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REVIEW ON AI IN THE FIELD OF PHARMACOGENOMICS

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ABSTRACT
Pharmacogenomics has seen a dramatic change as a result of artificial intelligence (AI), which has made it possible to create customized treatment models based on a patient's genetic composition. Thus, many facets of genetic data might be analyzed by machine and deep learning algorithms of artificial intelligence to precisely predict how patients will react to specific drugs and prescriptions. The synergy also contributes to better drug efficacy, reduced adverse drug effects, and enhanced efficiency in drug development. This is not yet the case, though, as AI in pharmacogenomics has certain drawbacks, such as ethical and data privacy issues and the requirement for sufficient framework validation before it can be used in reality.

KEYWORDS: *Artificial Intelligence (AI), Pharmacogenomics, Personalized therapeutic models, Genetic makeup, Machine learning, Deep learning algorithms*

INTRODUCTION

Pharmacogenomics are research on how genetic variations among patients affect the way medications work is known as pharmacogenomics, and it is a component of personalized medicine. The vast amount of genomic data presents difficulties for some of the traditional pharmacogenomics techniques that have been used in the past, notwithstanding their practicality. With the introduction of advanced methods for analysing enormous amounts of genomic data, artificial intelligence (AI) has made it possible to accurately forecast individual drug reactions and—more importantly—to advise the best possible treatment regimens. AI subfields machine learning and deep learning have shown promise in making precise. Predictions about the efficacy of drugs and possible adverse effects from genomic data.[1]

Healthcare professionals will be able to create believable treatment and patient care plans by integrating AI into pharmacogenomics treatment plans, which will help lower the number of drug side effects. However, the application of AI in this setting also brings up a number of issues regarding ethics, privacy, and the reliability of AI models prior to their usage in clinical settings. This article describes the present and possible levels of pharmacogenomics and AI integration, as well as upcoming pharmacogenomics applications of AI and the challenges that need to be addressed to maximize this integration.[2]

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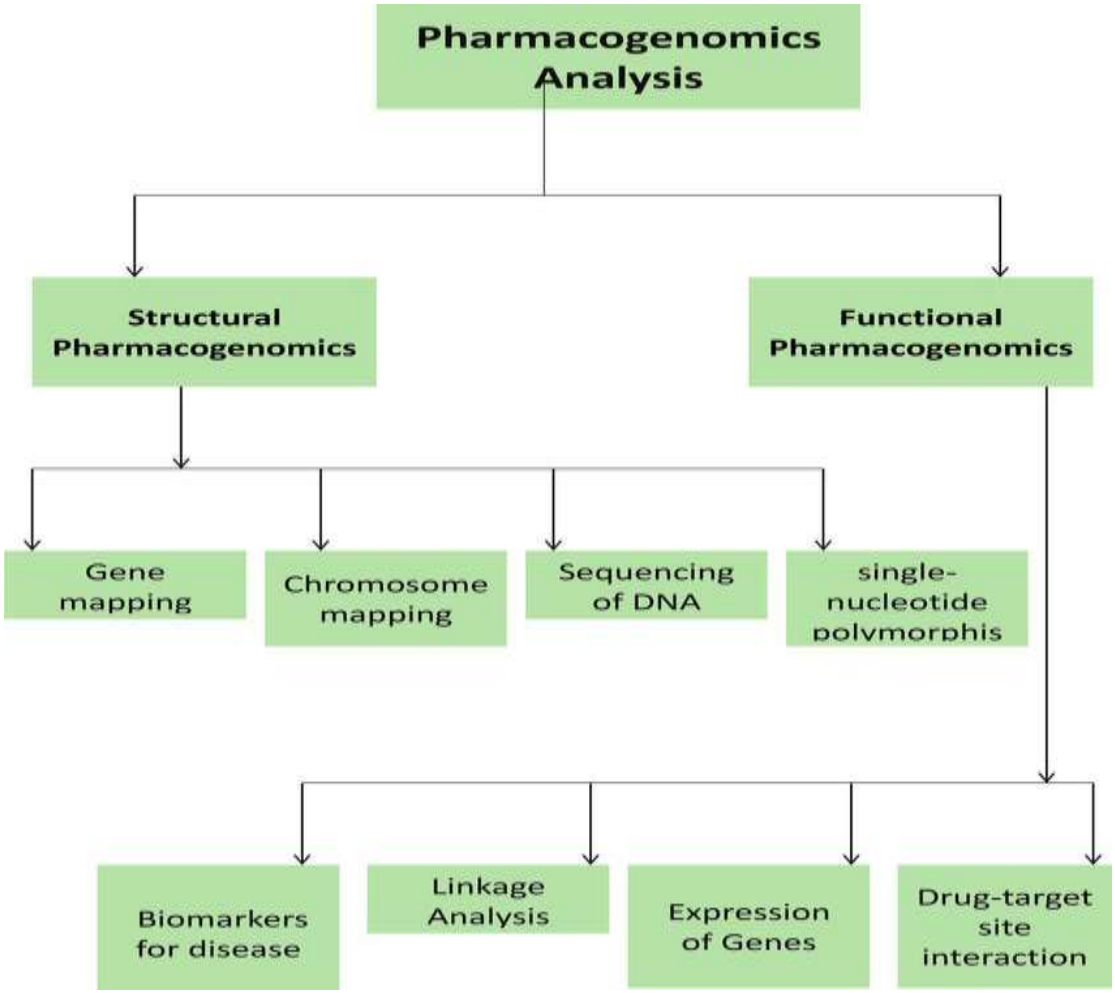


