasing treatment efficacy while minimizing side effects. Figure 4 shows targeted treatment nanodots<sup>[22]</sup>.*



Fig 4: Targeted treatment nanodots<sup>[10]</sup>.

#### 5.4. Applications of Medical Robots

Robotics in healthcare has emerged as an important tool for enhancing efficiency and accuracy. Healthcare robotics are used in a variety of applications, including refining surgical accuracy, patient recovery, and increasing access to medical services through telemedicine.

These uses of robotics in medical science illustrate the broad scope and potential benefits of this technology in patient care, improved surgical outcomes, and the changing nature of healthcare delivery. Some of the common applications are as follows <sup>[12, 22]</sup>:

**Robotic Automation system:** The use of robots to perform repetitive or complex tasks with minimal human intervention. Robotics is being applied to automate healthcare processes. Robots have the potential to automate low-level work, such as logistics, inventory management, and patient monitoring, reducing the burden on healthcare providers and enhancing efficiency. The pharmaceutical industry, including laboratory

research and development, is being transformed through robotic automation. Robotic dispensing systems in the pharmaceutical industry have also simplified the prescription-filling process by automating counting, labeling, and dispensing. This also enables the laboratory workers to pay more attention to data analysis and interpretation.

**Robotic Surgery:** The most notable use of robotics in medicine is in surgery. Robotic surgery is a surgical procedure conducted using robotic technology, in which a surgeon operates the system from a console. Robotics surgical systems, such as the da Vinci surgical system, enable surgeons to perform minimally invasive surgeries with increased precision, reduced blood loss, and shorter patient recovery times. Robotic surgery has revolutionized medicine, enabling complex procedures to be performed with precision and less invasively. Figure 5 illustrates the precision of robotics in surgery <sup>[22]</sup>.



Fig 5: Robotics' surgical precision <sup>[10]</sup>.

**Telemedicine:** This plays a central role in remote medicine. It uses telecommunications technology to deliver medical care remotely. Telemedicine uses robotics to deliver medical services remotely, thereby facilitating access to healthcare, particularly in isolated or underserved regions.

Robotics is also advancing telemedicine - the remote treatment of patients. A remote endoscopy has been developed as a remotely controlled, swallowable robot to assist doctors in performing remote endoscopy. The use of Telerobotic systems allows the surgeon to operate remotely, breaking geographical barriers and enabling specialized care to be given to patients across the globe. They facilitate remote surgeries, introducing specialized care to underserved locations.

**Rehabilitation** is the most extensive use of robotic technology for medical applications, with rehabilitation robotics traditionally including assistive robots, prosthetics, orthotics, and therapeutic robots. Robotic technology is being applied to patient aftercare. Therapy robots customize exercise routines, track patient progress, and speed up motor recovery, helping patients return to normal activities sooner. Rehabilitation robotics has revolutionized the way patients recover from injuries, as robotic devices provide controlled and repetitive movements to restore motor function. They play a crucial role in the recovery of people with disabilities

by improving mobility, strength, coordination, and quality of life. Virtual reality is being integrated with rehabilitation robots to expand the range of therapy exercises, increasing motivation and physical treatment effects.

**Medical Transportation** involves robots delivering supplies, medications, and meals to patients and staff, thereby optimizing communication among doctors, hospital staff, and patients. Most of these machines have highly dedicated capabilities for self-navigation throughout the facility.

**Medical imaging** uses robots to enhance the accuracy and efficiency of techniques such as MRI and CT scans. Robots are increasingly being used to enhance the accuracy and efficiency of medical imaging techniques. For example, robotic systems can assist with patient positioning for MRI or CT scans, ensuring optimal imaging angles and reducing the need for repeat scans.

**In Drug Delivery**, robots equipped with advanced sensors and microprocessors can be employed for precise, targeted drug delivery. These robotic systems can navigate complex anatomical systems, delivering medications to specific parts of the body at the right time and dosage. Such practice can greatly enhance drug efficacy and minimize adverse effects.

#### 6. Results

The results of our findings are presented below.

The study's results show that robotics in medicine is one of

the most innovative technological advancements in modern medicine. Robotics are used in different fields such as surgery, rehabilitation, diagnosis, imaging, and prosthetics. It combines the concepts from engineering, computer science, and biomedical sciences to enhance the accuracy, efficiency, and quality of patient care. Further findings also suggest the benefits and challenges with robotics in medicine. The benefits include enhanced precision, reduced errors, teleoperation, high-quality care, streamlined clinical workflows, and safer work environments. However, the study's further outcomes also suggest that challenges such as technical issues, change management, and ethical concerns must be addressed.

