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Artificial Intelligence used in Pharmaceutical and Healthcare Industry: A Review

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Abstract: *The pharmaceutical and healthcare sectors have transformed thanks to AI, which has sped up innovation and efficiency in many areas. By anticipating prospective medication candidates and modeling their interactions with biological systems, AI quickens the procedure for finding and creating novel medications. Through tailored treatment, early illness diagnosis, and increased diagnostic precision, AI-driven data analysis improves patient care. Robotic surgery technologies driven by AI increase operation accuracy. Predictive analytics reduces medicine shortages and waste in the pharmaceutical supply chain. AI is essential in medication safety monitoring because it can spot possible problems. Virtual health assistants powered by AI offer round-the-clock assistance and information, while chatbots simplify arranging appointments and making medical questions. However, data privacy, legal compliance, and ethical issues still need to be addressed. The increasing convergence of AI and these industries has enormous potential to transform healthcare delivery and pharmaceutical innovation.*

Keywords: Artificial intelligence, healthcare, pharmaceuticals, drug discovery, disease diagnostic, epidemic.

I. INTRODUCTION

The use of artificial intelligence (AI) has ushered in a disruptive age for the pharmaceutical and healthcare sectors. Drug development and research have been sped up by AI, requiring less time and money. AI systems may more accurately anticipate prospective medication candidates by evaluating large databases of chemical substances & biological relationships, resulting in revolutionary cures. Scientists can simulate complicated biological structures using AI-driven modeling, which helps them make better judgments and avoid spending money on expensive trials. Artificial intelligence learning algorithms are being used to analyze medical pictures for precise illness identification in the medical field, which has increasingly adopted AI to improve the results for patients and processes. Predicting illness patterns and hazards, based on artificial intelligence statistical analysis is revolutionizing patient treatment and enabling healthcare practitioners to efficiently manage resources and give early treatment. AI games a key role in customized healthcare, customizing therapies to patients' unique genetic characteristics while expediting processes. But integrating AI is difficult because of issues with privacy, legal restrictions, and ongoing algorithm evaluation. It is still important to strike the correct balance between moral concerns and technical innovation. Overall, AI's revolutionary effects are paving the way for an era where speed, accuracy, and superior results combine for the benefit of society.

II. METHODOLOGY

The empirical research was conducted on “Artificial intelligence used in the pharmaceutical and healthcare industry” from May 2023 to July 2023 using various databases ScienceDirect, ResearchGate, PubMed, Google Scholar, etc. A combination of keywords, including AI, machine learning, AI used in healthcare, AI in the pharmaceutical industry, etc. was used to conduct a search target on AI used in the pharma and healthcare industry via multiple databases in the current review, considering language limitation. In this article, the literature search was limited to scientific papers that were included in those databases and may be used as references by the scientific community.

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1:- The use of AI and machine learning are utilized in pharmaceutical development and research

Over the last 10 years, machine learning (ML) and artificial intelligence (AI) have emerged as the latest developments that are most anticipated to have a transformative influence on drug development and research (R&D). This is partly affected by the rapid advancements in technology for computers and the concurrent elimination of past obstacles to the collection and processing of enormous volumes of data. In the meantime, the cost of making new pharmaceuticals available to consumers and the public has escalated to an exorbitant level. As a result of their computerized nature, strong predictive capabilities, and anticipated growth in inefficiency, AI/ML technologies are appealing to the pharmaceutical industry given these difficulties. ML techniques have been applied to drug discovery with increasing complexity over the previous 15 to 20 years. The newest region of it is important to look past the accompanying buzzwords and variations since the most recent sector of medicine development wherein As AI and machine learning (AI/ML) start developing a beneficial impact, R&D will increasingly incorporate AI/ML. Furthermore, it is crucial to understand that using research to draw conclusions regarding the outcomes of clinical research is an effective use of time. The COVID-19 pandemic may speed up the use of AI/ML in clinical research because of the growing dependence on technological developments in clinical study activities[1].

