

Review Article

Artificial Intelligence and Machine Learning as Catalysts for Precision Medicine: Implications for Diagnosis and Drug Development

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Abstract:

Precision medicine aims to deliver the right treatment to the right patient at the right time, yet its widespread clinical adoption remains limited by challenges in accurate diagnosis, slow drug development processes and the difficulty of translating complex biological data into actionable clinical decisions. Conventional diagnostic and therapeutic approaches often rely on population averages, which can overlook individual genetic, molecular and clinical differences, leading to variable treatment responses and high drug development failure rates. In recent years, Artificial Intelligence (AI) and Machine Learning (ML) have gained increasing attention as clinical support tools capable of analyzing complex and large-scale biomedical data, improving diagnostic accuracy, accelerating drug development and enabling more personalized approaches to patient care. This study presents a systematic literature review conducted in accordance with the PRISMA guidelines, examining recent evidence on how AI and ML act as catalysts for precision medicine, particularly in diagnosis and drug development. Peer-reviewed studies published between 2019 and 2025 were systematically identified from major academic databases and screened using predefined inclusion and exclusion criteria. The selected studies were analyzed to assess clinical applications, AI techniques employed and their implications for personalized healthcare and pharmaceutical innovation. The findings indicate that AI and ML significantly enhance diagnostic accuracy through applications in medical imaging, genomics and electronic health record analysis, supporting earlier and more precise disease detection. In drug development, AI-driven methods improve target identification, lead optimization, toxicity prediction and clinical trial design, contributing to reduced development time and cost. Furthermore, the integration of multi-omics and clinical data through AI enables more personalized treatment strategies, improving therapeutic selection and dosing. This study concludes that AI and ML are powerful catalysts for precision medicine and capable of bridging the gap between complex biomedical data and clinical decision-making. With appropriate validation, explainable models and robust ethical and regulatory frameworks, these technologies have the potential to accelerate drug development and support clinicians in delivering more accurate diagnoses, more effective treatments and safer patient-centered, precision-based healthcare.

Keywords: Artificial intelligence (AI); Machine Learning (ML); Precision Medicine; Diagnosis; Drug Development

Introduction

Artificial Intelligence (AI) and Machine Learning (ML) are transforming healthcare in ways that were unimaginable just a few years ago. These technologies are increasingly being applied in diagnosis, personalized medicine and drug development, offering opportunities to make treatments faster, safer and more tailored to individual patients (Kaggwa, 2025; Johansson & Carter, 2025). By analyzing vast amounts of biological, chemical and clinical data, AI can uncover patterns that humans might miss, predict outcomes more accurately and even suggest entirely new therapeutic strategies (Serrano et al., 2024; Amin & Rahman, 2025). Traditionally, drug discovery has been a lengthy, expensive and high-risk process, often taking decades and billions of dollars to bring a new medicine to market. AI and ML offer a way to accelerate this process by predicting which compounds are likely to work, optimizing clinical trials and minimizing failures in late-stage development (Wang et al., 2019; Sethuraman, 2020). In addition, AI-driven techniques such as deep learning, neural networks and explainable AI have improved transparency and interpretability, allowing researchers to trust and validate AI predictions while collaborating effectively across disciplines (Jiménez-Luna et al., 2020; Archer & Germain, 2021).

In diagnosis, AI tools can analyze medical images, genetic data and electronic health records to detect diseases earlier and more accurately than conventional methods (Gaonkar et al., 2025; Ghosh & Datta, 2025). For example, AI systems can identify subtle patterns in radiology scans or predict cardiovascular risks from electrocardiograms, helping clinicians make informed decisions and improve patient outcomes (Abbas et al., 2025; Zeng et al., 2026). Personalized medicine, also called precision medicine, takes this a step further by tailoring treatments to individual patients' genetic makeup, lifestyle and disease profile. AI plays a critical role here, integrating multi-omics data, pharmacogenomics and patient histories to design therapies that are more effective and have fewer side effects (Roy, 2025; Koul & Koul, 2025). Machine learning models can even predict drug response, optimize dosing and support the design of patient-specific drug delivery systems, making healthcare more targeted and efficient (Panchpuri et al., 2025).

