

Artificial Intelligence in Medicine and Pharmaceuticals

Mohamed El Amine SELADJI *

Laboratory public services and development
Djilali Liabes University - Sidi Bel Abbes
Algeria

amineseladji3@gmail.com

Omar ABBAR

Laboratory public services and development
Djilali Liabes University - Sidi Bel Abbes
Algeria

abbar.omar@gmail.com

Date of submission: 24/06/2025 - Date of acceptance: 24/07/2025- Date of publication: 29/07/2025

Abstract: In medicine, it improves diagnostic accuracy, supports clinical decisions, monitors chronic conditions, and predicts diseases by analyzing large datasets. Machine learning enhances medical imaging and lab test analysis, reducing errors and improving efficiency.

In pharmaceuticals, AI accelerates drug discovery and clinical trials by identifying potential compounds and optimizing study design. It also enables personalized medicine through genetic data analysis and powers surgical robots, remote monitoring, and AI-based consultations.

However, challenges remain, including ethical issues, data privacy concerns, regulatory gaps, and limited professional training. Successful integration requires clear standards, interdisciplinary collaboration, and effective legal frameworks.

Keywords: pharmaceutical- medicine- artificial- application- patient- health

*Corresponding author: Mohamed El Amine SELADJI.

Introduction:

Artificial Intelligence (AI) refers to the simulation of human intelligence processes by machines, particularly computer systems. These processes include learning (acquiring data and creating rules for its use), reasoning (applying rules to reach approximate or definite conclusions), and self-correction. AI encompasses a wide range of subfields, including machine learning, natural language processing, robotics, and computer vision. As AI technologies advance, their applications continue to expand across various sectors, including healthcare, education, finance, manufacturing, and transportation.

In healthcare in particular, AI has shown remarkable potential to enhance diagnostics, improve treatment planning, support drug discovery, and optimize hospital operations. From AI-powered chatbots assisting patients to robotic surgeons performing delicate procedures, the technology is transforming how medical services are delivered and experienced.

Despite the rapid development of AI and its integration into health-related applications, several challenges remain. These include ethical dilemmas, data privacy concerns, regulatory uncertainties, and limited understanding among healthcare professionals of how AI systems operate. Moreover, the lack of clear frameworks for accountability, especially when AI-driven decisions impact patient safety, raises concerns about trust and adoption.

This study aims to explore the evolving role of artificial intelligence in the healthcare and pharmaceutical sectors, particularly its applications in drug development, medical diagnostics, and robotic surgery. It also seeks to identify the key challenges that hinder its widespread adoption and propose recommendations for ethical and effective implementation.

The significance of this study lies in its potential to provide a comprehensive understanding of how AI can enhance healthcare delivery and medical innovation. As the world continues to face growing health demands and complex diseases, AI offers scalable and data-driven solutions. By addressing the current limitations and clarifying its benefits, this research can help policymakers, medical professionals, and technologists align efforts to safely and efficiently integrate AI into healthcare systems.

Section one: Definitions by Renowned Sources:

1. Oxford English Dictionary:

"The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."

2. John McCarthy (Father of AI):

AI is defined as "the science and engineering of making intelligent machines, especially intelligent computer programs."

3. European Commission (2021):

"Artificial intelligence (AI) refers to systems that display intelligent behavior by analyzing their environment and taking actions—with some degree of autonomy—to achieve specific goals."

Artificial Intelligence in Medicine and Pharmaceuticals

4. Russell and Norvig, Artificial Intelligence: A Modern Approach:

AI is “the study of agents that receive percepts from the environment and perform actions.”

A- Key Characteristics of AI:

- Automation: Performing tasks without human intervention.
- Adaptability: Learning and improving from experiences.
- Autonomy: Making decisions independently based on data.

B- Applications of AI:

- Virtual assistants (e.g., Siri, Alexa)
- Predictive analytics
- Autonomous vehicles
- Medical diagnostics

For further reading:

- McCarthy, J. (2007). *What is Artificial Intelligence?. Stanford University.
- Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach. Pearson.

The intersection of Artificial Intelligence (AI) and law involves the application of AI technologies to legal processes, practices, and policies. AI is transforming how legal systems operate, from automating routine tasks to enhancing decision-making, but it also raises significant ethical, regulatory, and philosophical questions.

C- Applications of AI in Law:

1. Legal Research and Analysis:

AI-powered tools, such as Lexis Nexisor Westlaw Edge, use natural language processing (NLP) to analyze legal texts and provide relevant case law or statutory information¹.

- Example: AI systems can scan millions of pages to identify precedents in seconds, saving significant time for lawyers.

2. Contract Analysis and Drafting:

AI systems, like Law Geex or Kira Systems, automate the review and drafting of contracts by detecting inconsistencies or risky clauses.