A novel drug's development is a time-consuming, expensive procedure with a poor completion rate. The robotic nature, analytical powers, and anticipated rise in the effectiveness of AI/ML approaches make them enticing. It is necessary to raise the likelihood of success (POS), decrease expenses, and make drug development more effective[2]. Since around 15 years ago, ML techniques have been applied to drug discovery with growing sophistication. Due to a greater dependence on digital technologies for The COVID-19 pandemic could help the deployment of AI/ML in research studies by accelerating the collection of patient information. This post aims to provide a balanced approach, aid in distinguishing illusion from actuality, and inform visitors on the best ways to apply AI/ML in medication research[3,4].

II. ARTIFICIAL INTELLIGENCE IN THE CREATION AND FINDING OF DRUGS

2.1 AI in Drug Discovery

By identifying hit and lead substances, validating pharmacological goals, and improving the layout of structures, machine learning (AI) can assist with the time and resource-intensive drug creation cycle. AI must address the issues of data size, expansion, variety, and unreliability[5]. Large data sets and complex biological traits are challenging for traditional artificial intelligence (ML) algorithms to handle. To evaluate the efficacy and safety of pharmacological drugs, big data modeling and analysis may be employed. These techniques make use of recently developed AI technologies like deep learning (DL) and modeling studies. Merck sponsored a QSAR ML competition in 2012 to highlight the benefits of DL in the pharmaceutical sector[6,7].

The virtual chemistry spaces PubChem, ChemBank, Drug-Bank, and Chem-DB map the positions and properties of molecules. Virtual screening (VS) facilitates the selection of appropriate compounds for further investigation[9]. Improved profile evaluation, nonlead chemical elimination, and more economically advantageous medicines are selected by the application of in silico approaches, structure, and ligand-based procedures[8,12]. Molecular similarities, in silico methods, and predictive models may all be used to predict complex formations. Deep-VS docking devices have shown outstanding success in docking sites and increasing potency patterns.[10]

2.2 How AI is boosting the creation of medicinal products

AI has the potential to revolutionize drug formulation creation and displace the present trial-and-error techniques. Problems with porosity, dissolution, and stability can be resolved with the use of computational approaches like QSPR [14]. Decision-support technologies use systems based on rules to choose excipients based on the physicochemical characteristics of the medication and to monitor the procedure [15]. Scientists used Model Expert System (MES) for the creation and artificial neural networks (ANN) for the backpropagation developing is used to generate direct-filling hard gelatin capsules encapsulating piroxicam [13]. Powder flow characteristics and the visual characteristics of tablets have been investigated using mathematical methods such as computational fluid dynamics (CFD), discrete element modeling (DEM), and finite element modeling (FEM). The manufacture of pharmaceuticals might be highly expensive[16,17].

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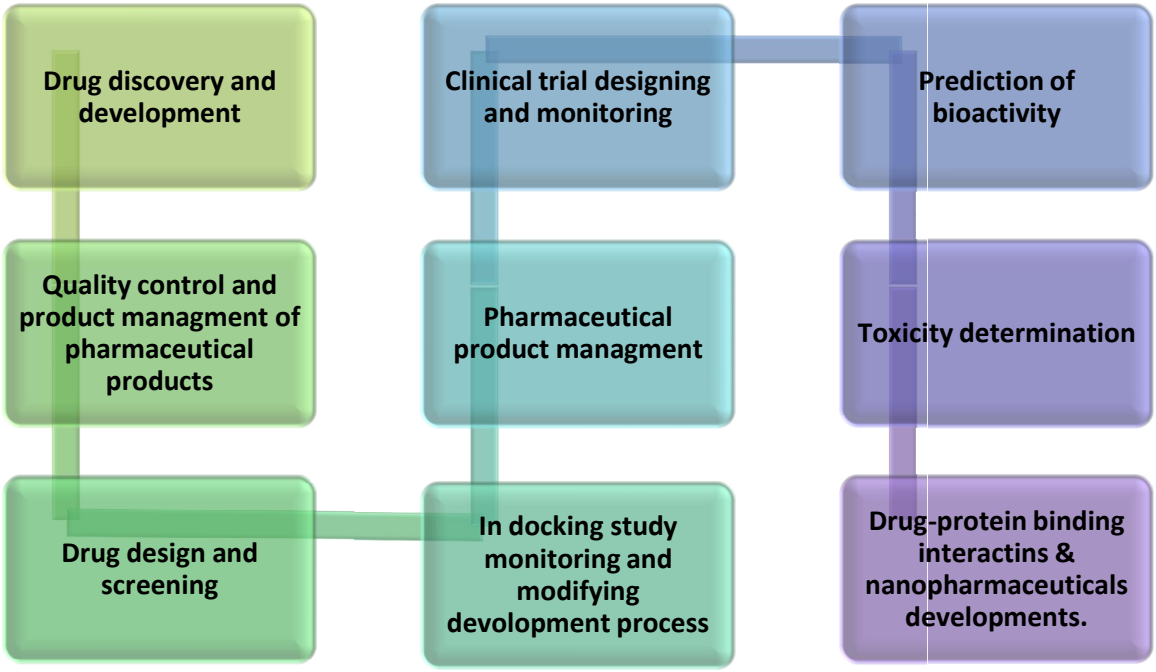

