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Review Article

**THE FUTURE OF PHARMACY HOW AI IS TRANSFORMING
THE INDUSTRY****Sakshat Shankarrao Ghuge [1] , Aditi V Tikait [2] , Dr Swati P Deshmukh [3]**

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Abstract:

Artificial intelligence [AI] has become a transformative force in the pharmaceutical sector, revolutionizing drug discovery, clinical decision-making, and healthcare delivery. AI applications in pharmacy include drug development, personalized medicine, formulation, and pharmacovigilance. With the ability to analyze vast datasets, AI models enhance predictive accuracy for pharmacokinetics, therapeutic outcomes, and dosing guidelines, thereby improving patient care and operational efficiency. The integration of AI in clinical and hospital pharmacy enables automation, error reduction, and improved healthcare accessibility. However, challenges such as data privacy, ethical concerns, and limited awareness hinder its widespread adoption. Addressing these barriers through targeted strategies and regulatory frameworks is essential to fully realize AI's potential in modern pharmacy practice.

Keywords:

Artificial intelligence, pharmacy, drug discovery, personalized medicine, healthcare technology, pharmacovigilance.

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INTRODUCTION:

Artificial intelligence [AI], a subfield of computer science, is the study of problem solving via symbolic programming. [1]

New initiatives to use AI technology in pharmacy include medication development, formulation, and delivery, as well as other medical uses. [1] Early turning points in the application of AI in pharmaceuticals were IBM Watson's 2011 demonstration of processing medical data. [2]

In 2021, DeepMind's AlphaFold found the solution to the protein folding conundrum, providing a wealth of structural information for medications. Furthermore, Benevolent AI has gone one step further by employing AI to repurpose current medications for ailments like ALS and aiding in the discovery of unidentified illnesses that have long been untreated. Second. [2] Clinical pharmacy has a 90% failure rate, takes 10 to 15 years, and costs an average of \$2.6 billion to generate a single new medication. [2]

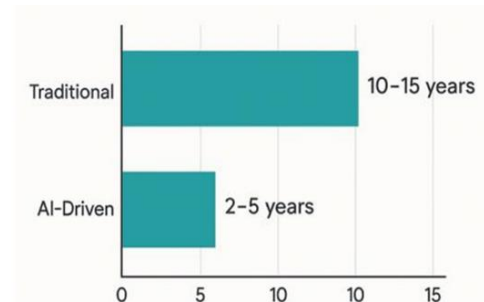


Figure 1: Graphical Comparison of Traditional and AI Drug Discovery. [3]

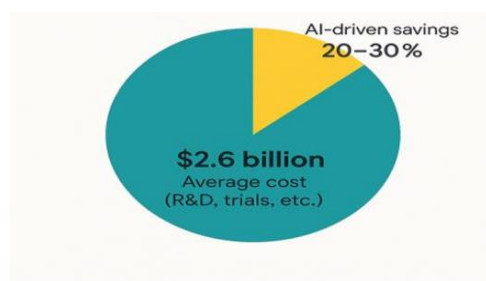


Figure 2: A pie chart dissecting the \$2.6billion average cost [R&D, trials, etc.], highlighting AI-driven savings of 20-30%. [3]

John McCarthy, a physicist who is regarded as the father of artificial intelligence, first used the term "artificial intelligence" in 1956 at the Dartmouth College conference in England, United Kingdom. [3] AI may assist the pharmacy in a number of areas, including prescriptions, medicine distribution, error prevention, patient analysis, and more. [4]

AI models can predict in-vivo responses and pharmacokinetics therapeutic parameters and dosing guidelines. [4]

To satisfy the needs of both society and patients in the twenty-first century, the current drug discovery process must undergo significant transformation with AI. [4]

With the aid of artificial intelligence Automation is a result of industrialization, motivated by the need to boost production, produce consistent quality, and reduce hazardous and heavy work for workers. [4]

Technological innovations are currently the fundamental building blocks of automation. Most pharma players understand. [4]

As AI technology transforms healthcare, it's important to address the barriers to its application in pharmaceutical environments developing targeted strategies to overcome obstacles and integrate AI technology in pharmacies is vital for future success. [5]

Evolution of Traditional Pharmacy to AI Pharmacy:

Early stage [1950s-1990s]

Computerization: Beginning in the 1980s, the first computer applications in pharmacies mechanized operations like data collecting and inventory.

Expert systems: In the 1950s, expert systems were developed to aid pharmacists with responsibilities

such as medication interaction detection and drug formulary management. [6]

The rise of AI and machine learning [2000s-2010s]
Overcoming Limitations: Machine learning and deep learning algorithms were developed in the early 2000s to address limitations in previous AI models.

Advanced Applications: These developments permitted increasingly complicated applications, moving away from basic rule-based systems and toward more sophisticated tools.