¹ Surden, H. (2019). Artificial Intelligence and Law: An Overview. Annual Review of Law and Social Science, 15, p 433–450.

3. Predictive Analytics:

AI predicts legal outcomes based on historical case data. Tools like Premonition analyze past judicial decisions to estimate case outcomes².

4. Automating Routine Tasks:

- E-discovery tools, such as Relativity and Everlaw, automate document review in litigation.

- Chatbots like DoNotPay assist users with simple legal matters, such as appealing parking tickets³.

5. RegTech (Regulatory Technology):

AI helps organizations comply with legal standards by monitoring changes in regulations and ensuring adherence.

Section two: Challenges and Ethical Concerns:

1. Bias in AI Systems: Algorithms can inherit biases present in their training data, potentially leading to unfair or discriminatory outcomes.

Example: COMPAS, a tool used in the U.S. for criminal sentencing, has been criticized for racial bias.

2. Accountability and Liability: Determining responsibility when AI makes incorrect or harmful decisions remains a critical legal challenge.

3. Privacy Concerns: AI systems handling sensitive legal data must comply with regulations like the General Data Protection Regulation (GDPR).

4. Legal Personality of AI: Philosophical debates arise over whether AI systems should have legal status or be treated as tools.

A-Regulation of AI in Law:

1. Ethical Guidelines for AI: Documents like the European Commission's *Ethics Guidelines for Trustworthy AI* provide frameworks for AI development and usage in legal contexts.

2. Global Legislative Initiatives: European Union: The proposed Artificial Intelligence Act aims to regulate AI based on risk levels.

United States: Federal and state regulations, such as the Algorithmic Accountability Act, focus on transparency and fairness.

² <https://harvardlawreview.org>

³ Katyal, S. K. (2019). Private Accountability in the Age of Artificial Intelligence. *UCLA Law Review*, 66,p 54–116.

Artificial Intelligence in Medicine and Pharmaceuticals

3. AI in Courtrooms: Some jurisdictions are exploring AI for case management or even assisting judges, but with caution to avoid over-reliance.

Artificial Intelligence (AI) is revolutionizing medical robotics by enhancing precision, efficiency, and personalization in healthcare. AI-driven medical robots are used in various applications such as surgery, diagnostics, rehabilitation, and patient care. Below is an overview of the integration of AI in medical robotics, along with references to support the claims.

B- Applications of AI in Medical Robotics

1. Surgical Assistance: AI-powered robotic systems, like the da Vinci Surgical System, improve the precision and dexterity of surgeons. These robots assist in minimally invasive procedures, reducing recovery times and improving patient outcomes. Machine learning algorithms process vast amounts of data to guide robotic arms, ensuring precision in delicate tasks such as tumor resections⁴.

2. Diagnostics and Imaging: - AI-integrated robots can analyze medical images like MRIs and CT scans to detect abnormalities more accurately and quickly than traditional methods. Algorithms, such as convolutional neural networks (CNNs), enhance diagnostic capabilities by identifying patterns in imaging data⁵.

3. Rehabilitation Robotics - AI assists in designing adaptive rehabilitation programs tailored to individual patients. Robotic exoskeletons, enhanced by AI, help patients regain mobility and strength⁶.

- These systems use machine learning to monitor progress and adjust therapy in real time.

4. Patient Care and Assistance

- Robots with natural language processing (NLP) capabilities interact with patients, providing emotional support and reminders for medication.

- Robotic systems like "Pepper" or "Moxi" are designed to assist in caregiving tasks, reducing the workload on healthcare professionals⁷.

5. Drug Delivery and Pharmacy Automation

- AI-driven robotic systems ensure precise dispensing of medications and automate drug compounding in pharmacies⁸.

⁴ Hung, A. J., et al. (2018). "Validation of the da Vinci Xi Surgical System for Urological Surgery." *Journal of Urology*, 199(5), p1012-1018.

⁵ Esteva, A., et al. (2017). "Dermatologist-level classification of skin cancer with deep neural networks." p115–118.

⁶ Krebs, H. I., et al. (2013). "Robot-assisted neurorehabilitation." *Advances in Rehabilitation Science and Technology* p1-5.

⁷ Broadbent, E., et al. (2009). "Robots as medical assistants: An experimental study of a telepresence robot's role in managing healthcare delivery." *Journal of Medical Internet Research*, 11(2), e1

⁸ Ventola, C. L. (2014). "The role of medical robotics in pharmacy practice." *Pharmacy and Therapeutics* p176–178.

- These robots minimize human error, enhancing patient safety.

C- Benefits of AI in Medical Robotics

- Increased Precision: Machine learning algorithms improve the accuracy of surgical and diagnostic procedures, Personalized Treatment: AI adapts to patient-specific data, offering tailored healthcare solutions. Operational Efficiency: Robots reduce human workload and streamline repetitive tasks.