Despite advances in medical research, many patients still receive treatments that are not optimally

tailored to their genetic makeup, lifestyle or disease profile, leading to suboptimal outcomes and avoidable side effects (Roy, 2025; Amin & Rahman, 2025). Although AI and ML hold immense promise to address these challenges, their full potential has not yet been realized. Current applications show great strides in speeding up drug discovery, improving diagnostic accuracy and supporting personalized medicine (Johansson & Carter, 2025; Serrano et al., 2024), but several barriers remain. These include data quality issues, lack of interpretability of AI models, ethical concerns and limited integration of AI tools into standard clinical and pharmaceutical workflows. As a result, the healthcare system struggles to harness AI's capabilities efficiently, leaving a gap between technological potential and practical implementation (Jiménez-Luna et al., 2020; Uriti, 2025).

Several studies have demonstrated that AI and ML have the capacities to accelerate drug discovery, optimize clinical trials and improve patient-specific treatment planning (Sethuraman, 2020; Moingeon, 2021; Parvathaneni et al., 2023). However, a comprehensive understanding of how these technologies simultaneously impact diagnosis, personalized medicine and drug development remains limited. Most research focuses on isolated applications, either on drug discovery pipelines or on AI-assisted diagnostics, without exploring the synergistic potential of AI across the entire healthcare continuum (Craig et al., 2022; Zeng et al., 2026).

Additionally, while several studies highlight AI's predictive capabilities, issues of explainability, ethical implementation and integration with real-world healthcare workflows are not adequately addressed (Jiménez-Luna et al., 2020; Abbas et al., 2025). This creates uncertainty for clinicians, researchers and policymakers about how to adopt AI safely and effectively, particularly in personalized medicine where patient-specific factors are critical (Otolape, 2026). Therefore, there is a clear need for a systematic, holistic review that synthesizes current knowledge on AI and ML applications in diagnosis, personalized medicine and drug development, identifies practical challenges and ethical considerations and highlights opportunities for future research. This study seeks to fill this gap by providing a detailed, integrated understanding of AI's transformative potential across these critical areas of healthcare.

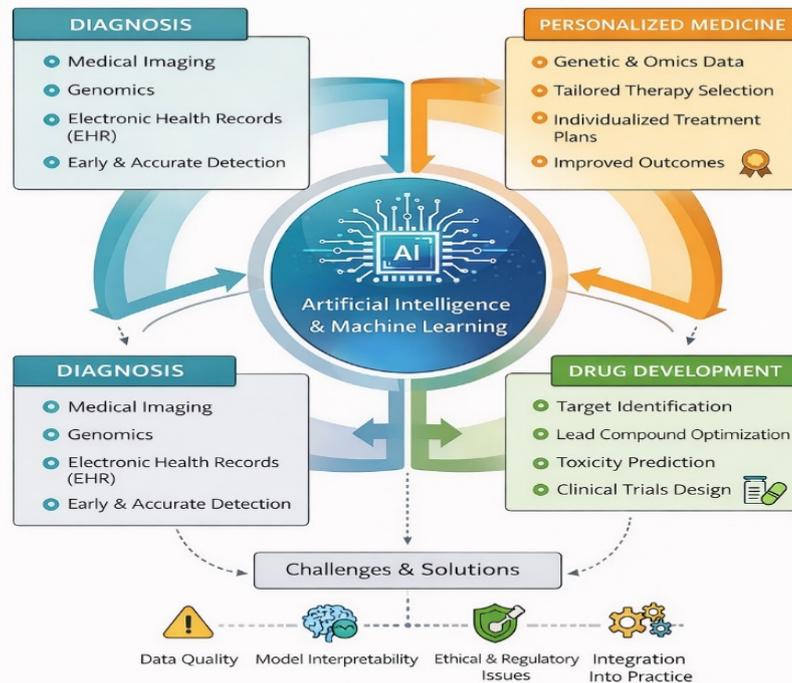
Conceptual Framework

The conceptual framework illustrates how Artificial Intelligence (AI) and Machine Learning (ML)

act as central enablers in transforming modern healthcare. At the core of the framework, AI and ML

techniques process and analyze large volumes of health-related data, including medical images, genomic

information and electronic health records (Bansah, 2024; Otunlape, 2026).



Source: Authors

Figure 1: Conceptual Framework

AI and ML influence three key application domains. In diagnosis, AI and ML enhance early detection and diagnostic accuracy through advanced pattern recognition and predictive analytics. In personalized medicine, AI integrates genetic, clinical, and lifestyle data to support tailored treatment decisions and improve patient outcomes (Okolo et al., 2022). In drug development, AI accelerates target identification, lead compound optimization, toxicity prediction, and clinical trial design, thereby reducing time and cost. The framework in Figure 1 also highlights cross-cutting challenges, such as data quality, model interpretability, ethical and regulatory concerns, and integration into existing medical workflows (Bansah, 2024; Otunlape, 2026). Addressing these challenges is essential to ensure that AI-driven healthcare solutions are safe, transparent, and patient-centered (Olorunfemi et al., 2024; Okolo et al., 2024).