Figure 1. Artificial intelligence (AI) applications in pharmaceutical fields

III. SCIENCES OF COMPUTATIONAL PHARMACEUTICALS

The pharmaceutical industry is only one of a number that has experienced a rapid increase in interest in artificial intelligence (AI) and machine learning [19]. The volume of novel applications for artificial intelligence in a variety of pharmaceutical sciences is rapidly increasing as a result of the enormous expansion of data through diverse sources, current improvements of different analytical instruments, and continuing advances in machine-learning algorithms. The historical, present, and prospective future impacts of machine learning techniques on many pharmaceutical-related fields, particularly drug research and exploration, structure, and packing, are summarized in the following paper [20]. Neural network models receive special attention when discussing computerized learning methods because they may mimic non-linear correlations that are frequently seen in drug development and are thus frequently employed by drug developers [21]. Making advantage ofEqually a financial and a regulatory perspective are considered when it comes to the application of machine learning and AI technologies in the medical sector [22]. The use of artificial intelligence in pharmaceutical companies to provide more effective, quick, and affordable treatments is also highlighted. This goes beyond the usage of traditional technology in computers[18].

IV. EXPLORATION OF PHARMACEUTICALS AND HEALTHCARE USING ARTIFICIAL INTELLIGENCE

4.1 Diseases diagnostics

For effective medicines to be developed and the welfare of patients to be ensured, an in-depth evaluation of the health issue is necessary [24]. AI is an essential tool in the medical field since human error and incorrect interpretation of generated data make precise diagnoses difficult. In reaction to the increasing demand for healthcare, various solutions have been developed to address the inconsistencies in sickness diagnosis figure 2 [25]. A medical diagnosis is an important first step in determining a patient's condition according to current problems. It is essential to keep patient health records on hand to collect the majority of assessments found throughout examinations and testing. AI is becoming more crucial in the diagnosis of cancer and dementia since approaches that are not owned or already associated with previous experience cannot be biased. However, for scientific tracking, a topical and accurate database is required [26]. By making changes that adapt and change forecasts, linkages from artificial intelligence may be reached, but bigger databases and more relevant items can make AI more beneficial [23].

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Numerous methods utilizing deep learning may be applied in labs, such as the diagnosis of heart failure and the categorization of epidermal illnesses [27–29]. For the purpose of method computing, crossover validation may be employed to partition information into several distinct groups. The 3 main components of AI are reliability, kindness, and originality.

Findings in a broader strategy may be produced by clinical appointment parts which may guide AI and machine learning platforms via methods like logistic reconstruction, naive Bayes, discriminate analysis, support vector machine, nearest neighbor, random forest, decision tree, and neural network with convolution [30–32]. The source, quantity, and diversity of characteristics that exist in the training information and the test information may be taken into account in the algorithm-driven assessments of effectiveness. Reason and choice-making are merged in the diagnosis to research liver diseases [33]. Forecasting has been used for Parkinson's disease early detection. Rib segments have been developed for the diagnosis of lung illnesses using chest X-ray images. To operate successfully, a multiple ecosystems system catches up on image properties and enhances rib isolation. [34].