And improved Outcomes: Enhanced precision and adaptability lead to better patient care and faster recovery times.

D- Challenges and Ethical Considerations

- Data Privacy: Handling sensitive medical data requires robust security protocols.
- Cost: High development and implementation costs can limit accessibility.
- Accountability: Determining liability in cases of robotic errors remains complex.
- Bias in Algorithms: Ensuring diverse datasets is crucial to avoid biased AI systems⁹.

Section three: The Relationship Between Artificial Intelligence and Medicine:

A- The concept of medicine: Medicine refers to a chemical or biological substance used to prevent, diagnose, treat, or alleviate the symptoms of diseases, and it represents one of the fundamental pillars of the healthcare system. Medicines work by influencing physiological processes in the body¹⁰, often through interactions with specific molecules known as receptors or enzymes, thereby modifying or regulating certain biological functions. There are various types of medicines, including pain relievers, antibiotics, anti-inflammatory drugs, and medications for chronic conditions such as diabetes and hypertension¹¹.

The legal framework of medicine is a fundamental component of the public health system, as it governs the processes of developing, manufacturing, distributing, and marketing pharmaceutical products to ensure patient safety and treatment efficacy. In most countries, medications are subject to strict regulation by specialized authorities such as the U.S. Food and Drug Administration (FDA), the European Medicines Agency (EMA)¹², or national regulatory bodies in Arab countries. These agencies are responsible for evaluating the quality, effectiveness, and safety of drugs before granting marketing authorization.

This legal framework involves several mandatory stages, starting with licensing for research and development centers, approval for conducting clinical trials, scientific review of submitted data, and finally, granting marketing approval. Moreover, drug use is monitored even

⁹ Obermeyer, Z., et al. (2019). "Dissecting racial bias in an algorithm used to manage the health of populations." *Science* p 447–453.

¹⁰ Jumper, J. et al. (2021). Highly accurate protein structure prediction with AlphaFold. *Nature* P12.

¹¹ Obermeyer, Z., & Emanuel, E.J. (2016). Predicting the future — big data, machine learning, and clinicaledicine. *The New England Journal of Medicine* P 36.

¹² Zhavoronkov, A. (2020). Artificial Intelligence for Drug Discovery, Biomarker Development, and Generation of Novel Chemistry. *Molecular Pharmaceutics* p15.

Artificial Intelligence in Medicine and Pharmaceuticals

after it enters the market through a system known as pharmacovigilance, which aims to track side effects and ensure the long-term safety of the medication¹³.

Pharmaceutical legislation also imposes strict regulations on packaging, storage conditions, medical labeling, advertising, and drug distribution¹⁴. It defines the responsibilities of all stakeholders in the supply chain—from manufacturers to pharmacies—ensuring that patients' rights are protected, counterfeit or substandard drugs are prevented, and public trust in the healthcare system is reinforced.

With the rapid advancement of technology, legal frameworks have begun to adapt to new developments such as biological drugs, gene therapies, and the integration of artificial intelligence in drug development¹⁵. These innovations present emerging challenges that require ongoing updates to regulatory systems in order to strike a balance between fostering innovation and safeguarding public health.

B- The Relationship Between Artificial Intelligence and Medicine:

Artificial intelligence (AI) has become a cornerstone of the digital revolution in the healthcare sector, particularly in the field of drug discovery and development. Traditionally, developing a new drug could take 10 to 15 years and cost billions of dollars, with a success rate sometimes below 10%. However, AI has transformed this equation. Today, it is used to analyze massive databases containing molecular, clinical, and genetic information, allowing researchers to predict promising compounds and test their efficacy virtually before moving to laboratory experiments.

Machine learning and deep learning techniques are employed to identify hidden patterns in complex data—patterns that might be missed by human researchers. This accelerates the identification of biological targets for drugs and shortens the timeline for discovering new molecules¹⁶. AI also improves clinical trial design by selecting the most suitable participants based on their biological profiles and medical history, resulting in more efficient and cost-effective trials.

Moreover, AI is a driving force in the field of precision medicine, enabling the development of personalized treatments tailored to individual patients based on genetic analyses and lifestyle data, rather than relying on a one-size-fits-all approach. Its applications also extend to monitoring potential drug interactions, predicting side effects, and even accelerating vaccine development, as seen during the COVID-19 pandemic¹⁷.

Despite these advantages, several challenges still hinder the full integration of AI into the drug development pipeline. These include concerns over data privacy, algorithmic bias, and the need for clear regulatory frameworks. Nevertheless, the future is promising—AI is expected to

¹³ <https://www.pearson.com>.

¹⁴ Björnsson, B., et al. (2020). Digital twins to personalize medicine. *Genome Medicine*, p12.