Review of Related Studies

Artificial Intelligence (AI) and Machine Learning (ML) are gradually changing the way healthcare works, especially in areas like drug discovery, diagnosis and personalized medicine. When you look across the existing studies, one thing becomes very clear: most researchers agree that AI can make drug development much faster and more efficient. For example, Wang et al. (2019), Tang et al. (2021) and Mhatre (2023) all show how AI can process very large

and complex datasets, something that would take humans a long time to handle and use this information to predict how drugs will interact with targets in the body. This helps scientists identify promising drug candidates earlier in the process. In the same way, Sethuraman (2020) and Sahgal and Sundarasekar (2024) explain how AI can improve drug formulation and manufacturing processes, making them more cost-effective. Taken together, these studies strongly agree that AI reduces the time, cost and uncertainty that usually come with developing new drugs.

That said, when we look a little deeper, not all studies agree on how ready these AI tools are for real-world use. Some researchers are quite optimistic. For instance, Parvathaneni et al. (2023) highlight advanced tools like AlphaFold and Deep Docking as major breakthroughs, suggesting that AI is already solving real problems in drug discovery. On the other hand, studies like Ujjwal (2024) and Acharjee et al. (2023) take a more cautious view. They argue that while AI looks promising, many of these tools are still being tested and have not been fully validated in real clinical environments. This difference in opinion is important because it shows that AI is not at the same stage everywhere, some areas are more advanced than others, while some are still developing.

Another area where there is strong agreement is in personalized medicine. Many studies show that AI

is helping move healthcare away from the traditional “one-size-fits-all” approach toward treatments that are tailored to each individual patient. For example, Moingeon (2021), Roy (2025) and Amin and Rahman (2025) explain how AI can combine different types of patient data, such as genetic information, medical history and lifestyle factors, to design treatments that are more precise and effective. Similarly, Johansson and Carter (2025) and Uriti (2025) show that AI can help doctors decide which treatment is best for a specific patient and even predict how that patient might respond. Beyond treatment selection, Panchpuri et al. (2025) extend this idea to drug delivery, showing how AI can help target drugs to specific parts of the body, reducing side effects and improving outcomes. Altogether, these findings suggest that AI is playing a key role in making healthcare more patient-centered.

Even with all these benefits, the studies also point to several important challenges. One of the biggest issues is data quality and availability. AI systems rely heavily on data and if the data is incomplete, biased or poorly organized, the results can be misleading. Archer and Germain (2021), Craig et al. (2022) and Ujjwal (2024) all highlight this problem, noting that many healthcare systems do not yet have the kind of high-quality data that AI needs to perform well. This means that even the best AI models can produce unreliable results if the data they are trained on is weak.

Another challenge that comes up repeatedly is the issue of model interpretability. Many AI systems, especially deep learning models, are very complex and do not easily explain how they arrive at their decisions. This is often referred to as the “black box” problem. Jiménez-Luna et al. (2020) and Ghosh and Datta (2025) try to address this by promoting explainable AI (XAI), which makes it easier for humans, especially doctors, to understand and trust AI decisions. However, not all studies use these explainable approaches and this creates a gap. If clinicians cannot understand how an AI system makes decisions, they may be hesitant to rely on it in real clinical practice.

Table 1: Summary of Related Studies

Authors	AI Techniques Used	Domain / Focus	Main Findings	Relevance to Study
Wang et al. (2019)	ML, data mining	Drug Development	AI predicts drug-target interactions, identifies lead compounds, accelerates trials	Early example of AI in drug discovery
Sethuraman (2020)	ML, neural networks, genetic algorithms	Drug Development	AI optimizes formulation, improves efficiency, reduces costs	Highlights AI in pharmaceutical process optimization

A further limitation is the issue of generalizability, which simply means whether an AI model works well across different settings. Many studies, such as Borkotoky et al. (2022) and Nguyen et al. (2023), report very good results, but these are often based on controlled datasets or specific populations. As Zeng et al. (2026) and Abbas et al. (2025) point out, a model that works well in one hospital or country may not perform the same way in another. This raises concerns about how reliable these models are when applied to diverse patient groups or different healthcare systems. In simple terms, success in the lab does not always translate to success in the real world.

