ejpmr, 2021,8(3), 212-216

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

A REVIEW ON THE STATUS QUO OF ARTIFICIAL INTELLIGENCE IN PHARMACY SECTOR

***[1]Poonguzhali S., [2]Sriram S. and [2]Jasmine Fathima A.**

[1]Professor, Department of Physics, Sri Ramakrishna College of Arts and Science, Coimbatore.
[2]College of Pharmacy, SRIPMS, Coimbatore.

***Corresponding Author: Poonguzhali S.**

Professor, Department of Physics, Sri Ramakrishna College of Arts and Science, Coimbatore.

Article Received on 24/12/2020 **Article Revised on 14/01/2021** **Article Accepted on 04/02/2021**

ABSTRACT

In this review article, the current status of Artificial Intelligence (AI) in the Pharmacy field is discussed. Even though AI is new and is not much familiar, it already started revolutionizing every walks of human life. Application of AI in pharmaceutical sectors like drug discovery, drug designing, clinical trials, pharmacy, and so on has enormously reduced the failure rates and ultimately reducing both cost and time spent. With appropriate use of Machine learning (ML), it can further revolutionize the Pharmacy sector in a number of ways. Pharmacists can accomplish their clinical responsibilities more rapidly and seamlessly with the aid of AI and without compromising patient safety. In this data-driven age use of AI can assist the pharmacy sector to achieve the peak of efficiency.

KEYWORDS: Artificial Intelligence, Deep Learning, Machine Learning, Pharmacy sector, Pharmaceutical industry, Clinical Trial, Drug discovery.

1. INTRODUCTION

"Artificial intelligence" is generally used to describe the theory and development of computer systems to perform tasks that normally would require human intelligence.[2] AI uses processes like acquiring information, developing rules for using the information, drawing approximate or definite conclusions, and self-correction.[11] The process involved in AI includes Machine Learning (ML), Natural Language Processing (NLP) and Deep Learning(DL).[9] There are different types of machine learning like supervised learning, unsupervised learning, semisupervised learning, and reinforcement learning, supervised learning is the most commonly used.[2] A division of Machine learning is Deep learning. It uses artificial neural networks (ANNs), a computing system roughly inspired by the biological neural network. ANN learns by processing data that contains input and output. The deep learning algorithm performs successive adjustments to ameliorate the output and terminates at a certain point, which is called supervised learning.[9]

AI is employed in diverse divisions like education to business to bring revolutions and cybernation.[11] Almost all healthcare utilization of AI are termed 'narrow AI' because they execute only a solitary, explicit task and cannot perform more than that. They just replace a normal task that needs a human intellect. A compound task can be made to perform by combining all these narrow tasks.[2] AI is employed already in the pharmaceutical sector to execute numerous pharmaceutical care activities like drug interactions, forecasting adverse drug events, and to enhance patient medication compliance through digital platforms. Pertinent use of AI can warrant better patient care through appropriate diagnosis and treatment.[5] Use of AI has broadened in the past decade and is still growing. Pharmacists play a crucial role in expanding, assessing, and executing AI in healthcare which can make clinical activities rapid and easy to refine clinical outcomes.[2] The very plan of embracing AI in the pharmacy sector has given hope and this review article focuses on the pharmaceutical applications of Artificial Intelligence which are discussed below.

2. Pharmaceutical Applications of AI

2.1 Drug Development

AI is used in diverse phases of drug development like the selection of disease targets, designing lead molecule, synthesis of drug-like compounds, predicting mode of action of compounds, drug repurposing, drug design, selection of right patients, improve R&D regulation, and so on with the help of technologies. Appropriate use of AI provides the chance to overcome all the flaws that can arise normally during the drug development process with human intellect. It helps in minimizing prejudice and improving efficiencies.[11]

Other than this AI is also used for the prediction of feasible synthetic routes for drug-like molecules, pharmacological properties, protein characteristics as well as efficacy, drug combination and drug–target association and drug repurposing. Also, the identification of new pathways and targets using analysis becomes possible via the generation of novel biomarkers and therapeutic targets, personalized medicine based on markers and discovering the connections between drugs and diseases.[11]

2.12 Selecting Disease targets

With the incorporation of genomic data, biochemical traits and target tractability AI has revamped the pathway or target identification for the treatment of diseases/disorders.[11] Due to ADR or lack of efficacy most drugs do not qualify phase II and phase III of clinical trials, this is because of the intricate nature of the human system which prevents them from responding to drugs in the same manner. With access to more disease information and better disease biology understanding AI can produce improved target selection. AI can perform this process expeditiously and can provide output for millions of documents as a knowledge graph with several relationships in just seconds, which generally requires hours of manual work to go through all the vast information available and to map a relationship between them.[9]