Fig : Structural and functional pharmacogenomics analysis

THE ROLE OF AI IN PHARMACOGENOMICS

By enhancing the processing of intricate genomic data, artificial intelligence is revolutionizing pharmacogenomics. More precise drug response predictions are made possible by the patterns found in large datasets by machine learning and deep learning models (Marques et al., 2024). By integrating multi-omics data, these models reveal connections between pharmacological efficacy and genetic variants (Abdelhalim et al., 2022). Large-scale genomic datasets are processed effectively by sophisticated algorithms. To find biomarkers that affect medication metabolism, convolutional and recurrent neural networks examine high-dimensional data (Jyothi, 2023).

By dividing patients into genetic groupings, clustering algorithms enable more accurate treatment recommendations (Lin, Lin, & Lane, 2020). It is a breakthrough to predict drug responses based on genetic variances. AI algorithms that have been trained on clinical and genomic data evaluate how people metabolize medications, minimizing side effects and increasing effectiveness (Weinshilboum & Wang, 2017) . [3]

Enhanced Clinical Decision Support

In clinical practice, CDS technologies use AI to assist medical staff by offering recommendations and decision support regarding prescription selection, dosage, and possible drug interactions. These technologies give doctors the ability to base their treatment regimens on evidence-based recommendations based on patients' genetic information (Lin et al., 2020). Given that pharmacogenomic variations are essential, AI helps designers prescribe drugs for individuals with complex illnesses including cancer and mental illnesses with better outcomes (Pardinas et al., 2021) . [4]

Validation and Trust in AI Models in Pharmacogenomics

The mental health of the models is the primary determinant of the accuracy and acceptability of AI algorithms in pharmacogenomics. Prior to being used in customized medicine, artificial intelligence-based predictions need to pass a number of clinical trials.

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Inadequate or even harmful treatment that can be of no assistance to the patient may result from bias and incorrect suggestions made to patients in the absence of rigorous validation.[6] This study recognizes that the quality of the datasets utilized in the modelling process has a significant impact on an AI model's accuracy. However, many models have significant bias about particular demographics since they are trained on datasets that are significantly non diverse (Weinshilboum & Wang, 2017). [5]

DISCUSSION

The development of artificial intelligence has greatly benefitted pharmacogenomics by filling the gap in medication prescriptions to improve treatment efficacy. Additionally, AI-powered solutions for drug response predictions reduce adverse drug reactions (ADRs) and greatly expedite the drug discovery process. Even so, there are still certain issues with artificial intelligence-based pharmacogenomics that must be resolved before it can be widely used in clinical settings. [7]

The first issue is how to properly handle, store, and safeguard the data that was gathered for the study. Large volumes of clinical and genetic data are used in pharmaceutical genomics systems, which raise serious ethical concerns because the data can be compromised. Given how sensitive patient information is, it should be mentioned that sharing genetic data requires stringent privacy protections (Dhieb & Bastaki, 2025). This means that there are situations in which the genetic information could be exploited, posing ethical and legal concerns, if secure methods of exchanging inherited genetic material are not combined with encryption. Only by implementing conventional approaches to AI governance and data protection can such threats be avoided, ensuring patient and healthcare professional confidence.[8]

It is important to realize that these systems are black box algorithms, even though it is now possible to predict a drug's response with a high degree of accuracy. [9]

When AI-based recommendations have an impact on crucial decision-making, the lack of interpretability of such a framework presents three distinct accountability difficulties in clinical practice. In order to ensure that suggested prescriptions adhere to the highest ethical standards and best practices of the medical field, the article also urges physicians to comprehend how AI models create predictions. This can be prevented by establishing clear rules for the explanation of AI use, which would guarantee that pharmacogenomic decisions made by AI are comprehensible and clinically sound. Finally, there are concerns about model validation and a lack of confidence in their results. Since many datasets are not diverse, recent outcomes rely heavily on the training data; hence, some groups of people are frequently left behind during the training process (Pardinas et al., 2021). [10,11]

CONCLUSION

By enhancing the understanding of intricate genetic data, forecasting specific medication reactions, and enabling individualized treatment plans that improve safety and efficacy, artificial intelligence (AI) substantially enhances pharmacogenomics. AI-powered pharmacogenomics is a ground breaking step toward more accurate, efficient, and individualized healthcare, despite obstacles relating to data privacy, ethical issues, and clinical integration. Its full potential in clinical practice requires ongoing innovation and interdisciplinary cooperation.[12,13]

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