There are also noticeable differences in how researchers treat ethical and regulatory issues. Some studies, like Acharjee et al. (2023) and Amin and Rahman (2025), give serious attention to concerns such as data privacy, algorithmic bias and ethical use of AI. They stress that these issues must be addressed before AI can be widely adopted in healthcare. However, other studies focus mainly on technical performance and pay less attention to these concerns. This imbalance suggests that while AI technology is advancing quickly, the ethical and regulatory discussions are not always keeping pace. In summary, when we bring all these studies together, a clear picture emerges. There is strong agreement that AI and ML are powerful tools that can transform drug discovery, improve diagnosis and support more personalized treatments. At the same time, there are still important gaps that need to be addressed. These include problems with data quality, lack of transparency in AI models, limited ability to generalize results and challenges in integrating AI into everyday clinical practice. These issues show that while AI holds great promise, it cannot work in isolation. It requires careful validation, collaboration between different experts and strong ethical and regulatory frameworks. Building on these insights, this study aims to provide a more balanced and practical understanding of how AI can be applied in precision medicine in a way that is not only effective but also safe, reliable and patient-centered.

Authors	AI Techniques Used	Domain / Focus	Main Findings	Relevance to Study
Jiménez-Luna et al. (2020)	Explainable AI, DL	Drug Development	XAI improves model transparency for molecular prediction and compound generation	Emphasizes interpretability in AI models
Archer & Germain (2021)	ML, predictive modeling	Drug Development	AI speeds preclinical optimization, virtual screening, clinical trials	Shows AI impact on reducing time and cost
Tang et al. (2021)	ML, data mining	Drug Development	AI predicts molecular properties, supports de novo design, drug reuse	Demonstrates AI in molecular-level innovation
Moingeon (2021)	Multimodal AI	Personalized Medicine	AI aids disease modeling, target selection, biomarker discovery	Supports AI in precision treatment
Borkotoky et al. (2022)	ML, in silico ADMET modeling	Drug Development	AI predicts ADMET properties, streamlines discovery	Optimizes drug safety and efficacy
Lluka & Stokes (2022)	ML, systems biology modeling	Drug Development	AI discovers new antibiotics, studies mechanisms, uses open datasets	Shows AI solving resistance and discovery challenges
Patnaik et al. (2023)	ML, NLP	Drug Development	AI aids repurposing, predicts toxicology, improves trial outcomes	Demonstrates AI in cost/time optimization
Nguyen et al. (2023)	ML, predictive modeling	Drug Development	AI predicts GPCR targets, ligands and therapeutic response	Highlights specialized receptor-targeted AI applications
Serrano et al. (2024)	ML, DL, advanced computational methods	Personalized Medicine, Drug Delivery	AI optimizes treatment, predicts toxicity, enhances patient outcomes	Supports AI for individualized treatment strategies
Sahgal & Sundarasekar (2024)	ML, predictive modeling	Drug Development	AI accelerates pipelines, lowers cost, improves molecular design	Supports AI in drug discovery efficiency
Huanbutta et al. (2024)	ML, predictive modeling	Drug Development	AI optimizes discovery, manufacturing, QC and surveillance	Shows AI across the full pharmaceutical lifecycle
Chakravarthi et al. (2024)	AI, bioinformatics, CADD	Drug Development	AI improves data integration, visualization and design time	Demonstrates AI-bioinformatics synergy
Patne et al. (2024)	SMILES, DL, GANs	Drug Development	AI optimizes target finding, binding and lead compounds	Shows cutting-edge AI applications for drug discovery
Kaggwa (2025)	ML, DL	Drug Development	AI speeds up drug discovery, predicts compounds, reduces time & cost	Shows AI's impact on accelerating drug pipelines
Johansson & Carter (2025)	ML, DL, AI platforms	Drug Development, Personalized Medicine	AI improves target identification, preclinical/clinical testing, patient stratification	Demonstrates full pipeline application and personalization