¹⁵ Mak, K.-K., & Pichika, M.R. (2019). Artificial intelligence in drug development: present status and future prospects. *Drug Discovery Today* p 6.

¹⁶ DiMasi, J.A., Grabowski, H.G., & Hansen, R.W. (2016). Innovation in the pharmaceutical industry: New estimates of R&D costs. *Journal of Health Economics* p22.

¹⁷ Chen, H., Engkvist, O., Wang, Y., Olivecrona, M., & Blaschke, T. (2018). The rise of deep learning in drug discovery. *Drug Discovery Today* P14.

become a permanent partner in pharmaceutical laboratories and medical research centers worldwide¹⁸.

C- Health Products and Artificial Intelligence

The healthcare sector is undergoing unprecedented transformation through the integration of artificial intelligence (AI) technologies in the development of innovative health products aimed at improving the quality of care, enhancing prevention, and accelerating diagnosis and treatment. AI-powered health products range from smartphone applications that monitor users' vital signs—such as heart rate, oxygen levels, and physical activity—to wearable devices that use intelligent algorithms to analyze health data in real time¹⁹.

These products also include AI-assisted diagnostic systems capable of analyzing medical images such as X-rays, MRIs, and dermatological or ophthalmological scans with accuracy comparable to—if not surpassing—that of human physicians. In the realm of personalized medicine, AI technologies are used to analyze genetic and comprehensive health data to design individualized treatment plans, increasing therapeutic effectiveness and reducing side effects.

Such innovations are not limited to patients alone. Healthcare professionals also benefit from Clinical Decision Support Systems (CDSS) that provide evidence-based recommendations by analyzing thousands of medical records and scientific studies. Additionally, AI-powered medical chatbots are being used to offer fast, guided preliminary consultations, particularly in areas suffering from shortages of medical staff²⁰.

Despite these advancements, such products require robust legal regulation and ethical safeguards to protect user privacy and avoid overreliance on technology. Nevertheless, the integration of artificial intelligence in health products paves the way toward a smarter, more efficient, and more equitable future in healthcare.

Conclusion:

AI in medical robotics holds immense potential to transform healthcare by improving precision, efficiency, and patient outcomes. Intelligent robotic systems are increasingly being used in a variety of clinical settings—from robotic-assisted surgeries and rehabilitation devices to automated diagnostic tools and hospital logistics systems. These AI-enhanced robots can perform complex tasks with greater accuracy than human hands, reduce the margin of error during surgeries, and enable minimally invasive procedures that result in faster recovery times and reduced complications.

Moreover, AI algorithms embedded within these robots can continuously learn from vast datasets, including surgical recordings, sensor inputs, and patient feedback. This learning capability allows robotic systems to optimize their performance over time and adapt to individual patient needs. In rehabilitation, for instance, robotic exoskeletons powered by AI can

¹⁸ Mak, K.-K., & Pichika, M.R. (2019). Artificial intelligence in drug development: present status and future prospects. *Drug Discovery Today*.

¹⁹ Ramesh, A. N., et al. (2004). Artificial intelligence in medicine. *Annals of the Royal College of Surgeons of England* p40.

²⁰ Topol, E. (2019). *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*. Basic books p9.

Artificial Intelligence in Medicine and Pharmaceuticals

tailor movement support to the user's progress, providing dynamic feedback and improving motor recovery outcomes.

In hospital environments, AI-driven robots are also streamlining non-clinical tasks such as medication delivery, sanitation, and inventory management, thereby reducing the burden on healthcare workers and minimizing human exposure to infectious diseases, especially during pandemics.

However, the integration of AI in medical robotics is not without challenges. Ethical concerns such as accountability in case of error, patient consent, and the risk of over-reliance on machines must be addressed. Additionally, practical barriers like high implementation costs, data privacy risks, and the need for specialized training can hinder widespread adoption.

Recommendations:

- **Develop Clear Ethical Guidelines:** Regulatory bodies should collaborate with medical experts and technologists to establish frameworks for responsibility, data handling, and transparency in AI-assisted robotic procedures.

- **Invest in Training and Education:** Healthcare professionals must receive hands-on training to work effectively with AI-augmented robots, ensuring both safety and confidence in their use.

- **Support Interdisciplinary Research:** Governments and institutions should promote research that brings together AI developers, biomedical engineers, and clinicians to design patient-centered robotic solutions.

- **Ensure Equity of Access:** Policies should aim to make robotic technologies accessible in both urban and underserved healthcare settings, minimizing health disparities.

- **Promote Post-Deployment Monitoring:** Continuous monitoring and evaluation of robotic systems in real-world clinical use can help refine performance and maintain patient trust.

By proactively addressing these considerations, AI in medical robotics can become a cornerstone of next-generation healthcare, delivering safer, smarter, and more equitable services.