

Re-Imagining Personalized Medicine through Artificial Intelligence: From Diagnosis to Drug Delivery

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ABSTRACT

By enabling previously unheard-of personalization of medical treatments through advanced computer analysis of intricate biomedical data, Artificial Intelligence (AI) has emerged as a revolutionary force in precision medicine. The changing field of AI applications in precision medicine is examined in this study, which highlights both well-established technology and cutting-edge developments that are changing clinical practice. AI is transforming every aspect of patient care in the field of personalized medicine, from early diagnosis and risk assessment to the development of tailored treatment regimens and targeted drug delivery systems. Large-scale medical data, computational modelling, and state-of-the-art machine learning algorithms have come together to enable these developments. This study investigates how AI improves personalized illness management through the integration of technology from several domains, such as clinical decision support systems, genomic data analysis, medical imaging, and predictive analytics. AI's capacity to interpret genetic data and analyze medical imaging allows for both early and precise disease detection as well as patient-specific treatment plans. Additionally, by combining traditional and complementary therapies, AI-driven technologies promote integrative medicine, optimize therapy pathways, and modify medication regimens. AI improves the efficiency of healthcare workflows by streamlining administrative chores in addition to its clinical applications. The study's findings suggest that AI has significantly improved diagnostic accuracy, shortened the time needed to identify diseases, and increased the efficacy of individualized treatment regimens.

Keywords: Artificial intelligence, Drug Delivery Optimization, Personalized healthcare, Precision Therapeutics.

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INTRODUCTION

Healthcare is undergoing a remarkable transformation as advances in Artificial Intelligence (AI) and biomedical science reshape the way diseases are diagnosed, treated, and managed. Traditional medical practice has long relied on standardized treatment approaches, where patients with the same disease often receive similar therapies despite differences in their genetic makeup, lifestyle, environment, and overall health. However, growing evidence shows that individuals can respond very differently to the same treatment, highlighting the need for a more personalized approach to healthcare (Seyedhamzeh *et al.*, 2025).

Personalized medicine aims to provide the right treatment to the right patient at the right time by considering each

individual's unique biological and clinical characteristics. Recent breakthroughs in genomics, molecular biology, medical imaging, wearable technologies, and electronic health records have generated enormous amounts of patient-specific data. While these data hold tremendous potential for improving healthcare, their complexity makes them difficult to interpret using conventional analytical methods. Artificial intelligence has emerged as a powerful solution by enabling the rapid analysis of complex datasets, identifying hidden patterns, predicting disease risk, and supporting evidence-based clinical decision-making (Wei *et al.*, 2026).

The integration of AI into personalized medicine is redefining every stage of the healthcare journey. During diagnosis, AI-powered algorithms can analyse medical images, laboratory findings, genomic information, and clinical records with remarkable speed and accuracy, helping clinicians detect diseases earlier and make more precise diagnoses. In disease prediction and prognosis, machine learning models can estimate an individual's risk of developing specific conditions and forecast disease progression, enabling timely interventions and preventive strategies. AI also supports treatment selection by identifying



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therapies that are most likely to benefit a particular patient while minimizing adverse effects (Panchpuri *et al.*, 2025).

Beyond diagnosis and treatment planning, AI is transforming drug discovery, development, and delivery. By analysing biological pathways, molecular interactions, and clinical data, AI accelerates the identification of novel drug targets, predicts drug responses, and facilitates drug repurposing, significantly reducing the time and cost associated with pharmaceutical development. In drug delivery, AI contributes to the design of intelligent delivery systems capable of optimizing dosage, improving targeted delivery, and enabling real-time monitoring of therapeutic outcomes. These innovations enhance treatment efficacy, reduce toxicity, and improve patient adherence, bringing personalized medicine closer to routine clinical practice (Singh *et al.*, 2024).

Despite its enormous potential, the widespread adoption of AI-driven personalized medicine is accompanied by important challenges. Issues related to data privacy, algorithmic bias, model transparency, regulatory approval, ethical considerations, and equitable access must be addressed to ensure that AI technologies are safe, reliable, and beneficial for diverse patient populations. Collaborative efforts among healthcare professionals, data scientists, researchers, regulatory authorities, and policymakers will be essential for translating AI innovations into effective clinical solutions (Amin *et al.*, 2025).

