

# A Review on Comparative Analysis of Traditional Pharmacy Vs AI In Pharmacy

Mr. Shaikh Rehan Sirajuddin<sup>1</sup>, Mr. Shaikh Mustakim Mansur<sup>2</sup>, Mr. Khan Usama<sup>3</sup>, Ms. Trupti D. Shetane<sup>4</sup>, Ms. Priya Jaware<sup>5</sup>, Dr. Santosh Payghan<sup>6</sup>  
<sup>1,2,3,4,5,6</sup>Rajesh Bhaiyya Tope College of B Pharmacy

**Abstract**—Pharmacy has evolved from traditional practices to AI-driven approaches. Traditional pharmacy depends on human expertise, while AI enhances speed, accuracy, and efficiency in drug discovery, formulation, and patient care. This review compares both approaches, highlighting benefits, limitations, and the need for integration.

The practice of pharmacy has traditionally been grounded in human expertise, professional judgment, and established methodologies for drug development, formulation, and patient care. Over time, these conventional approaches have ensured safety and therapeutic effectiveness, but they are often associated with limitations such as longer development timelines, higher costs, and the possibility of human error. With the rapid advancement of technology, artificial intelligence (AI) has emerged as a transformative force in pharmaceutical sciences, introducing data-driven and automated solutions across various domains.

This review explores the key differences between traditional pharmacy practices and AI-based approaches, focusing on areas such as drug discovery, formulation development, clinical decision-making, pharmacovigilance, and supply chain management. AI techniques, including machine learning and predictive modeling, have shown considerable potential in accelerating research processes, improving accuracy, and optimizing healthcare outcomes. However, despite these advantages, challenges such as data dependency, ethical concerns, lack of transparency, and regulatory complexities remain significant.

In contrast, traditional pharmacy continues to play an essential role by offering critical thinking, ethical oversight, and personalized patient interaction, which are difficult to replicate through automated systems. Therefore, rather than viewing AI as a replacement, it is more appropriate to consider it as a complementary tool that enhances existing practices.

This review highlights the strengths and limitations of both traditional and AI-driven pharmacy, emphasizing the importance of integrating technological advancements with human expertise to achieve a more

efficient, accurate, and patient-centered healthcare system.

**Index Terms**—Traditional Pharmacy, Artificial Intelligence, Drug Discovery, Machine Learning, Clinical Pharmacy, Pharmacovigilance

## I. INTRODUCTION

Overview of traditional pharmacy

Traditional pharmacy refers to the conventional practices involved in the discovery, preparation, dispensing, and monitoring of medications, primarily driven by human knowledge, experience, and established pharmaceutical principles. For decades, this approach has formed the backbone of healthcare systems worldwide, ensuring the safe and effective use of drugs.

In traditional pharmacy, drug discovery is largely based on experimental methods, including trial-and-error techniques, natural product screening, and chemical synthesis. These processes often require extensive laboratory work, long development timelines, and significant financial investment. Despite these challenges, traditional methods have contributed to the development of many life-saving medications.

Formulation development in traditional pharmacy relies on physicochemical principles and empirical knowledge. Pharmacists and researchers manually design dosage forms such as tablets, capsules, and injections by considering factors like drug stability, solubility, and bioavailability. This process requires repeated testing and optimization to achieve the desired therapeutic effect.

Dispensing and patient care are central components of traditional pharmacy practice. Pharmacists play a critical role in interpreting prescriptions, ensuring

accurate dispensing, and providing counseling to patients regarding drug usage, dosage, and potential side effects. This human interaction helps in building trust and ensures better adherence to treatment.

Another important aspect is pharmacovigilance, where adverse drug reactions are monitored and reported manually. Although effective, this process can be time-consuming and may sometimes delay the detection of safety issues.

Overall, traditional pharmacy is characterized by its reliance on human expertise, ethical decision-making, and personalized patient care. While it has proven to be reliable and essential, it also faces limitations such as slower processes, higher costs, and susceptibility to human error, which have paved the way for the integration of advanced technologies like artificial intelligence.