An example of an AI platform is IBM Watson for Drug Discovery. It has identified five new RNA-binding proteins (RBPs) linked to the pathogenesis of amyotrophic lateral sclerosis (ALS), a neurodegenerative disease.[11]

2.13 Designing a lead molecule

AI screens compound for desired properties for synthesis based on the data from known compounds like pharmacokinetic data, safety parameters, or affinity for binding. All the processes are fed back into the system for later reference.[9] AI employs chemical space for the discovery of drugs which provides a platform for discovering new and high-quality compounds. It makes it possible to computationally enumerate numerous molecules.[11] Machine learning suggests molecules that are synthetically tractable and to create a plan for how to build them.[9] AI reduces the number of synthesized compounds and further testing in vivo or in vitro systems, thereby reducing the R&D expenditure and attrition rates. AI can select molecules depending on the ease of synthesis.[11]

2.14 Synthesis of drug-like compounds

The following are the properties of Drug-like compounds; (i) molecular weight <500 Da; (ii) H-bond donors <5; (iii) H-bond acceptor < 10; and (iv) calculated Log P (cLogP) <5. Retrosynthesis is generally used for the synthesis of these molecules. Conversion of them into smaller fragments is the first step in this approach. This is followed by the selection of feasible organic reactions from the available literatures. It predicts the voids that can cause failure in the organic reaction. These voids are nothing but the unpredictable steric and electronic effects and partial understanding of the reaction mechanism. Computer Aided Organic Compound Synthesis (CAOCS) systems are available to perform these tasks.[11]

2.15 Predicting Mode of Action of compounds

AI platforms can predict in vivo safety profile and target effects of compounds way before they are synthesised in the drug development process. This can reduce drug development time and costs. DeepTox (which can predict the toxicity of new compounds) and PrOCTOR (which can predict the probability of toxicity) are a few examples of such a platform. The predictive accuracy of these platforms can be enhanced if enormous and clear data on the efficacy and therapeutic profile of various compounds available.[11]

2.16 Drug Repurposing

It is otherwise called as Drug repositioning in which new therapeutic purposes for existing drugs are investigated. These drugs can go through Phase II trials directly for a different indication by detouring Phase I and Pre-clinical phases. In silico methods predicts pharmacological properties of drugs and aids for drug repurposing with the help of transcriptomic data containing varied biological systems through Deep Learning. Evolution in Precision Medicine resulted in the rise of succeeding generation AI which has the ability to design drug compounds/ molecules from the Generative Adversarial Networks (GANs). Reinforcement Learning is another AI method that is used in in silico medicine. An important advantage of this method is that it is less dependent than any other method, thus it is easy to recognize strategies for molecule design.[11]

2.17 Polypharmacology

Polypharmacology is nothing but the use of drugs that can act on multiple targets or pathways. Because of the deeper perception of pathological processes in diseases, ‘one-disease-multiple-targets’ dominates over the ‘one-disease-one-target’ model. Integration of diverse information of molecular pathways, crystal structures, binding affinities, drug targets, disease relevance, chemical properties, and biological activities are done by many databases like PDB, ZINC, PubChem, Ligand Expo, KEGG, ChEMBL, etc. which are scrutinized by AI to design polypharmacological agents.[11]

2.2 Drug Design

Possible therapy of new drugs is designed by AI based on monitoring the interaction of the 3D models of molecules and target sites (receptors, enzymes). This is achieved by the application of deep learning based on the existing behavioural history of the molecules.[10]

2.21 Predicting the 3D structure of the target protein

AI tools predict 3D structure of the target protein more accurately, and this is important because new drug molecules are designed based on the 3D environment of the binding site of the target protein.[3]

2.22 Predicting Drug-Protein Interactions

Quantum mechanics predicts this in drug discovery because they study the quantum effects in a simulated environment (mainly in the atomic level), thereby offers greater precision than other methods. DL is used to predict the potential energies of small molecules, thereby replacing computationally demanding quantum chemistry calculations by a fast ML method.[3]

2.3 Clinical Trials

Clinical trials are costly and time-consuming. AI has potential applications in this area which ca help reduce cost and time. AI helps in identifying potential candidates for trials, sample size to improve sensitivity, managing Electronic Health Records (EHR of patients) to control bias and ultimately help in reducing cost and minimizing time. It can also be used to keep a track of patients like updates on lab reports of patients, signs of ADR or injury, or death of the patients participating in the trial.[10]