Re-imagining personalized medicine through artificial intelligence represents more than a technological advancement; it signifies a fundamental shift toward predictive, preventive, precise, and patient-centered healthcare. By bridging diagnosis, therapeutic decision-making, and intelligent drug delivery, AI has the potential to improve clinical outcomes, optimize healthcare resources, and shape the future of modern medicine. As AI technologies continue to evolve, their integration into personalized medicine is expected to transform healthcare into a more efficient, accurate, and individualized system that ultimately enhances the quality of patient care (Figure 1) (Thorat *et al.*, 2026).

EXPANDING HORIZONS OF AI ACROSS VARIOUS FIELDS

Role Of AI in Diagnosis

Artificial intelligence has significantly enhanced disease diagnosis by improving the speed, accuracy, and reliability of clinical decision-making. AI systems utilize machine learning and deep learning algorithms to analyze diverse healthcare data, including medical images, laboratory investigations, patient histories, and electronic health records. These algorithms can detect subtle disease patterns that may be overlooked during conventional examination, thereby enabling earlier diagnosis and timely clinical intervention (Thorat *et al.*, 2026).

One of the most successful applications of AI is in medical imaging. AI-powered systems assist radiologists in interpreting X-rays, CT scans, MRI images, mammograms, and pathology slides with remarkable precision. Diseases such as breast cancer, lung cancer, diabetic retinopathy, Alzheimer's disease, and cardiovascular disorders can be detected at earlier stages, significantly improving treatment success rates. Beyond imaging, AI also predicts disease risk by integrating genetic information, lifestyle factors, biomarkers, and family medical history. Predictive models support clinicians in identifying high-risk individuals before symptoms become severe, allowing preventive healthcare strategies to be implemented. Additionally, AI-based clinical decision support systems provide evidence-based recommendations that reduce diagnostic variability and enhance patient safety. By enabling accurate, personalized, and timely diagnosis, AI serves as the foundation of precision medicine and supports the delivery of individualized healthcare (Barrett *et al.*, 2019).

AI in Genomics

Genomics plays a central role in personalized medicine because genetic variations influence disease susceptibility, progression, and response to treatment. Advances in next-generation sequencing have generated vast amounts of genomic data that are difficult to interpret using traditional analytical methods. Artificial Intelligence addresses this challenge by rapidly processing complex genomic datasets and identifying clinically relevant genetic variations associated with specific diseases (Rajaram *et al.*, 2025).

Machine learning algorithms analyze DNA sequences, gene expression profiles, and molecular biomarkers to detect disease-causing mutations and predict individual responses to medications. AI also supports biomarker discovery by identifying molecular signatures that assist in early diagnosis, prognosis, and treatment selection. In oncology, AI has become particularly valuable in precision cancer medicine, where tumor genomic profiles are analyzed to recommend targeted therapies specific to an individual's genetic mutations. Furthermore, AI contributes to pharmacogenomics by predicting how genetic differences influence drug metabolism, efficacy, and toxicity. This information enables clinicians to prescribe medications that maximize therapeutic benefits while minimizing adverse drug reactions. By integrating genomic information with clinical and environmental data, AI enhances the development of personalized treatment strategies and facilitates more accurate disease prediction, making genomic medicine more practical and accessible in routine clinical practice (Ali *et al.*, 2026).

AI in Drug Discovery

Drug discovery is traditionally a lengthy, expensive, and high-risk process that often requires more than a decade to develop a new therapeutic agent. Artificial Intelligence has transformed this

field by accelerating the identification, design, and optimization of potential drug candidates. AI algorithms rapidly analyze millions of chemical compounds, biological targets, and scientific publications to identify promising molecules with high therapeutic potential (Ali *et al.*, 2026).

Machine learning models predict drug-target interactions, estimate toxicity, optimize molecular structures, and prioritize compounds for laboratory testing. These capabilities significantly reduce research costs and shorten the time required for drug development. AI also supports drug repositioning, an approach in which existing approved drugs are identified for new therapeutic indications. Since the safety profiles of these drugs are already established, drug repositioning offers a faster and more cost-effective pathway for treating emerging diseases. During recent global health emergencies, AI demonstrated its value by accelerating candidate drug identification and vaccine research. Furthermore, AI integrates genomic and clinical information to facilitate personalized drug development, ensuring that therapies are better matched to specific patient populations. As a result, AI is reshaping pharmaceutical research by making drug discovery more efficient, precise, and patient-focused (Subramanian *et al.*, 2020).

AI in Treatment Selection

Selecting the most appropriate treatment for an individual patient is one of the primary goals of personalized medicine. Artificial Intelligence supports this objective by integrating multiple sources of patient information, including genetic profiles, clinical history, laboratory findings, medical imaging, and lifestyle characteristics. By analyzing these complex datasets simultaneously, AI predicts which treatment is most likely to produce favorable outcomes for a specific patient.