Authors	AI Techniques Used	Domain / Focus	Main Findings	Relevance to Study
Amin & Rahman (2025)	ML, DL, predictive analytics	Diagnosis, Personalized Medicine	AI analyzes imaging, genomics and clinical data for tailored therapies	Illustrates AI in patient-specific diagnosis and treatment planning
Uriti (2025)	ML, DL, NLP, generative AI	Drug Development, Personalized Medicine	AI handles complex datasets for drug discovery, patient stratification and trial optimization	Highlights AI in precision medicine and clinical efficiency
Panchpuri et al. (2025)	ML, DL, genetic algorithms	Drug Delivery, Personalized Medicine	AI + biotech enables smart drug delivery and theragnostics	Shows AI innovation in drug targeting and patient-specific delivery
Gaonkar et al. (2025)	DL, NLP, data analytics	Diagnosis	AI enhances early detection and monitoring in oncology, cardiology, neurology, dermatology	Demonstrates broad AI applications in accurate disease diagnosis
Debosree Ghosh & Datta (2025)	ML	Personalized Medicine	AI tailors treatment to genetic, lifestyle and physiological data	Reinforces AI for patient-centered therapies
Shahid Abbas et al. (2025)	ML, DL, predictive modeling	Diagnosis, Personalized Medicine	AI improves diagnosis, risk assessment and treatment optimization	Supports predictive, personalized healthcare
Zeng et al. (2026)	ML, DL, NLP	Precision Medicine, Diagnosis, Drug Development	AI enables personalized treatment plans, optimizes drug discovery, integrates monitoring	Shows AI's transformative role across healthcare ecosystem

Source: Authors

Across all these studies, three clear patterns consistently emerge. First, AI significantly accelerates drug discovery while reducing development costs by predicting molecular targets, optimizing lead compounds and streamlining clinical trial design. AI also plays a central role in advancing personalized medicine by integrating genetic information, clinical records and lifestyle data to support more tailored treatment decisions that reflect individual patient

Methodology

This study adopts a Systematic Literature Review (SLR) approach to explore how Artificial Intelligence (AI) and Machine Learning (ML) are being applied in diagnosis, personalized medicine and drug development. In simple terms, an SLR is a careful and organized way of reviewing existing research so that nothing important is missed and the findings are not biased. Instead of selecting a few studies randomly, this approach follows clear steps to collect, evaluate and combine evidence. This makes the study more transparent, reliable and easy for other researchers to replicate. By using this method, the study is able to identify key trends, compare findings across different studies and highlight important gaps in the rapidly growing field of AI-driven healthcare.

differences. However, issues related to data quality, model interpretability, ethical concerns and the integration of AI tools into existing clinical workflows remain significant barriers. Building on these insights, this study examines how AI and ML may further improve diagnosis, personalized treatment and drug development in ways that are safe, effective and truly patient-centered.

To gather relevant studies, a comprehensive search was carried out across well-known academic databases, including PubMed, Scopus, Web of Science, IEEE Xplore and Google Scholar. These databases were chosen because they contain high-quality and peer-reviewed research in both healthcare and technology. The search focused on studies published between 2019 and 2026 so that the review reflects the most recent developments in AI and ML. A clear search strategy was developed using keywords such as "Artificial Intelligence," "Machine Learning," "drug discovery," "personalized medicine," and "diagnosis." These terms were combined using Boolean operators like AND and OR to ensure that the search captured studies that sit at the intersection of these areas. For example,

combinations like “AI AND drug discovery AND diagnosis” helped narrow the results to highly relevant studies.

To maintain quality and focus, clear inclusion and exclusion criteria were applied. Only peer-reviewed journal articles, conference papers and high-quality review studies written in English and published within the selected time frame were included. Studies that were not directly related to AI or ML applications in diagnosis, personalized medicine or drug development were excluded. In addition, non-peer-reviewed materials, incomplete studies and papers

without accessible full texts were removed to ensure that only credible and complete evidence was used.

The selection of studies followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which provides a clear and standardized process for screening and selecting studies. As shown in the PRISMA flow diagram (Figure 2), the process began with the identification stage, where 1,245 records were retrieved from database searches and an additional 87 records were identified from reference lists.