Historically, traditional pharmacy evolved from the use of natural products such as herbs, minerals, and animal-derived substances. Early pharmacists relied on empirical knowledge and observation to prepare remedies, which later developed into more structured scientific approaches with the advancement of chemistry and pharmacology.

One of the core components of traditional pharmacy is drug discovery, which typically involves laboratory-based experimentation, screening of natural and synthetic compounds, and trial-and-error methods. These processes are often time-consuming and resource intensive, sometimes taking several years to develop a single drug. However, they provide a strong scientific basis for understanding drug action and safety.

Another important area is formulation development, where dosage forms such as tablets, capsules, syrups, and injections are designed. This process depends on physicochemical properties like solubility, stability, and compatibility of ingredients. Formulators rely heavily on experience and repeated experimentation to achieve optimal drug delivery and therapeutic effect.

Traditional pharmacy also emphasizes compounding practices, where pharmacists prepare customized medications for individual patients. This is particularly important in cases where commercially available formulations are not suitable, such as pediatric, geriatric, or rare disease patients.

In terms of dispensing and patient care, pharmacists act as a bridge between the physician and the patient.

They ensure the correct interpretation of prescriptions, accurate dispensing of medicines, and provide essential counseling on dosage, administration, storage, and possible side effects. This human interaction improves patient adherence and therapeutic outcomes.

Clinical pharmacy services are another key aspect, where pharmacists are involved in monitoring drug therapy, identifying drug interactions, and optimizing medication regimens. Their clinical judgment plays a crucial role in preventing medication errors and ensuring patient safety.

Traditional pharmacy also includes pharmacovigilance, which involves the detection, assessment, and reporting of adverse drug reactions (ADRs). Although this process is effective, it largely depends on manual reporting systems and may result in delays in identifying potential safety concerns.

Additionally, supply chain and inventory management in traditional pharmacy are handled manually or through basic systems. This includes procurement, storage, and distribution of medicines, which can sometimes lead to inefficiencies such as stock shortages or wastage.

From a regulatory perspective, traditional pharmacy follows well-established guidelines and ethical standards to ensure drug safety, efficacy, and quality. Regulatory bodies oversee drug approval processes, clinical trials, and manufacturing practices, ensuring that medicines meet required standards before reaching patients.

Despite its strengths, traditional pharmacy faces several limitations, including longer development timelines, higher costs, dependency on human expertise, and the possibility of errors. These challenges have encouraged the adoption of advanced technologies, particularly artificial intelligence, to improve efficiency and accuracy.

Overall, traditional pharmacy remains a cornerstone of healthcare, providing reliability, ethical decision-making, and personalized patient care. However, the growing complexity of modern healthcare systems highlights the need for integration with innovative modern healthcare systems highlights the need for integration with innovative approaches to effectiveness

#### Role of pharmacists

The pharmacist plays a central and indispensable role

in traditional pharmacy, acting as a key link between drug development, healthcare providers, and patients. Their responsibilities extend far beyond dispensing medications, encompassing clinical, educational, regulatory, and managerial functions that ensure the safe and effective use of medicines.

One of the primary roles of the pharmacist is prescription evaluation and verification. Pharmacists carefully analyze prescriptions to ensure their accuracy, appropriateness, and safety. This includes checking for correct dosage, frequency, potential drug interactions, contraindications, and patient-specific factors such as age, weight, and existing medical conditions. Their intervention helps prevent medication errors and enhances therapeutic outcomes. Another crucial responsibility is accurate dispensing of medications. Pharmacists ensure that the correct drug, dosage form, and quantity are provided to the patient. They also maintain proper labeling, including instructions for use, storage conditions, and warning labels, which are essential for patient safety.

Patient counseling and education is one of the most significant aspects of a pharmacist's role. Pharmacists guide patients on how to take medications correctly, inform them about possible side effects, drug interactions, and precautions, and emphasize the importance of adherence to therapy. This personalized interaction builds trust and improves patient compliance, especially in chronic diseases.