Machine learning algorithms evaluate previous clinical cases and treatment responses to identify patterns associated with therapeutic success or failure. This evidence-based approach helps clinicians choose medications, treatment combinations, and dosage regimens that are tailored to each patient's biological characteristics. In cancer care, for example, AI analyzes tumor genetics to recommend targeted therapies and immunotherapies that are more likely to be effective than conventional chemotherapy. AI also supports treatment monitoring by continuously evaluating patient responses and recommending modifications when necessary. Such adaptive treatment strategies improve clinical outcomes while reducing unnecessary side effects and healthcare costs. By minimizing trial-and-error prescribing and promoting individualized therapeutic decisions, AI contributes significantly to safer, more efficient, and patient-centered medical care (Seyedhamzeh *et al.*, 2025).

AI in Drug Delivery

Drug delivery is a critical component of personalized medicine because therapeutic success depends not only on selecting the right drug but also on delivering it to the correct target at the appropriate dose and time. Artificial Intelligence has introduced significant innovations in this area by optimizing drug delivery systems through predictive modeling and intelligent design. AI analyzes patient-specific factors, disease characteristics, and pharmacokinetic data to recommend personalized dosing schedules and delivery methods (Wei *et al.*, 2026).

AI also plays a vital role in the development of targeted drug delivery systems, particularly those based on nanotechnology. Smart nanoparticles can transport drugs directly to diseased tissues, reducing exposure to healthy organs and minimizing adverse effects. Machine learning models predict drug release behavior, carrier stability, and therapeutic efficiency, enabling researchers to design more effective delivery platforms. In oncology, AI-guided nanocarriers improve the precision of chemotherapy by concentrating drugs at tumor sites while reducing systemic toxicity. Furthermore, AI supports the integration of wearable devices and smart sensors that monitor patient responses in real time and enable adaptive drug administration. These advancements improve therapeutic effectiveness, reduce complications, and represent a major step toward fully personalized healthcare.

Clinical Applications

Artificial Intelligence has significantly expanded the clinical applications of personalized medicine by enabling more accurate diagnosis, individualized treatment planning, and continuous patient monitoring across multiple medical specialties. In oncology, AI analyzes genomic profiles, tumor characteristics, and clinical records to identify targeted therapies and predict treatment responses, thereby improving survival rates while minimizing unnecessary toxicity. In cardiology, AI-based algorithms evaluate electrocardiograms, echocardiograms, and patient health records to detect cardiovascular diseases at an early stage and estimate the risk of future cardiac events.

Neurology has also benefited from AI, particularly in the early detection of neurodegenerative disorders such as Alzheimer's and Parkinson's diseases through advanced analysis of brain imaging and cognitive data. In diabetes management, AI-powered wearable devices and continuous glucose monitoring systems provide real-time recommendations for insulin dosing and lifestyle modifications, enabling personalized disease management. AI also assists in diagnosing rare genetic disorders by identifying disease-causing mutations from genomic sequencing data, reducing the time required for accurate diagnosis. Furthermore, AI supports infectious disease surveillance, intensive care monitoring, and personalized rehabilitation programs. Across these diverse clinical settings, AI improves decision-making,

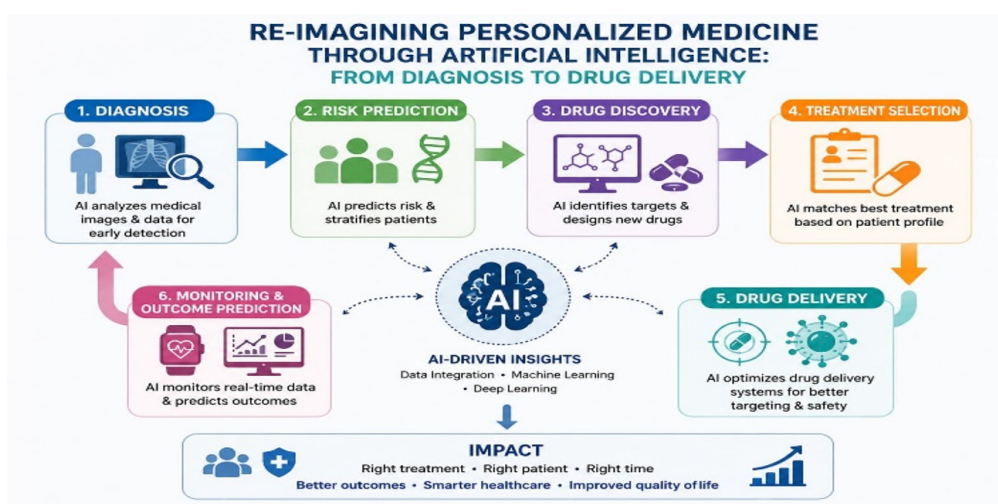


Figure 1: AI-enabled personalized medicine workflow.

reduces diagnostic errors, enhances treatment precision, and promotes patient-centered healthcare, making personalized medicine more effective and accessible in routine clinical practice (Panchpuri *et al.*, 2025).