Figure 2: PRISMA Flow Diagram for Study Selection

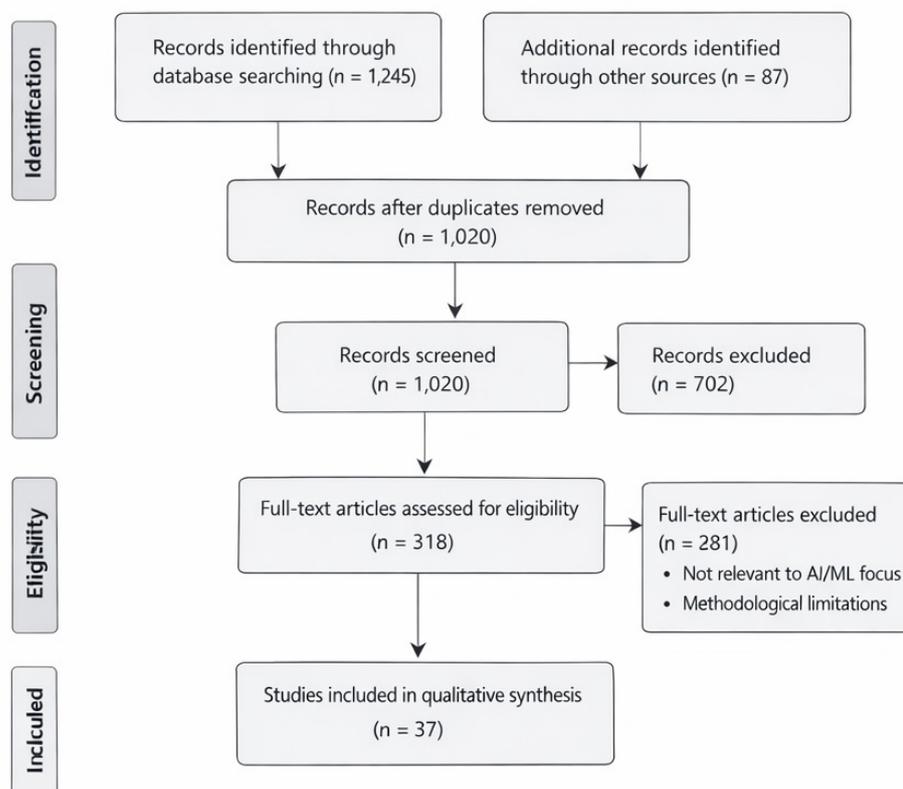


Figure 2. PRISMA flow diagram of the study selection process. This figure illustrates the systematic review process, from identification of records through database searches and other sources, to screening, eligibility assessment, and final inclusion of studies focusing on AI and ML in healthcare from 2019 to 2026.

After removing 312 duplicate records, 1,020 studies remained for screening. During the screening stage, titles and abstracts were reviewed carefully, leading to the exclusion of 702 studies that were not relevant to the focus of this research. In the eligibility stage, 318 full-text articles were examined in detail using the predefined criteria. After this rigorous evaluation, 37 studies were selected for the final review. These studies form the foundation of the analysis presented in this paper.

To ensure consistency, data from the selected studies were extracted using a standardized format.

Key information collected included the authors and year of publication, study objectives, AI or ML techniques used, application area (diagnosis, personalized medicine or drug development), main findings and overall relevance to the study. This structured approach made it easier to compare studies and identify patterns. The extracted data were then analyzed using a thematic synthesis approach, which involves grouping similar ideas and findings together. In addition, a simple quantitative summary was used to show how often certain AI techniques or application areas appeared across the studies. Together, these

methods provide a balanced and comprehensive understanding of the field.

To strengthen the reliability of the findings, a risk-of-bias and quality assessment was carried out for all included studies. Each study was carefully evaluated based on factors such as how clearly the research objectives were stated, the quality and representativeness of the data used, the appropriateness of the AI or ML methods and how well the results were explained and validated. Particular attention was given to common issues such as small datasets, lack of external validation and limited explanation of how models make decisions. Based on these criteria, studies were categorized as having low, moderate or high risk of bias. Only studies that met a minimum quality standard were included in the final

analysis, ensuring that the conclusions are based on credible and robust evidence.

While this systematic approach improves the transparency and rigor of the study, some limitations should be acknowledged. The review includes only English-language publications, which means that relevant studies published in other languages may have been missed. Also, by focusing only on peer-reviewed work, some emerging insights from newer or non-traditional sources may not be included. Finally, because AI is a rapidly evolving field, studies published after April 2026 are not captured. Despite these limitations, the methodology provides a strong and reliable foundation for understanding how AI and ML are shaping diagnosis, personalized medicine and drug development.

Discussion

When we look at the findings through the conceptual framework, everything starts to make more sense in a simple and connected way. Instead of seeing AI and ML as separate tools used in different areas, the framework helps us understand them as central drivers that connect three important parts of modern healthcare: diagnosis, personalized medicine and drug development. What becomes clear from the reviewed studies is that these areas do not work in isolation. Rather, they are closely linked and progress in one area naturally supports progress in the others. In other words, AI is helping to create a system where knowledge flows smoothly from one stage to another.