By analyzing ECG information, algorithms, and artificial intelligence have been utilized to identify and categorize cardiac arrhythmia [35-37]. In a different study, support vector machine (SVM) and optimization genetic algorithm (GA) classifiers were used to categorize and diagnose TB [23].

Figure 2. Artificial Intelligence for the health sector Development

4.2 AI in Digital Therapy/Personalized Treatment

Using the raw datasheets, data AI possesses the ability to derive a meaningful relationship that may be used for identification, management, and disease mitigation. In almost every field of medical research, there is the potential to employ a wide variety of more contemporary computational learning methodologies. To solve challenging clinical issues, it is necessary to obtain, assess, and use a wealth of knowledge (Figure 3). Due to the advancement in healthcare AI, doctors are now more equipped to handle challenging clinical issues. Healthcare professionals may manage this information with the help of technologies like artificial neural networks (ANNs), computing evolution, fuzzy expert systems, and hybrid intelligent devices [38]. The ANN Table 1 is built around the neural system of living things [39]. Making use of information processing Parallel computation is done via a network of computer processors referred to as synapses. A pair of binary sensitivity mechanisms was used to create the first artificial neuron. In the most common architecture, input, middle, and output were just a handful of the many levels. It was dubbed a layered feedback perceptron. Each neuron's terminals possess a particular mass[40].

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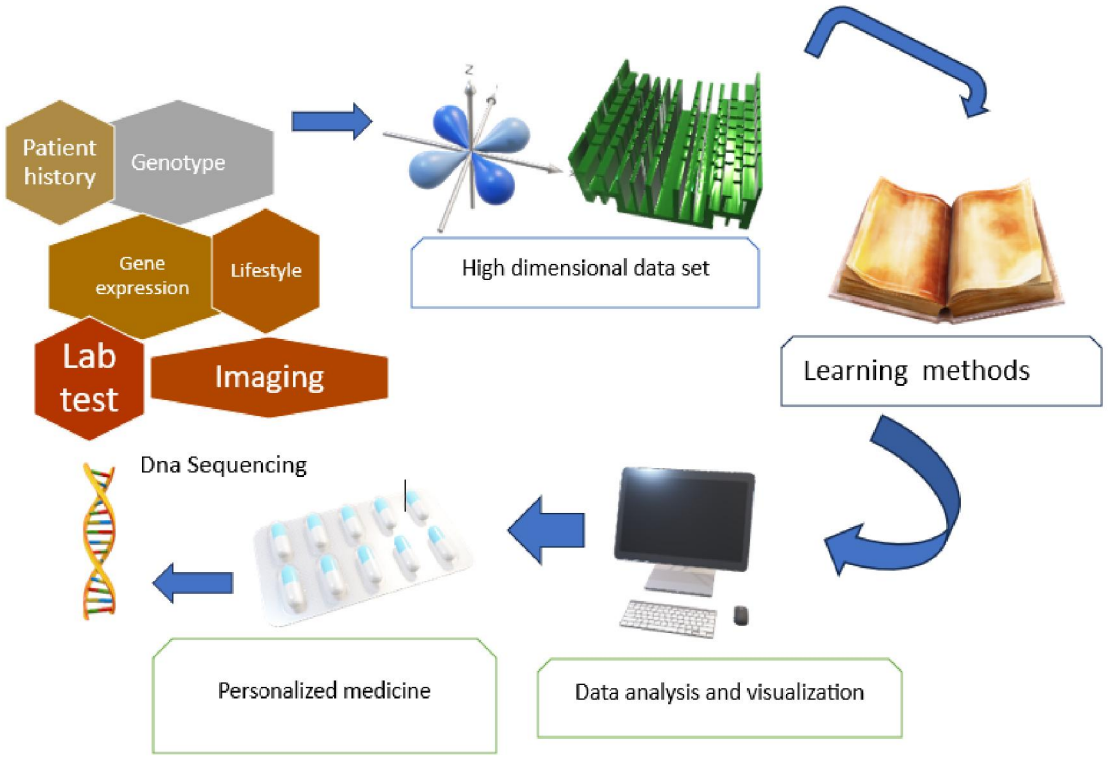