## 7. Discussions of Benefits and Challenges

### 7.1. Benefits

Medical robots provide greater opportunities that can be integrated into medicine to enable automation, improve accuracy, and support data-driven decision-making to enhance patient care and reduce medical errors. Robotics offers quantifiable improvements in treatment quality, hospital performance, and patient safety. The potential benefits, including improved Precision, shortened recovery times, and improved patient outcomes, remain the driving forces behind the application of healthcare robotics. Other benefits include the following<sup>[19, 20, 23]</sup>:

*Enhanced Precision*, performing complex and delicate procedures, is one of the benefits. Robotic tools minimize invasive procedures and ensure precise incisions, leading to fewer complications and faster patient recovery. The biggest advantages of robots are speed and accuracy, two features that are very important to pharmacies.

*Reduced Errors*, AI-powered systems assist doctors in decision-making, reducing the risk of human error in surgeries, diagnoses, and treatments. The use of robotic systems has led to major reductions in dispensing errors. Robots can execute tasks with a high degree of accuracy, reducing the margin of error in medical procedures.

Other benefits include *Improved Efficiency*. Robots automate logistics, supply delivery, and routine nursing tasks, allowing staff to focus on critical Care. Robotics could be used to reduce patient waiting times and the pressure on doctors and nurses. They are being developed to more quickly and efficiently diagnose lung cancer.

*Teleoperation* enables remote communication. For example, Telepresence robots connect doctors and patients remotely, bridging gaps in rural or underserved regions. This enables medical professionals to control robots remotely, allowing for procedures to be performed from a distance.

*High-Quality Care* is achieved using medical robots in hospitals and other care facilities that support minimally invasive procedures, customized and frequent monitoring for patients with chronic diseases, intelligent therapeutics, and social engagement for elderly patients.

*Streamlined Clinical Workflows* is another important benefit. Autonomous mobile robots (AMRs) simplify routine tasks, reduce the physical demands on human workers, and ensure more consistent processes. These robots can address staffing shortages and challenges by tracking inventory and placing timely orders to ensure supplies, equipment, and medication are in stock where needed.

*Safer Work Environments* are of great importance, as they help keep healthcare workers safe. AMRs are used to transport supplies and linens in hospitals where pathogen

exposure is a risk. Cleaning and disinfection robots limit pathogen exposure while helping reduce hospital-acquired infections (HAIs)—and hundreds of healthcare facilities are already using them.

Other advantages include *Enhanced Training*. As well as providing new ways to care for patients, robots are also being developed to support the training of new medical staff. Students can engage in role-play training with robots, which can be programmed to simulate a wide range of ailments.

### 7.2. Challenges

The study's findings indicate challenges and some concerns. While robotics technologies offer longer-term savings through greater efficiency, their implementation requires *significant upfront costs*. The initial investment in acquiring robots and training staff, along with ongoing maintenance, can be a barrier to adoption. Developing and implementing robotic systems in healthcare can be costly. Hospitals and health care providers must consider the advantages of these technologies and balance them with their financial constraints. The affordability of healthcare is directly linked to its accessibility.

*Technical Challenges* also arise when designing robots capable of performing complex medical tasks that require sophisticated engineering and control systems. It is essential to ensure a smooth flow of robotic systems into the current medical infrastructure and electronic health records. The reliability and safety of robotic systems are important in critical medical applications.

Robotics solutions should be smoothly integrated into working processes to achieve the greatest benefits and optimal coordination of Care. This involves ensuring it can be interoperated with other healthcare systems to access data in near-real time.

Another consideration is patient safety. Human-robot interaction safety is crucial because failures in the system might have serious outcomes. One of the available solutions to ensure that robots are used safely in healthcare and minimize this risk is testing and certifying the chosen systems and implementing safety protocols. The safety and reliability of robotic systems, ethical issues, the application of robotics in current health facilities, and the availability of these technologies to all classes of people are important aspects to consider. One critical challenge is *Data Security and privacy*: Every system collecting patient data should safeguard personal health information. Any solution under consideration that restricts patient safety must be comfortable with security components.