Starting with drug development, the framework shows how AI plays a very important role right from the beginning of the process. Techniques such as machine learning, deep learning and generative models are used to analyze large biological and chemical datasets. Studies like Wang et al. (2019), Sethuraman (2020) and Kaggwa (2025) explain that AI can quickly identify drug targets, design new molecules and select the most promising compounds. This is something that would normally take years using traditional methods. More advanced tools, such as AlphaFold discussed by Parvathaneni et al. (2023), make this process even stronger by accurately predicting protein structures, which is a key step in understanding how drugs will interact with the human body. As a result, the entire drug development process becomes faster, cheaper and more efficient. Importantly, the framework shows that the results from this stage such as optimized drugs and predicted responses, do not stop there. They move forward into personalized medicine, where they are used to design treatments for specific groups of patients.

In the diagnosis pathway, the framework highlights how AI uses different types of patient data to improve disease detection. These data include medical images, electronic health records and genetic information. Using tools like convolutional neural networks (CNNs) and natural language processing, AI can identify patterns that may not be easily seen by human experts. Studies by Gaonkar et al. (2025) and Abbas et al. (2025) show that this leads to earlier and more accurate diagnosis across many diseases. Within the framework, diagnosis is not just an endpoint; it is actually the starting point for personalized care. When diagnosis is accurate, it provides reliable information that helps doctors choose the best treatment for each patient. So, better diagnosis strengthens the entire system by ensuring that all decisions that follow are based on solid evidence.

At the center of the framework is personalized medicine, which brings everything together. This is where information from diagnosis and drug development is combined to create treatment plans that are tailored to individual patients. Studies such as Roy (2025), Amin and Rahman (2025) and Koul and Koul (2025) show how AI can bring together different types of data such as genomics, lifestyle factors and clinical history, to guide decisions about which drug to use, what dose to give and how to monitor the patient. This is where the real value of AI becomes clear. It is not just about doing things faster, but about doing them better and in a way that fits each patient's unique situation. The framework also shows a feedback loop here: once patients are treated, their outcomes generate new data, which is fed back into AI systems to improve future predictions and decisions.

At the same time, the framework helps us clearly see the challenges that still exist. One major issue

across all three areas is data quality. AI systems depend heavily on the data they are trained on. If the data are incomplete, biased or poorly organized, the results will also be unreliable. This can affect diagnosis, lead to less effective treatments and even slow down drug development. Another important challenge is model interpretability. Many AI systems, especially deep learning models, are often described as “black boxes” because it is not always clear how they arrive at their decisions. Studies like Jiménez-Luna et al. (2020) and Serrano et al. (2024) show that this lack of transparency can reduce trust among clinicians. If doctors do not understand how a model works, they may be reluctant to use it in real clinical settings. Thus, clinicians need tools that are not only accurate but also interpretable and easy to use within time-constrained environments.

Another key issue highlighted by the framework is generalizability. While many AI models perform very well in controlled research settings, they do not always work as well in real-world environments. As such, their adoption in everyday healthcare depends on trust, usability and integration into existing workflows. Studies such as Zeng et al. (2026) and Abbas et al. (2025) point out that models trained on specific datasets may not perform equally well across different populations, hospitals or countries. This creates a gap between what AI and ML can achieve in theory and what they can deliver in everyday clinical practice. Summarily, when we bring everything together, the conceptual framework shows that AI and ML are part of a connected ecosystem rather than isolated tools. Their real strength lies in how they link diagnosis, personalized medicine and drug development into one continuous, data-driven process. This connection allows healthcare to become more accurate, more efficient and more focused on the individual patient. However, the framework also reminds us that for this system to work fully in practice, key challenges such as data quality, interpretability and generalizability must be carefully addressed. Only then can AI and ML truly reach their full potentials in transforming healthcare.