IBM's Watson: One famous example is IBM's Watson, which was adapted to aid oncologists by comparing patient data against a huge collection of medical literature to offer treatment choices, such as its 2016 collaboration with Pfizer to speed drug development. [7]

Modern era [2010s] Broader impact: AI has become an essential component of many elements of pharmacy, including drug discovery, clinical decision-making, and operations management. [8]

AI is currently employed form Drug development, including identifying new targets and optimizing medication designs. Personalized medicine is the process of developing treatment regimens based on personal data about a patient. [9]

Contribution of AI in Pharmacy:

Clinical AI and NLP Research using machine learning and NLP to glean insights from radiology reports, pathology data, and clinical narratives in order to improve early detection and diagnostic capacities. [10]
Multi-Modal AI Systems: Studying integrated systems that integrate and analyses many data sources [such as wearables, text, imaging, and genomics] for all-encompassing health monitoring. [10]

AI speeds up drug discovery by quickly screening chemicals and forecasting molecular interactions, cutting down on research timescales from years to months. [10]

AI ensures patient safety and regulatory compliance by detecting adverse medication reactions, anticipating safety signals, and automating reporting. [11]

Regulatory Compliance: AI reduces manual labour and approval delays by automating documents, tracking compliance, and producing reports. [11]

Research & Objectives:

The research aims of AI in pharmacy systems may include:

RO-1: Evaluate the use of artificial intelligence in pharmacy systems for individualized medication management and 24/7 patient support.

RO-2: Evaluate AI's impact on medication adherence and patient outcomes, including hospitalizations, adverse drug reactions, and overall health condition.

RO-3: Identify ethical considerations, including data privacy and biases, when using AI in the pharmacy system.

RO-4: Address technological issues, such as data integration and system maintenance, and create ways to address them.

RO-5: Evaluate AI's usefulness for patients and pharmacists, identifying opportunities for improvement.

RO-6: Assessing the cost-effectiveness of AI in pharmacy systems and comparing it to existing medication management methods. [12]

Limitations of AI:

The lack of understanding and awareness of AI applications in pharmacy may be impeding the adoption of AI technology. [13]

A human pharmacist's empathy and personal touch may be lacking in artificial intelligence [AI], a machine-based technology. [13]

Inaccurate, incomplete, or biased data may lead to wrong or incomplete recommendations AI's linguistic proficiency depends on the training data it receives, which may not be sufficient. [13]

Maintaining and updating the complicated system, which involves large computational resources and technical skill, can be challenging for some pharmacies. [14]

AI applications require access to sensitive patient data, increasing privacy and confidentiality problems. [14]

Challenges of AI in Pharmacy:

High-quality, varied data is necessary for AI to produce precise forecasts.

Regulatory Frameworks: As regulations change, they must take AI's place in pharmaceutical practice into account.

Ethics and Bias: AI systems have the potential to reinforce prejudice; it is imperative to maintain equity and openness. [14]



Figure 6: Challenges of AI in Pharmacy [14]

Advantages of AI in Pharmacy:

AI has the ability to change the business by delivering tailored medicine management and 24/7 care to patients. However, it's crucial to use it ethically and address any constraints.

AI can improve drug management, eliminating the need for frequent healthcare visits.

Artificial intelligence has the potential to eliminate pharmaceutical errors and harmful drug interactions, leading to better patient outcomes.

It enhances healthcare access by offering tailored medication management and 24/7 support to patients. Implementing AI in the pharmacy system can enhance healthcare outcomes, lower costs, and increase access to services, resulting in a better world for all. [15]

Disadvantages of AI in Pharmacy:

AI lacks human touch as it cannot think and can only work through programs.

Building, repairing, and rebuilding can be quite costly and time-consuming.

Machines can readily cause destruction if used incorrectly.

As evidenced with smartphones and other technologies, humans are becoming increasingly reliant on AI and losing cognitive abilities.

AI-powered robots have the potential to enslave humanity. [16]

AI in Clinical Pharmacy:

AI systems help pharmacists and healthcare providers provide effective, efficient, and individualized patient care. [17]

Pharmacists can utilize this technology to analyse patient data, making better judgments and reducing risks and offer personalized therapeutic regimens. [18]

AI-powered solutions detect medicine usage and give targeted interventions to enhance patient compliance. [18]

AI tools can improve decision-making, workflows, and patient outcomes. [18]

AI plays a crucial role in patient-centered care, allowing for individualized treatment plans based on individual features and preferences. [19]

AI can help clinicians evaluate patients' illnesses and identify potential side effects or health hazards associated with drugs. [19]

AI-powered surgery simulators, including those for the heart, gastrointestinal tract, and brain, can help trainee surgeons gain valuable knowledge. [20]

AI in Hospital Pharmacy:

Implementing an AI system simplifies the collecting, storage, normalisation, and tracing of medical records, which is a complex operation. [21]

AI technology can help with repetitive jobs like analysing X-ray images, radiography, ECHO, and ECGs for detection identification of diseases or disorders. [21]

AI technology is highly effective in providing health care and pharmaceutical help. [21]

AI can give pharmacists real-time advice on medicine selection, dose, and any interactions. [22]

AI can help with the discovery and development of novel pharmaceuticals, as well as identifying potential new applications for existing ones. [22]

AI Technology Tools in Pharmaceutical Industry:

The pharmaceutical industry is leveraging AI technologies to improve drug development and patient care; here is a brief. [23]