In addition, pharmacists are actively involved in clinical pharmacy services, where they collaborate with physicians and other healthcare professionals to optimize drug therapy. They monitor patient responses, adjust dosages when necessary, and recommend alternative therapies based on clinical evidence. This role is particularly important in hospital settings.

Pharmacists also contribute to pharmacovigilance, which involves monitoring, detecting, and reporting adverse drug reactions (ADRs). By maintaining records and reporting safety issues to regulatory authorities, they help in ensuring the ongoing safety of pharmaceutical products.

Another important area is compounding and formulation, where pharmacists prepare customized medications tailored to individual patient needs. This is especially useful for pediatric, geriatric, or special-case patients who require specific dosages or dosage forms not readily available in the market.

Pharmacists also manage inventory and supply chain operations within pharmacies and healthcare institutions. They ensure the availability of essential medicines, maintain stock levels, prevent drug shortages, and ensure proper storage conditions to preserve drug stability and efficacy.

From a regulatory perspective, pharmacists ensure compliance with legal and ethical standards. They follow guidelines related to drug storage, dispensing, record-keeping, and controlled substances. Their adherence to regulations helps maintain the quality and safety of pharmaceutical services.

Furthermore, pharmacists play a role in public health and preventive care. They participate in health awareness programs, vaccination drives, screening services, and provide guidance on lifestyle modifications, thereby contributing to overall community health.

Despite these extensive responsibilities, the effectiveness of pharmacists in traditional systems largely depends on their knowledge, experience, and workload. Human limitations such as fatigue, time constraints, and variability in decision-making can sometimes impact efficiency, highlighting the need for supportive technologies.

Overall, pharmacists are the backbone of traditional pharmacy, ensuring that medications are used safely, effectively, and responsibly. Their role remains irreplaceable, particularly in areas requiring human judgment, ethical decision-making, and direct patient interaction. -Limitations of manual systems

## II. INTRODUCTION TO AI

In recent years, artificial intelligence (AI) has gradually become an important part of many scientific fields, including pharmacy. Unlike traditional systems that rely mainly on human effort and experience, AI focuses on using computer-based models and algorithms to perform tasks that normally require human thinking, such as learning from data, identifying patterns, and making decisions.

In the pharmaceutical field, AI is not a single technology but a combination of different approaches like machine learning, deep learning, and data analytics. These tools allow researchers and healthcare professionals to work with large and complex datasets that would be difficult to handle manually. For example, information from clinical trials, patient

records, and drug databases can be analyzed together to generate useful insights in a shorter time.

The growing interest in AI in pharmacy is mainly due to the challenges faced by traditional methods, such as long drug development timelines, high costs, and the risk of human error. AI offers a way to support these processes by improving speed and consistency. It can assist in identifying potential drug candidates, predicting how drugs will behave in the body, and even suggesting suitable treatment options based on patient-specific data.

Another important aspect of AI is its ability to continuously learn and improve over time. As more data becomes available, AI systems can refine their predictions and provide more accurate results. This makes them particularly useful in areas where large amounts of information are involved, such as pharmacovigilance and clinical decision-making.

At the same time, it is important to understand that AI does not function independently of human input. The quality of its output depends on the data it is trained on, as well as the design of the algorithms. Issues such as data privacy, lack of transparency in decision-making, and regulatory concerns are still being discussed in the pharmaceutical field.

Overall, AI is gradually changing the way pharmacy is practiced by introducing more efficient and data-oriented approaches. However, it is not intended to replace traditional pharmacy but rather to support and enhance existing systems. The combination of human expertise and AI-based tools is likely to play a significant role in the future of pharmaceutical sciences.

### III. AI APPLICATIONS IN PHARMACY

Artificial intelligence is being applied in several areas of pharmacy, gradually changing how different processes are carried out. Its ability to handle large amounts of data and identify meaningful patterns has made it useful in improving efficiency, accuracy, and decision-making across pharmaceutical sciences.

One of the most significant applications of AI is in drug discovery and development. Traditionally, discovering a new drug takes many years and involves extensive laboratory work. With the help of AI, researchers can analyze large chemical and biological datasets to identify potential drug candidates more quickly. AI models can predict how a drug molecule

will interact with a target in the body, which helps in reducing the time and cost involved in early-stage research.