CHALLENGES

Despite its remarkable potential, the integration of Artificial Intelligence into personalized medicine faces several scientific, technical, ethical, and regulatory challenges. One of the primary concerns is data privacy and security, as AI systems require access to large volumes of sensitive patient information, including genomic data and electronic health records. Ensuring confidentiality while maintaining data accessibility remains a significant challenge. Another important limitation is algorithmic bias, which occurs when AI models are trained on datasets that do not adequately represent diverse populations. Such bias may lead to inaccurate predictions and unequal healthcare outcomes for certain patient groups.

The lack of transparency in many AI models, often referred to as the "black-box" problem, makes it difficult for clinicians to understand how specific decisions are generated. This limitation can reduce trust and hinder widespread clinical adoption. In addition, AI systems require high-quality, standardized, and well-annotated datasets, which are not always available across healthcare institutions. Regulatory approval, legal responsibility, and ethical considerations surrounding AI-assisted medical decisions also remain evolving areas. Furthermore, integrating AI technologies into existing healthcare infrastructure requires significant financial investment, technical expertise, and continuous validation. Addressing these challenges through robust regulations, transparent algorithms, interdisciplinary collaboration, and responsible data governance will be essential for ensuring the safe and equitable implementation of AI in personalized medicine.

FUTURE PERSPECTIVES

The future of personalized medicine will be increasingly shaped by the continued evolution of Artificial Intelligence and related digital technologies. Emerging AI models are expected to become more accurate, transparent, and capable of integrating multiple sources of biomedical information, including genomic, proteomic, metabolomic, imaging, and real-time physiological data. One of the most promising developments is the concept of digital twins, which involves creating virtual models of individual patients to simulate disease progression and predict responses to different treatment strategies before actual clinical intervention.

Federated learning is another important advancement that allows AI models to learn from healthcare data stored at multiple institutions without transferring sensitive patient information, thereby improving privacy and security. Explainable Artificial Intelligence (XAI) is expected to increase clinicians' confidence by providing understandable explanations for AI-generated predictions and recommendations. In addition, the integration of AI with wearable devices, biosensors, telemedicine, and the Internet of Medical Things (IoMT) will facilitate continuous health monitoring and enable real-time personalized interventions. AI-driven nanomedicine and smart drug delivery platforms are also likely to improve treatment precision by delivering medications directly to targeted tissues while minimizing adverse effects. As these technologies continue to mature, AI will support a healthcare system that is more predictive, preventive, personalized, and patient-centered, ultimately improving clinical outcomes and enhancing the overall quality of healthcare delivery.

CONCLUSION

Artificial intelligence has emerged as a transformative force in personalized medicine by enabling healthcare systems to deliver more accurate, efficient, and individualized patient care. From early disease diagnosis and genomic analysis to drug

discovery, treatment selection, and intelligent drug delivery, AI has improved nearly every stage of the healthcare continuum. Its ability to analyze vast and complex biomedical datasets allows clinicians to make evidence-based decisions tailored to the unique characteristics of each patient, thereby enhancing therapeutic effectiveness and reducing adverse drug reactions.

Although significant progress has been achieved, important challenges related to data privacy, algorithm transparency, ethical concerns, regulatory frameworks, and clinical validation must be carefully addressed before AI can be fully integrated into routine healthcare practice. Continuous collaboration among healthcare professionals, researchers, data scientists, policymakers, and regulatory agencies will be essential to ensure the responsible development and implementation of AI technologies. Looking ahead, innovations such as explainable AI, digital twins, federated learning, and AI-powered smart drug delivery systems have the potential to further transform precision healthcare. Overall, the integration of artificial intelligence into personalized medicine represents a major step toward a future where healthcare is predictive, preventive, personalized, and patient-centred, ultimately improving patient outcomes and advancing global healthcare.

ABBREVIATIONS

AI: Artificial Intelligence; **CT:** Computed Tomography; **MRI:** Magnetic Resonance Imaging; **XAI:** Explainable Artificial Intelligence; **IoMT:** Internet of Medical Things.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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