ARTIFICIAL INTELLIGENCE IN CLINICAL PHARMACOLOGY: CURRENT APPLICATIONS, CHALLENGES, AND FUTURE PERSPECTIVES

Mirzaolimova Mohijamol Kodirjon kizi
Namangan International Medical College,
University of Business and Science, Namangan Region, Uzbekistan
E-mail: mohijamolmirzaolimova52@gmail.com

MAQOLA MALUMOTI

MAQOLA TARIXI:
Received:26.06.2026
Revised: 27.06.2026
Accepted:28.06.2026

KALIT SO'ZLAR:
Artificial Intelligence, Clinical Pharmacology, Machine Learning, Precision Medicine, Pharmacogenomics, Drug Discovery..

ANNOTATSIYA:

Artificial intelligence (AI) has rapidly transformed numerous aspects of modern healthcare, including clinical pharmacology. Machine learning, deep learning, and advanced predictive analytics have enhanced drug discovery, individualized therapy, pharmacovigilance, and clinical decision-making. AI-based technologies facilitate the analysis of large biomedical datasets, allowing clinicians to optimize drug selection, improve treatment safety, and reduce adverse drug reactions. This review summarizes current evidence regarding the applications of artificial intelligence in clinical pharmacology, discusses existing challenges, and explores future perspectives. Literature published in major scientific databases was evaluated, focusing on AI-assisted drug development, precision medicine, therapeutic drug monitoring, pharmacogenomics, and medication safety.

Current evidence indicates that AI has considerable potential to improve pharmacological practice by supporting personalized medicine and optimizing therapeutic outcomes. However, issues related to data quality, algorithm transparency, ethical considerations, *and regulatory approval remain significant barriers to widespread implementation.*

Introduction

Clinical pharmacology is a multidisciplinary medical science focused on the safe and effective use of medicines in humans. Increasing therapeutic complexity, expanding pharmaceutical databases, and the growing availability of electronic health records have created opportunities for artificial intelligence to transform pharmacological research and clinical practice. Artificial intelligence refers to computational systems capable of performing tasks that traditionally require human intelligence, including pattern recognition, prediction, decision-making, and natural language processing. In recent years, AI has become increasingly integrated into drug discovery, pharmacokinetic modeling, adverse drug reaction prediction, and personalized medicine.

Traditional drug development requires considerable financial investment and often takes more than ten years from discovery to clinical application. AI technologies have significantly accelerated this process by identifying promising molecular targets, predicting biological activity, and optimizing clinical trial design.

Furthermore, individualized pharmacotherapy has become increasingly important due to substantial interindividual variability in drug metabolism, efficacy, and toxicity. AI algorithms integrating pharmacogenomic, clinical, and laboratory information provide valuable support for personalized therapeutic decision-making.

Aim of the Study

To review current scientific evidence regarding the applications of artificial intelligence in clinical pharmacology, evaluate its advantages and limitations, and discuss future perspectives for AI-assisted pharmacological practice.

Materials and Methods

A narrative review of published scientific literature was conducted using PubMed, Scopus, Web of Science, and Google Scholar databases. Publications published between 2020 and 2026 focusing on artificial intelligence, clinical pharmacology, pharmacogenomics, machine learning, precision medicine, and drug discovery were included. Original clinical investigations, systematic reviews, meta-analyses, and high-quality review articles published in English were evaluated. Conference abstracts, duplicate publications, editorials, and studies lacking sufficient methodological quality were excluded.

The selected studies were analyzed according to research objectives, AI methodology, pharmacological applications, clinical outcomes, limitations, and future implications.

Results

The reviewed literature demonstrates rapid expansion of AI applications throughout clinical pharmacology. Machine learning algorithms have significantly accelerated drug discovery by identifying novel therapeutic compounds and predicting drug-target interactions. Several pharmaceutical companies now utilize deep learning models to reduce development time and research costs.

Artificial intelligence has also improved pharmacogenomic analysis by integrating genomic information with clinical characteristics to predict individual responses to medications. Personalized therapeutic recommendations generated by AI systems may reduce treatment failure and adverse drug reactions.

In pharmacovigilance, natural language processing algorithms analyze millions of electronic health records and adverse event reports, enabling earlier identification of medication safety signals than conventional surveillance systems.

AI-assisted therapeutic drug monitoring has demonstrated improved dosing accuracy for medications with narrow therapeutic indices, including anticoagulants, immunosuppressants, and certain antimicrobial agents.

Additionally, predictive models have successfully identified patients at increased risk of drug toxicity, hospital readmission, and medication-related complications.

Discussion

The integration of artificial intelligence into clinical pharmacology represents one of the most significant technological advances in modern medicine. AI enables simultaneous analysis of complex biological, clinical, pharmacological, and genomic datasets that exceed human analytical capacity. Machine learning models improve therapeutic decision-making by recognizing hidden patterns associated with drug efficacy and toxicity. Personalized medicine supported by AI has the potential to replace traditional "one-size-fits-all" therapeutic approaches with individualized treatment strategies.

Despite these advantages, several important challenges remain. High-quality clinical data are essential for algorithm development, yet incomplete or biased datasets may reduce predictive accuracy. Algorithm transparency, interpretability, patient privacy, cybersecurity, and ethical considerations continue to limit widespread implementation.

Regulatory authorities are developing new frameworks for validation and approval of AI-based medical software. Close collaboration among clinicians, pharmacologists, computer scientists, and regulatory agencies will be essential for successful integration of AI into routine pharmacological practice.

Future research should emphasize prospective multicenter clinical trials evaluating AI-assisted pharmacotherapy, cost-effectiveness analyses, and standardized reporting guidelines for AI applications in medicine.

Conclusion

Artificial intelligence has become an increasingly valuable tool in clinical pharmacology, improving drug discovery, individualized therapy, pharmacovigilance, and clinical decision-making. Although significant technical, ethical, and regulatory challenges remain, current evidence suggests that AI will play a central role in the future of precision medicine.

Continued interdisciplinary research and international collaboration will facilitate safe and effective implementation of AI technologies in pharmacological practice, ultimately improving patient outcomes and healthcare quality.

Conflict of Interest

The authors declare no conflict of interest.

Funding

This study received no external financial support.

References (Sample)

1. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019.
2. Esteva A, Robicquet A, Ramsundar B, et al. A guide to deep learning in healthcare. Nat Med. 2019.
3. Paul D, Sanap G, Shenoy S, et al. Artificial intelligence in drug discovery and development. Drug Discov Today. 2021.
4. Zhavoronkov A. Artificial intelligence for drug discovery. Nat Rev Drug Discov. 2022.
5. Chen H, Engkvist O, Wang Y, et al. The rise of deep learning in drug discovery. Drug Discov Today. 2018.
6. Pesapane F, Codari M, Sardanelli F. Artificial intelligence in medical imaging. Eur Radiol Exp. 2018.
7. Rajkomar A, Dean J, Kohane I. Machine learning in medicine. N Engl J Med. 2019.
8. Beam AL, Kohane IS. Big data and machine learning in healthcare. JAMA. 2018.
9. Collins FS, Varmus H. A new initiative on precision medicine. N Engl J Med. 2015.
10. Johnson KB, Wei WQ, Weeraratne D, et al. Precision medicine and AI. Nat Med. 2021.