Figure 3.AI in collecting and evaluating information about patients to tailor therapy

Table 1. A thorough analysis of the drawbacks and difficulties of artificial intelligence in medical and pharmaceutical study [35]

Divisions	**Artificial technologies used**	**Applications**	**Drawbacks**
Epidemic/Pandemic [40,41,42]	MLP	Look into COVID-19's potent pattern.	• Unpredictable. • Proper model operation; • Challenging and costly analyses. • Relies on the size of the instructions
	FNN	Look into COVID-19's potent pattern.	• Needs several hidden layers. • As looking for space's depth grows, learning becomes increasingly challenging. • The issue is even worse with color photographs.
	ARIMA	Look into COVID-19's potent pattern.	• Reversal points are hard to forecast. • High computational expenses. • Poor results for long-term projections. • Annual sequences cannot be utilized. • More difficult to explain than exponentially smoothing.
Drug discovery [43-48]	Deep learning neural networks with the ALGOPS algorithm and the ADMET forecast	Lipophilicity and solubility predictions	
	Chem Mapper Deep learning	Drug-target interaction	• Models' absence of adaptability and universality

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	Deep Tox, eTOXPred, Targe Tox	Prediction of Toxicity of the Drug	
	PrOCTOR	Decide whether a medication's study failure will be caused by a hazard.	
	BNMs Dirichlet process mixture model mTPI, MCMC	CT design, dose selection	• Lack of a strong reviewed clinical assessment; • Implementation-related logistical challenges
	OCR, NLP	CT patient assessment and diagnosis	• Costly
	Deep learning SAAIMM SDII-FFNNML-AMM	Forecast seasonal influenza forecast	• For the training process, a lot of input and target pairings are needed.
	HNN [49]	Prediction of Ebola	
	DNN [50]	Prediction of Zika	• It performs better than other strategies, but it needs a lot of data to do so. • High cost. • no accepted theory can be used to pick deep learning technologies.
	SVR BNM [51]	forecasting and monitoring the dengue epidemic	
	ANN, CNN TB-AI [52]	Quick identification of TB bacilli for TB suspected	
	MPNN [53]	Identification of yellow fever	
Disease diagnosis [54,55,56]	In-depth learning the neural network Unsupervised education	Arial fibrillation, cancer, dementia, dermatological conditions	• Difficult, and growth takes a lot longer. • Needs a lot more data than conventional ML algorithms. • More costly economically than conventional methods.
Digital therapy and personalized treatment [57,23,64]	computational evolution ANN Uncertain systems for expertise smart hybrid technology computerized scheduling of therapy	Analyzing images and interpreting data Vasodilator and anesthetic dosage	• Hardware reliance. • unclear Network operation. • It is challenging to choose the right network structure. • Difficulty in communicating the issue to the network. • Values do not always translate into the best outcomes.
	Radiomics	Radiotherapy Radiation treatment outcome prediction	

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	Assistance in medical judgment computerized training that is knowledgeable	and toxicity Diabetes management	

V. EMPLOYMENT EFFECTS ON THE HEALTHCARE SECTOR FOR AI

- **Job Transformation:** Artificial Intelligence (AI) adoption in healthcare has the potential to automate routine tasks, leading to concerns about job redundancies. Basic jobs like data entry and simple diagnostics could be automated by AI, potentially resulting in job losses for individuals in these roles.
- **Evolution of Roles:** While AI may not eliminate certain healthcare positions, it could reshape their nature. For instance, roles such as radiologists might transition into supervisory roles, overseeing AI systems that assist in medical imaging analysis.
- **Skill Enhancement:** Integrating AI into healthcare may necessitate healthcare professionals to acquire new skills for effectively using and interpreting insights generated by AI systems. This shift could pose challenges for individuals who need to upskill.
- **Ethical and Legal Dimensions:** The incorporation of AI in healthcare introduces concerns about patient privacy, data security, and liability. This might lead to the emergence of new job roles related to ethics, compliance, and cybersecurity.
- **Patient-Provider Dynamics:** AI's introduction could influence the relationship between patients and healthcare providers. In specific scenarios, direct interaction with healthcare professionals might decrease due to AI involvement.