AI is also playing a role in formulation development. It can be used to predict the stability, solubility, and compatibility of different drug components. This reduces the need for repeated experimental trials and helps in designing better dosage forms. As a result, formulation processes become more efficient and less time-consuming.

Another important area is clinical decision support. AI systems can assist healthcare professionals by analyzing patient data, medical history, and laboratory results to suggest appropriate treatment options. This helps in improving the accuracy of clinical decisions and supports personalized medicine, where treatments are tailored to individual patients.

In the field of pharmacovigilance, AI helps in the early detection of adverse drug reactions. It can scan large volumes of data from patient reports, electronic health records, and online sources to identify patterns that may indicate safety issues. This allows quicker response compared to traditional manual reporting systems.

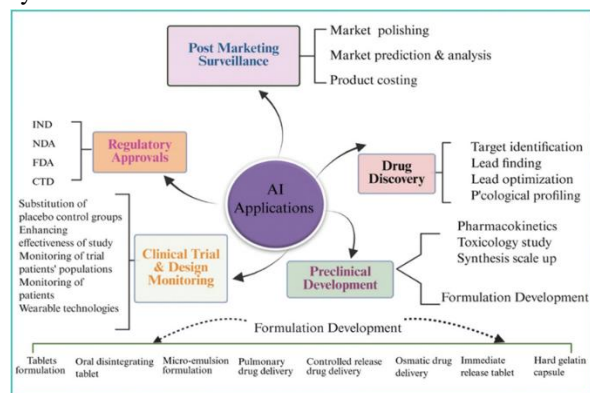


Fig.1 AI Application in Pharmacy

AI is also being used in hospital and retail pharmacy operations, particularly in medication dispensing and error reduction. Automated systems supported by AI can help in verifying prescriptions, detecting potential errors, and ensuring the correct medicines are dispensed. This improves patient safety and reduces the workload on pharmacists.

Another growing application is in supply chain and inventory management. AI can predict demand for medicines based on past data and trends, helping pharmacies maintain optimal stock levels. This

reduces the chances of drug shortages as well as wastage due to overstocking.

AI also contributes to personalized medicine, where treatment is customized according to individual patient characteristics such as genetic profile, lifestyle, and disease condition. By analyzing such data, AI can help in selecting the most effective drug and dosage for a particular patient.

Additionally, AI is being explored in drug repurposing, where existing drugs are identified for new therapeutic uses. This approach saves both time and cost compared to developing new drugs from scratch.

Despite these wide-ranging applications, the use of AI in pharmacy is still evolving. Its effectiveness depends on the availability of high-quality data and proper implementation. Therefore, while AI offers many advantages, it is most effective when used alongside human expertise.

#### Benefits of AI

Although artificial intelligence has introduced many advancements in pharmacy, it is not without its limitations. Despite its growing use in different areas, several challenges still affect its reliability, acceptance, and overall implementation in pharmaceutical practice.

One of the major limitations of AI is its strong dependence on data quality and availability. AI systems require large volumes of accurate and well-structured data to function effectively. If the data used is incomplete, biased, or outdated, the results generated by AI may be misleading or incorrect. In pharmacy, where patient safety is critical, such errors can have serious consequences.

Another important issue is the lack of transparency and interpretability. Many AI models, especially deep learning systems, function as “black boxes,” meaning that it is difficult to clearly understand how they arrive at a particular decision or prediction. This creates challenges for healthcare professionals who need to trust and justify these decisions in clinical practice.

Data privacy and security concerns are also significant. AI applications often involve handling sensitive patient information, including medical history and personal data. Ensuring the confidentiality and protection of such data is essential, and any breach can lead to ethical and legal issues.

The implementation of AI in pharmacy also faces

regulatory challenges. Existing regulatory frameworks are not fully adapted to evaluate and approve AI-based systems. This creates uncertainty in terms of validation, standardization, and acceptance of AI tools in healthcare settings.