Novel Contribution of the Study

This study makes several unique contributions to the growing field of AI and Machine Learning in healthcare, particularly in diagnosis, personalized medicine and drug development. While numerous reviews have explored AI applications in these areas individually, this research integrates insights across the entire healthcare pipeline, providing a comprehensive perspective on how AI can simultaneously enhance drug discovery, patient diagnosis and treatment personalization. Firstly, this study synthesizes the latest empirical and review studies (2019-2026), capturing the most recent advancements in AI-driven drug discovery

and precision medicine. Secondly, the study emphasizes the interconnected role of AI across diagnosis, drug development and personalized treatments, highlighting how innovations in one area (e.g., predictive modeling in drug discovery) can inform and enhance others (e.g., individualized therapy planning). This cross-domain perspective is particularly valuable for researchers, clinicians and pharmaceutical companies aiming to implement AI holistically rather than in isolated silos. Thirdly, the study identifies critical gaps and challenges, including data quality, algorithmic bias, interpretability and regulatory compliance and links these to practical implications for healthcare implementation. Finally, the study highlights emerging trends and future directions for AI in healthcare, such as explainable AI, multi-omics integration and smart drug delivery systems, offering a forward-looking roadmap for innovation in the field.

Industry Implications

The findings of this study have important implications for the pharmaceutical and healthcare industries. First, the integration of AI and Machine Learning can make drug discovery faster, cheaper and more efficient. Companies can analyze massive datasets, predict which compounds are likely to work and even design new molecules, which reduces the time and cost compared to traditional methods (Kaggwa, 2025; Wang et al., 2019). This means pharmaceutical firms can bring new drugs to market more quickly, respond faster to emerging health threats and improve patient outcomes.

Second, AI can improve diagnostic accuracy. Healthcare providers can use AI to interpret medical images, analyze genetic data and track patient records more precisely, leading to earlier and more accurate detection of diseases (Gaonkar et al., 2025; Debosree & Datta, 2025). For hospitals and clinics, this could mean more efficient workflows, better resource allocation and higher quality of care for patients (Olugbade et al., 2024; Falayi et al., 2026). Third, AI can help design individualized treatment plans that are safer, more effective and more tailored to each patient (Sudipta Roy, 2025; Amin & Rahman, 2025). For the pharmaceutical industry, this opens opportunities to develop targeted therapies and smart drug delivery systems, which could increase treatment success rates and reduce side effects. Finally, this study suggests that industries that adopt AI strategically can gain a competitive advantage, innovate faster and provide better healthcare services. Integrating AI across drug development, diagnostics and personalized treatment is not just a technical upgrade, it represents a shift toward more efficient, patient-centered and data-driven healthcare practices.

Conclusion and Recommendations

This study shows clearly that AI and ML are reshaping healthcare, especially in diagnosis, personalized medicine, and drug development. They make it possible to detect diseases earlier, design better treatments and develop drugs more efficiently. However, the findings also make one important point very clear: technology alone is not enough. For AI to truly improve healthcare, it must be supported by high-quality data, transparent models, strong regulation and active human oversight. Based on these findings, this study recommends that healthcare organizations should invest in high-quality, well-structured and diverse datasets, as data quality directly affects AI performance. In addition, healthcare systems should promote collaboration between clinicians, data scientists and policymakers to ensure that AI tools are designed with real-world needs in mind. Ongoing training and capacity building should be provided for healthcare professionals to support effective AI adoption. Developers and researchers should prioritize explainable AI models that provide clear and interpretable results. Finally, regulatory bodies should establish standardized guidelines for AI validation, approval, and monitoring in clinical settings.

Limitations and Future Directions

Despite the promising results, this study acknowledges several limitations. The review primarily

relies on published literature, which may not fully capture proprietary or emerging AI applications in industry. Many studies reviewed are in the early stages or focus on proof-of-concept models, limiting evidence of real-world effectiveness. The study also concentrates specifically on drug discovery, diagnostics and personalized medicine, leaving out other healthcare domains such as hospital management, public health and mental health.

Looking ahead, several future directions are worth pursuing. Integrating multi-omics data, combining genomics, proteomics, metabolomics and clinical information, can further enhance precision medicine. Developing AI models that are transparent, interpretable and ethically robust will be critical for wider adoption. More studies should examine AI applications in real-world clinical settings to evaluate actual patient outcomes and healthcare impact. Emerging AI technologies, such as generative AI, reinforcement learning and quantum computing, offer opportunities to accelerate drug discovery and improve personalized therapies. Finally, research should focus on equitable implementation to ensure that AI-driven healthcare benefits populations in low-resource settings as much as it does those in advanced healthcare systems.

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Conceptualization and study design: Literature search, data collection and screening: Kehinde Falayi, Ome Akpughe, Kazeem Bello, Raphael Adewale, Bright Ladzro, Oluwatoyin Ayeni. **Data extraction, analysis, and interpretation:** Kehinde Falayi, Ome Akpughe, Kazeem Bello, Raphael Adewale, Bright Ladzro, Oluwatoyin Ayeni.

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