*Change Management*, New digital systems require extensive training and disrupt existing workflows. Any robotics system requires initial and ongoing staff training and ongoing maintenance to ensure successful, sustained use of the solutions. The most important aspect of adopting robotics solutions in healthcare settings is establishing clear guidelines and ethical standards.

*Ethical concerns*, such as the use of robotics in healthcare, bring about serious ethical and regulatory issues. The implementation of robotics in health care may raise ethical issues surrounding autonomy, decision-making, patient privacy, and the use of robotics. It is essential to ensure that robotic systems do not compromise patient safety and comply with high regulatory standards. The privacy of patient data and adherence to privacy laws, including HIPAA, are vital. The question of trust can be viewed as a challenge.

Healthcare professionals and patients might be reluctant to make use of robots. Successful adoption of robotics solutions is gained by building confidence. Healthcare providers can help reduce this problem through training and demonstration of capabilities, among other measures. Since medical and health robotics must work with both trained experts and lay users, acceptance must be obtained from both populations.

### 8. Future of Medical Robots

Healthcare robotics is evolving at an unprecedented pace, reshaping surgeries, rehabilitation, and hospital workflows. The future of robots in healthcare predominantly lies in remote presence and the performance of tasks without human presence. Robots will allow people to be present with increasing flexibility. This will help provide consistent services that are resilient to change and easy to adapt. The future of medicine will likely be collaborative, with human expertise and intelligent machines complementing each other to improve patient outcomes.

As medical robotic technology advances, we may see the barriers to adoption diminish, making robotic-assisted healthcare more accessible and widespread. To fully realize a future of widespread robot adoption, the necessary infrastructure must be developed. Investment in the systems that allow robots to operate is vital<sup>[24]</sup>.

With the development of machine learning, intelligence, data analytics, computer vision, and other technologies, medical robotics will be able to perform tasks more efficiently, autonomously, and accurately. Machine learning algorithms can identify patterns and forecast based on data, helping medical experts make well-informed, accurate decisions. AI has demonstrated immense potential to revolutionize systems and processes in the sector. The field of medicine is becoming increasingly dependent on AI and robotics, which are being used to modernize and transform industry<sup>[1]</sup>. Robotics with AI capabilities has the potential to process large volumes of patient health care information, such as medical history, imaging studies, and genetic data, to support diagnosis and treatment planning.

### 9. Conclusion

The analysis of the study demonstrates that robotics in medicine plays a significant role in accuracy, patient outcomes, and operational efficiency. With advances in technology, it is anticipated that medical robotics will become even more instrumental in shaping the future of healthcare, assisting health professionals and enhancing the quality of life of patients worldwide<sup>[25]</sup>. Robots are swiftly transforming sectors of our existence and labor, reshaping numerous professions. Robotics has transformed the healthcare industry by addressing acute challenges such as aging populations, limited access to specialized care, and increasing demands for accuracy and safety. Medical robots are used to assist with surgery, optimize clinical processes and hospital logistics, and improve patient care and work environment safety. The application of robots in the medical sector enhances care and patient outcomes and elevates operational efficiency. The use of emerging technologies such as AI, machine learning, computer vision, and big data in modern robotic systems demonstrates how they enhance robot capabilities and flexibility.

Not only are healthcare professionals assisted by robots in diagnosing and treating health conditions, but people with pre-diagnosed conditions are also assisted by robots to

improve their quality of life. Social needs, regulatory approval, and the financial impact of system deployment drive successful robotic system implementation. We may look forward to a healthcare environment in which robotic technologies are even more significant. In the future, robotics in medicine promises huge potential. More information on medical robots can be found in the books in<sup>[26-33]</sup> and the following related journals:

1. Robotica
2. Robotics
3. Robotics and Autonomous
4. Robotics and Computer-Integrated Manufacturing,
5. Advanced Robotics
6. Autonomous Robots
7. Automation in Construction
8. Journal of Robotics
9. Journal of Robotic Systems
10. Journal of Robotic Surgery
11. Journal of Robotics and Mechatronics
12. Journal of Intelligent & Robotic Systems
13. Journal of Mechanisms and Robotics-Transactions of the ASME
14. Journal of Automation, Mobile Robotics and Intelligent Systems
15. Journal of Future Robot Life
16. IEEE Robotics and Automation Letters
17. IEEE Transactions on Robotics
18. International Journal of Robotics Research
19. International Journal of Social Robotics
20. International Journal of Humanoid Robotics
21. International Journal of Advanced Robotic Systems
22. Science Robotics
23. Soft Robotics

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