Machine Learning [ML] algorithms analyse complicated datasets to identify trends, optimise drug design, and forecast outcomes, allowing for more effective medication discovery and development. [23]

Natural Language Processing [NLP] analyses unstructured medical data, such as clinical notes and research papers, to extract relevant information. [23]

Computer vision [CV] aids in drug discovery by analysing images and identifying medicinal

compounds and in disease diagnosis by medical imaging. [24]

Predictive analytics models [PAM] predict pharmacological responses, patient outcomes, and market trends to help with decision-making out of the drug development lifecycle. [25]

Deep learning [DL], a subset of machine learning, effectively analyses large-scale genomes and proteomics data to identify therapeutic targets and biomarkers. [26]

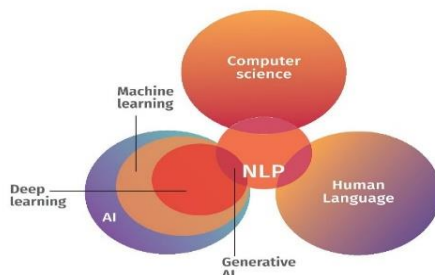


Figure 7: Different AI Technology Tools in Pharmaceutical Industry [26]

Applications of AI in Pharmacy:

AI in Pharmacovigilance:

An artificial intelligence [AI] system uses machine learning to provide forecasts, information,

recommendations, and judgments that can impact real or virtual surroundings, with explicit or implicit goals. After deployment, the levels of autonomy



Figure 8: Role of AI in Pharmacovigilance [27]

and adaptability differ between AI systems. The use of AI systems in pharmacovigilance improves drug safety monitoring, patient safety, and regulatory compliance.

An AI solution is intended to meet certain PV objectives solutions can be created using a single or several systems.

For decades, PV has relied on simpler AI systems like statistical signal detection over the last decade, AI skills have significantly improved, especially in image analysis and natural language processing.

These developments have led to a huge increase in their usage. Advancements in processing power and model architecture have led to the creation of enormous electronic databases that can be linked.

AI is being applied in various disciplines, including biological sciences being used in various life sciences

fields, including drug discovery, medical imaging, genomics, precision medicine, public health, and healthcare delivery. [27]

AI in Radiology:

From the discovery of X-rays to the integration of AI and ML, this field is constantly evolving and reshaping itself and the healthcare ecosystem it provides support. AI, specifically machine learning, is boosting radiology by strengthening picture processing and reducing diagnostic errors.

AI algorithms can process and comprehend data, outperforming human cognitive powers.

AI's impact on medical imaging, highlighting its dramatic shifts in radiology. [28]

AI in Cardiology:

AI in cardiology provides a collaborative approach that allows healthcare providers to give more precise and effective patient treatment by incorporating AI into existing healthcare infrastructure, the medical community stands to benefit greatly in terms of efficiency, accuracy, and patient outcomes.

PMcardio's AI algorithms are trained on a dataset of one million patient ECGs, making them extremely adept in diagnosing 38 different cardiovascular conditions.

PMcardio is a certified artificial intelligence [AI] that reads ECGs and provides a comprehensive assessment of 49 heart diseases.

Clinically validated in over 15 studies and trusted by over 100,000 professionals, it provides quick, expert-level interpretations, helping emergency physicians, GPs, nurses, paramedics, and cardiologists to act confidently at the point of treatment. [29]

AI in Accuracy of Medicine:

AI has significant applications in genomic research and genetic engineering. Deep Genomics, an AI framework, uses genetic codes to find mutations and their associations with diseases, surpassing the ability of medical records. This provides insight into a cell's DNA mutations caused by genetic variety. Craig Venter, known as the father of the Human Genome Project, developed an algorithm that identifies visual features of patients based on their DNA. "Human Longevity" AI technology identifies cancer and vascular disorders at an early stage and pinpoints their specific location. [30]

AI in Drug Discovery:

The structural properties of drug molecules can be directly or indirectly examined during the drug discovery process using computer-assisted design tools marketing, and post-marketing surveillance.

The "NVIDIA DGX-1" program for pharmaceutical AI is used to obtain scientific knowledge about the chemicals used in production in order to find new drugs.

With the discovery of 200 million protein structures in 2021, DeepMind's AlphaFold is a remarkable accomplishment that will transform target identification for illnesses like Alzheimer's and cancer. [31]

AI in Health Care System:

In 2016, the Open AI Framework identified the open AI ecosystem as one of the top ten most promising innovations in technology good technology can compare and collect data on social awareness algorithms.

Medical firms collect extensive data on patients, including their treatment history from childhood to the present. This data must be analyzed to provide recommendations for their lives. [32]

CONCLUSION:

Artificial Intelligence [AI] is revolutionizing the pharmacy and healthcare industries by enhancing drug discovery, formulation, and personalized medicine while improving patient safety and clinical outcomes. Through the integration of advanced tools such as machine learning, natural language processing, and predictive analytics, AI enables faster drug development, accurate diagnosis, and efficient pharmaceutical operations. Its applications in clinical, hospital, and community pharmacy settings have streamlined decision-making, reduced human error, and expanded healthcare accessibility.

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