VI. MORAL RAMIFICATIONS

A number of moral difficulties increase the complexity of the application of AI in medicine. Employing smart machines to arrive at or help with healthcare choices raises concerns about responsibility, openness, consent, and privacy because historically, almost all medical choices have been done by humans[67].

Creating visibility could be a particularly challenging problem to accomplish with the technology that is now accessible. Many AI systems are quite hard to figure out or believe, particularly the algorithms that are utilized for picture interpretation. A patient will undoubtedly want to know why if he or she finds out that a photograph led to a cancer diagnosis. Even medical professionals who are typically familiar with deep learning algorithms may be unable to provide clarification.

AI will undoubtedly have errors. Mechanisms govern the patient's medical care and therapy, and it could be difficult to hold them responsible. There will also be situations in which artificial intelligence (AI) systems provide people with clinical data that they would prefer to get from a kind doctor. Algorithmic bias may also be present in healthcare machine learning algorithms, which may anticipate greater disease risk due to ethnicity or sexual orientation even though these are not the actual cause factors.

There are a variety of ethical, medical, professional, and technological advancements that AI for healthcare is expected to bring about. Medical institutions, as well as political and regulatory entities, must create mechanisms to detect important problems, respond appropriately, and implement management processes to prevent negative outcomes. Given that this technique has a substantial This technology will require continual maintenance and attentive regulation for several decades while it has a profound and long-lasting impact on civilization as a whole. [65,66]

VII. THE FUTURE OF AI

From our perspective, AI is going to make a big impact on the forms of medical treatment that are offered in future years. This skill largely enables accurate medicine, which is universally acknowledged to be an incredibly necessary advancement in healthcare. It takes the form of machine learning. We anticipate that while initial attempts at providing

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diagnosis and therapies proved difficult, AI will eventually become proficient in that field. Considering how rapidly AI for radiology examination is evolving, it is feasible that eventually, a computer will review the majority of radiology and pathology picture data. Voice and text detection will be utilized frequently for activities like speaking with people and translating medical notes. The primary obstacle to AI in numerous medical fields is getting away from jobs and responsibilities that require human-specific skills like empathy, persuasion, and overall coordination. Perhaps the only healthcare professionals who oppose the use of artificial intelligence will ultimately lose their jobs. [66]

VIII. CONCLUSION

Digitalization of the pharmaceutical sciences is a very promising area where various AI and machine learning technologies may be created and effectively used. The rising efficacy of machine learning technology in a range of pharmaceutical settings shows great potential for the creation of applications for AI that go beyond its more traditional functions. The kind and quantity of the dataset, among other factors, may have an impact on the machine learning strategy that is finally used. The appropriate machine learning strategy to utilize may thus depend on the problem at hand.

using enough carefully selected data, developing high-value apps using cutting-edge AI algorithms may become a common practice. This has the potential to solve many problems in drug research and development. With efficient, rapid, and economical solutions, AI is probably going to help the pharmaceutical business into a new era of digital innovation. In conclusion, it can be very beneficial for both consumers and drug research to combine substantial R&D expertise with cutting-edge ML/AI algorithms.

The application and dissemination of AI/ML technologies can offer simple tools for increasing productivity and promoting the use of innovative approaches in R&D. But understanding the difference between association and causality is crucial, as is realizing that improving one's predicting abilities will not make the scientific method obsolete. Credible reasoning nonetheless requires sound quantitative judgment, and given its direct impact on the development of medications, this becomes particularly crucial.

This emphasizes once more how important it is to have an in-depth understanding of ML/AI methods in addition to adequate domain experience in R&D for optimal usage in the process of producing medications.

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Authors' contribution:

Sourajyoti Goswami: writing, drafting, statistical analysis. **Mohit Kumar Singh:** drafting, statistical analysis, editing. All authors reviewed and finalized the manuscript for publication.

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