Another limitation is the high cost of implementation and maintenance. Developing and integrating AI systems requires advanced infrastructure, skilled professionals, and continuous updates. This may not be feasible for smaller healthcare setups or pharmacies with limited resources.

AI systems also lack human judgment and emotional understanding, which are essential in-patient care. Pharmacists often rely on experience, intuition, and direct interaction with patients to make decisions. AI cannot fully replicate this human element, especially in situations that require ethical considerations or personalized communication.

There is also a concern regarding over-reliance on technology. Excessive dependence on AI may reduce the involvement of healthcare professionals in decision-making processes, which could be risky if the system provides incorrect recommendations.

Additionally, AI models may face difficulties in handling complex and unpredictable clinical scenarios, where multiple variables and uncertainties are involved. In such cases, human expertise remains crucial.

Overall, while AI offers significant advantages in improving efficiency and accuracy, its limitations highlight the need for careful implementation. It should be viewed as a supportive tool rather than a replacement for human expertise. A balanced approach that combines AI capabilities with the knowledge and experience of pharmacists is essential for safe and effective pharmaceutical practice

#### Challenges of AI

While artificial intelligence offers promising opportunities in pharmacy, its practical implementation is associated with several challenges that need to be addressed for its effective and safe use. These challenges are not only technical but also organizational, ethical, and infrastructural in nature.

One of the key challenges is the integration of AI systems into existing healthcare infrastructure. Many pharmacies and healthcare institutions still rely on traditional or semi-digital systems. Incorporating AI into these setups requires significant changes in

workflow, software compatibility, and staff training, which can be difficult to manage. Another major challenge is the availability of skilled professionals. The successful use of AI in pharmacy requires expertise in both pharmaceutical sciences and data science. However, there is currently a gap in professionals who possess this combined knowledge, making implementation and maintenance of AI systems more complex.

The issue of data standardization also poses a challenge. Data collected from different sources such as hospitals, laboratories, and pharmacies often exist in varied formats and structures. This lack of uniformity makes it difficult for AI systems to process and analyze information efficiently.

Ethical concerns remain a significant challenge in the adoption of AI. Questions related to accountability, decision-making authority, and patient consent need to be clearly addressed. For instance, if an AI system makes an incorrect clinical recommendation, it becomes difficult to determine responsibility.

Another important challenge is the acceptance and trust among healthcare professionals. Pharmacists and clinicians may be hesitant to rely on AI systems due to concerns about accuracy, reliability, and loss of professional control. Building confidence in AI tools requires proper validation, transparency, and user-friendly design.

The high initial investment required for AI adoption is also a barrier. Setting up AI infrastructure involves costs related to software development, hardware, data storage, and continuous system updates. This can be a major limitation for smaller healthcare facilities.

AI systems also require continuous monitoring and updating. Medical knowledge and clinical guidelines evolve over time, and AI models must be regularly updated to remain accurate and relevant. Failure to do so may result in outdated or incorrect recommendations.

Another challenge is the risk of bias in AI algorithms. If the training data contains biases, the AI system may produce biased results, which can negatively affect patient care and decision-making.

Lastly, there are challenges related to regulatory approval and standardization. The lack of clear and universally accepted guidelines for AI-based tools makes it difficult to ensure their safety, quality, and consistency across different healthcare settings.

In summary, while AI has the potential to transform

pharmacy practice, these challenges highlight the need for careful planning, proper training, and strong regulatory frameworks. Addressing these issues is essential for the successful and responsible integration of AI into pharmaceutical sciences.

#### IV. COMPARISON BETWEEN TRADITIONAL PHARMACY AND AI IN PHARMACY

The comparison between traditional pharmacy and artificial intelligence-based approaches highlights the shift from experience-driven practices to data-driven systems. Traditional pharmacy mainly depends on human knowledge, observation, and manual processes, whereas AI-based pharmacy utilizes computational models and algorithms to perform similar tasks with higher speed and consistency.