An example of such an AI tool is AiCure, which is a mobile platform to check medication adherence in a Phase II trial.[11]

2.31 Selection of right patient

There is a vast amount of information available these days which makes it impossible for the researchers to go through all information available and establish links between the available patient data and certain diseases. This makes it more difficult for them to predict whether patients can respond to the given therapy, patients at more risk for side effects, and the course of the disease. Without the involvement of AI, it would be difficult for the researcher to explore these vast data to establish the link.[9] All clinical trial poses inclusion and exclusion criteria. Patients meeting criteria are eligible for the study. But sometimes a specific set of patients might not meet the criteria based on their medical history. Patient recruitment into a study is a complex process and often is the major reason for the delay of trial because most studies don't meet enrolment timelines.[7]

AI is an ideal tool to aid in clinical trials, where it helps in recognizing the right patient with appropriate gene targets and can forecast the effect of the drug candidates. An important phase in a clinical trial is the selection of patients. AI tool uses predictors like human biomarkers of disease, thereby helps in recruiting patients with those biomarkers who are apt for that trial. Ultimately it results in improving the success rate.[11] Selecting patients with the same disease characteristics can lessen variation, ultimately reducing cost. Understanding a patient's characteristics before selecting a candidate can increase the success rate of the trial.[9]

AI models and methods can also be used to enhance patient cohort selection through one or more of the following means identified by the Food and Drug Administration (FDA): (i) by reducing population heterogeneity, (ii) by choosing patients who are more likely to have a measurable clinical endpoint, also called 'prognostic enrichment', and (iii) by identifying a population more capable of responding to treatment, also termed 'predictive enrichment'.[7]

2.32 Patient Monitoring

Patient recruitment into study requires enormous time and cost. The patients must adhere to the trial procedures throughout for successful completion of the trial. An only a small amount of trials do not meet dropout. The average dropout rate is 30%. This is because of a lack of adherence to trial procedures, leading to additional cost and time because of additional recruiting efforts. AI techniques offer personalized patient monitoring by integration with technologies.[7]

2.4 Drug Delivery

With the advanced knowledge of biological systems, AI incorporates nano-engineering efficiently to facilitate nano-system designs. For feasible drug delivery, the complex human body is divided into simple compartment models based on their physicochemical properties.

In modern drug discovery, creating the molecule libraries, identifying novel drug candidates with optimal properties, predicting the biological functions of proteins, and deep learning play critical roles. AI platforms are used by many biopharmaceutical companies for target identification, lead molecule identification thereby resulting in more effective drug discovery. Machine Learning (ML) easily identifies inactive or toxic compounds with the prediction of target-drug interactions thereby playing a key role in the identification of novel drugs/ targets.[8] Another important goal of drug delivery is drug accumulation in the site of action. The controlled local accumulation of drugs by delivering them to the site of action can function as an enhancer of the therapeutic effect with a reduction in toxicity.[1]

2.41 Predicting the effectiveness of drug dosing and delivery methods

A data-driven predictive system has been developed using a machine learning framework capable of modelling the pathogen-drug dynamics and predicting the effectiveness of dosing patterns and drug delivery methods.[8]

2.42 Rapid identification of the bioactive agents and monitoring of drug release

Artificial Neural Networks (ANNs) have the capability for modeling, pattern recognition, and predictions which are applied in pharmaceutical research areas like drug development, improvement of the pharmacological profile, and prediction of protein structure and function. It can also recognize similar structures, the concentration of chiral samples, etc. A trained ANN model along with pharmacokinetic simulations have been used for designing controlled release dosage forms. Formulation factors and cumulative percentage of drug released at various time points were selected as inputs and outputs, respectively.[8]

2.5 Healthcare
The most common application of AI in healthcare is precision medicine- predicts whether the treatment succeeds on a patient based on their characteristics. The great majority of machine learning and precision medicine applications require a training dataset for which the outcome variable (onset of disease) is known; this is called supervised learning.[4]

2.51 Diagnosis and treatment applications
IBM's Watson is an AI platform that integrates the use of Machine Learning (ML) and Natural Language Processing for precision medicine. Since many cancers have a genetic basis, human clinicians have found it increasingly complex to understand all genetic variants of cancer and their response to new drugs and protocols. Several firms focus specifically on diagnosis and treatment recommendations for certain cancers based on their genetic profiles.[4]

2.52 Patient adherence
Healthcare professionals develop clinical care to improve clinical outcomes of their patients. Noncompliance is a major problem affecting the outcomes of the patient. The greatest challenge to AI in these healthcare domains is not whether the technologies will be capable enough to be useful, but rather to ensure their adoption in daily clinical practice. For widespread adoption to take place, AI systems must be approved by regulators, integrated with EHR systems, taught to clinicians, paid for by public or private payer organizations, and updated over time in the field.[4]

2.6 Pharmacy
2.61 Drug product decisions using pharmacy-related images
Image processing is the major area used by Machine Learning in the pharmacy sector. It is widely used in the pharmacy supply chain. This helps in quicker identification of drug products. It enables pharmacists to detect mislabelled drug products.[6]

2.62 Drug selection decisions
Once a decision has been made to use drugs to address a particular health problem, ML may be able to inform drug selection. As an example of this, ML capable of indicating, through automated classification, who is and who is not likely to experience particular adverse effects from a particular drug could be useful.[6]

2.63 Dosing decisions
ML plays a major role in guiding drug dosing here because both dose and response to drug therapy are easily quantifiable. Response to drug therapy is also measurable. ML to support dosing decisions may offer advantages, for example, when blood levels of drugs or related factors can be routinely assessed.[6]

2.64 Inventory management decisions
ML helps to accurately predict medication use in hospitals and health systems. The major difficulty in applying ML to inventory management is that the drug use data is extremely large in hospitals and not readily or easily available. It is necessary to have a mechanism that can integrate patient and medication use data.[6]

2.65 Medication Adherence
Medicines are developed to treat/ cure diseases, which is possible only with proper adherence to therapy. Making patients to adhere to therapy and monitoring it is a challenging task. But with the advent of newer technologies therapy monitoring turned to be easier. Adherence to therapy is very important in case of chronic diseases like diabetes, hypertension because these patients often tend to skip a dose. Many researchers have applied AI to develop software to check adherence of patients to therapy and improve their clinical outcomes.[10]

2.7 Genetics
Genome sequencing is known to be a large, long-lasting venture, which is believed to allow scientists to inspect the etiology of numerous diseases. However, no one predicted the enormous amount of data they will receive and which someone will have to process to get useful information. Today, machine learning and hardware help to get to data with computer support, which further accelerates research. It is now known that the causes of various diseases do not lie in the mutation of a single gene, but involve multiple genes, as well as their interaction. The sequencing of the genome that earlier lasted for days has now been shortened for a few minutes, and the information can be used concretely.[10]

3. CONCLUSION
As year pass by AI is becoming more common in the field of Pharmacy. As Medicine experts, Pharmacists play a key role in understanding and applying the core concepts of AI to improve patient's clinical outcomes. Many Pharmaceutical industries are facing challenges due to increased cost and reduced efficiency. Successful integration of AI tools into this can reduce both cost and time. Even after successful adoption it cannot replace human intellect but can augment them to improve their efficiency.

BIBLIOGRAPHY

1. Colombo S. Applications of artificial intelligence in drug delivery and pharmaceutical development. Artificial Intelligence in Healthcare, 2020; 85-116.
2. Nelson S, Walsh C, Olsen C, McLaughlin A, LeGrand J, Schutz N et al. Demystifying artificial intelligence in pharmacy. American Journal of Health-System Pharmacy, 2020.

3. Chan H, Shan H, Dahoun T, Vogel H, Yuan S. Advancing Drug Discovery via Artificial Intelligence. Trends in Pharmacological Sciences, 2019; 40(8): 592-604.
4. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. Future Healthcare Journal, 2019; 6(2): 94-98.
5. Dentzer S. Creating the future of artificial intelligence in health-system pharmacy. American Journal of Health-System Pharmacy, 2019; 76(24): 1995-1996.
6. Flynn A. Using artificial intelligence in health-system pharmacy practice: Finding new patterns that matter. American Journal of Health-System Pharmacy, 2019; 76(9): 622-627.
7. Harrer S, Shah P, Antony B, Hu J. Artificial Intelligence for Clinical Trial Design. Trends in Pharmacological Sciences, 2019; 40(8): 577-591.
8. Hassanzadeh P, Atyabi F, Dinarvand R. The significance of artificial intelligence in drug delivery system design. Advanced Drug Delivery Reviews, 2019; 151-152: 169-190.
9. Hunter J. How artificial intelligence is driving innovation in the pharmaceutical industry. The Biochemist, 2019; 41(5): 6-9.
10. Kostic E, Pavlović D, Živković M. Applications of Artificial Intelligence in Medicine and Pharmacy - Ethical Aspects. Acta Medica Medianae, 2019; 128-137.
11. Mak K, Pichika M. Artificial intelligence in drug development: present status and future prospects. Drug Discovery Today, 2019; 24(3): 773-780.