In drug discovery, traditional methods involve lengthy experimental procedures and trial-and-error approaches. In contrast, AI can analyze large datasets and predict potential drug candidates in a much shorter time. This significantly reduces the time required for early-stage research.

When it comes to formulation development, traditional pharmacy relies on repeated laboratory experiments and empirical knowledge. AI, on the other hand, can predict formulation behavior based on existing data, thereby minimizing the need for multiple trials.

In clinical decision-making, pharmacists use their experience and clinical judgment to guide therapy. AI systems support this process by analyzing patient data and suggesting evidence-based recommendations. However, AI lacks the human understanding and contextual thinking that pharmacists provide.

#### V. NEED OF COMPARATIVE ANALYSIS

The need for comparing traditional pharmacy with AI-based approaches arises from the rapid changes occurring in the pharmaceutical and healthcare sectors. As new technologies are introduced, it becomes important to evaluate how they differ from existing methods and whether they truly offer improvements.

Traditional pharmacy has been reliable and effective for many years, but it faces challenges such as increased workload, longer development timelines, and the possibility of human error. At the same time,

AI is being promoted as a solution to many of these issues. However, without proper comparison, it is difficult to understand the actual benefits and limitations of AI in real-world settings.

A comparative analysis helps in identifying the areas where AI can enhance traditional practices and where human expertise remains essential. It also allows researchers and healthcare professionals to make informed decisions about adopting new technologies. Another important reason for this comparison is to ensure patient safety. Any new system introduced in healthcare must be carefully evaluated to avoid risks and unintended consequences.

Furthermore, such analysis supports policymakers and regulatory authorities in developing guidelines for the safe and effective use of AI in pharmacy.

Therefore, comparing traditional pharmacy and AI is necessary to understand their respective roles and to create a balanced approach that improves healthcare outcomes.

#### VI. SCOPE OF THE REVIEW

This review focuses on providing a comprehensive comparison between traditional pharmacy practices and the application of artificial intelligence in pharmacy. It covers key areas such as drug discovery, formulation development, clinical decision-making, pharmacovigilance, and pharmacy operations.

The review aims to analyze how traditional methods function in these areas and how AI is being used to improve or replace certain processes. It also examines the advantages and limitations associated with both approaches.

In addition, the review highlights the challenges involved in implementing AI in pharmaceutical practice and discusses the importance of maintaining human involvement in healthcare.

The scope of this review is limited to conceptual and application-based analysis rather than experimental or clinical data. It is based on previously published studies, reports, and available literature related to both traditional pharmacy and AI.

The review also explores future possibilities, particularly the idea of integrating AI with traditional pharmacy practices to achieve better efficiency, accuracy, and patient care.

Overall, this study is intended to provide a clear understanding of the current status and future potential

of AI in pharmacy, while recognizing the continued importance of traditional approaches.

#### VII. CONCLUSION

Pharmacy, as a discipline, has evolved significantly from traditional practices based on human expertise to more advanced, technology-driven approaches with the introduction of artificial intelligence. This review highlights that traditional pharmacy continues to play a crucial role in ensuring safe medication use, providing patient-centered care, and supporting ethical decision-making. The experience and judgment of pharmacists remain essential, particularly in complex clinical situations. At the same time, artificial intelligence has demonstrated considerable potential in improving various aspects of pharmacy, including drug discovery, formulation development, pharmacovigilance, and clinical decision support. Its ability to process large datasets and generate rapid insights offers clear advantages in terms of efficiency, accuracy, and time management. However, the adoption of AI is not without challenges. Issues related to data quality, transparency, cost, and regulatory acceptance need to be carefully addressed. Additionally, AI lacks the human touch that is often required in patient care and clinical decision-making. Based on the comparative analysis, it can be concluded that neither traditional pharmacy nor AI alone is sufficient to meet the growing demands of modern healthcare. Instead, a combined approach that integrates AI technologies with human expertise is likely to be the most effective way forward. Such a balanced model can enhance the quality of pharmaceutical services while maintaining safety, reliability, and patient trust. Overall, the future of pharmacy lies in the collaboration between technology and human professionals, where each complements the other to achieve better healthcare outcome

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