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PRESENT CONCEPTS AND FUTURE PERSPECTIVES OF ARTIFICIAL INTELLIGENCE IN PHARMACEUTICAL INDUSTRY. A NARRATIVE REVIEW.

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Abstract

The digitalization of data within the pharmaceutical industry has experienced a significant surge in recent years. However, digitization has resulted in the challenge of collecting, analyzing, and employing such knowledge to handle complex clinical issues. AI is being implemented for this purpose because it can automate the processing of enormous quantities of data. Artificial intelligence [AI] pertains to a technological framework comprising an assortment of advanced instruments and networks that emulate the capabilities of humans. Furthermore, it does not present a significant peril of replacing humans in all circumstances where they are physically present.

Artificial intelligence [AI] employs computers and software capable of autonomously analyzing and learning from data in order to determine the most effective course of action for accomplishing objectives. This review elucidates the exponential growth of its applications within the pharmaceutical sector. The extraction of data was conducted in accordance with the Cochrane systematic review methodology standard. A search was conducted across the PubMed, Web of Science, Scopus, and Embase databases for randomized clinical trials [RCTs] and observational studies from 2000 to 2022.

Keywords: ‘pharmaceutical’, ‘AI’, ‘machine learning’, ‘Artificial intelligence’.

Introduction

The digitalization of data within the pharmaceutical industry has experienced a significant surge in recent years. However, digitization renders the process of collecting, evaluating, and implementing this information to address intricate clinical challenges more challenging [1]. AI is being implemented for this purpose because it has the capacity to automate the processing of enormous quantities of data. Artificial intelligence [AI] pertains to a technological framework comprising an assortment of advanced instruments and networks that emulate the capabilities of humans. Furthermore, it does not present a significant peril of replacing humans in all circumstances where they are physically present. Artificial intelligence [AI] employs computers and software capable of autonomously analyzing and learning from data in order to determine the most effective course of action for accomplishing objectives [2]. This review elucidates the exponential growth of its applications within the pharmaceutical sector. According to a forecast by the McKinsey Global Institute, the exponential growth of AI-driven automation will fundamentally transform human labor.

In addition to an increase in population consumption and demands, the pharmaceutical industry is prospering on novel approaches to develop targeted drugs and combat diseases, owing to developments in biotechnology and artificial intelligence [AI] practice. Demand exists, both from a patient and business standpoint, for the development of cost-effective, efficacious medications [3]. Human intellect is associated with the cognitive capacity of the human brain to perceive, comprehend, and respond to a dynamic external milieu [4].

Materials and Method

Data sources

We conducted the data extraction in accordance with the Cochrane systematic review methodology standard. We identified randomized clinical trials [RCTs] and observational studies in the Pubmed, Web of Science, Scopus, and Embase databases from 2000 to 2022 using the following keywords: "pharmaceutical," "AI," "machine learning," and "artificial intelligence."

Screening of eligible studies, assessment of the methodological quality, and data extraction were conducted independently and in duplicate. Two reviewers evaluated the references using the same search strategy.

Components of artificial intelligence

The toolkit of AI encompasses solution search, knowledge representation, and reasoning, which are all fundamental components of the machine learning paradigm. ML-developed algorithms are capable of identifying patterns in further-sorted data. A subfield of machine learning, deep learning [DL] employs artificial neural networks [ANNs]. These are made up of a complex network of computer parts called "perceptons," which are meant to copy the structure of organic neurons in the brain and how electrical impulses move through it [5]. Algorithmic Neural Networks [ANNs] consist of a collection of nodes that, independently or in concert, process input data at multiple points and generate output. Convolutional neural networks [CNNs], recurrent neural networks [RNNs], and multilayer perceptron [MLP] networks are all types of ANNs that can be trained using either supervised or unsupervised approaches [6, 7]. MLP networks can be used as universal pattern classifiers [8] and are useful for a wide variety of tasks, such as pattern recognition, optimization assistance, process identification, and control. Recurrent neural networks [RNNs] are closed-loop networks that can memorize and retain data, like Boltzmann constants and Hopfield networks. Convolutional neural networks (CNNs) are a group of dynamic systems with local connections that are defined by their topology [9]. They are used to process images and videos, model biological systems, process complex brain functions, recognize patterns, and do high-level signal processing, among other things.

Artificial intelligence and machine learning

AI incorporates the human brain's physiology and function to build intelligent systems focusing on perception, learning, and reasoning. In the pharmaceutical industry, the implementation of artificial intelligence [AI] and machine learning [ML] will aid in the understanding of drug candidate selection, protein structure predictions, molecular compound design, disease mechanisms, the development of new prognostic and predictive biomarkers, biometric data analysis from wearable devices, imaging, precision medicine, and, more recently, clinical trial design, conduct, and analysis [10].

AlphaFold is an artificial intelligence network used to determine a protein’s 3D shape based on its amino acid sequence. AlphaFold released the predicted structures of five SARS-CoV-2 targets in 2020. These will help researchers understand how the disease works and target membrane proteins [11].

Machine-learning predictive models were also used in clinical development. These predictive models test whether the models derived from cell line screen data could be used to predict patient response to erlotinib [treatment for non-small cell lung cancer and pancreatic cancer] and sorafenib [treatment for kidney, liver, and thyroid cancer], respectively [12]. The use of AI and MI-assisted tools aids in data quality review trials. These contribute to data monitoring, the implementation of predictive analytics, visualization for cross-database checks, and real-time "smart monitoring" of clinical data quality [13]. With modern-day data collection, the demand for AI and ML techniques will increase and provide more opportunities for different scientific and other related purposes. However, practitioners must be aware that the conclusions of AI and ML methods can be misleading if not interpreted correctly with confounding factors, reliable algorithms, and clinical questioning [14].

Hiring activity related to artificial intelligence in pharmaceutical studies

According to a recent study that looked at the quarterly percentage change in job positions in the global pharmaceutical industry, "General and Operations Managers," with a 11% share, emerged as the top artificial intelligence-related job roles in the pharmaceutical industry in Q3 2022, with new job postings increasing by 12% quarter on quarter.

Software and Web developers, programmers, and testers came in second with a share of 8% in Q3 2022, with new job postings dropping by 2% over the previous quarter. "The other prominent artificial intelligence roles include data scientists, with an 8% share in Q3 2022, and biological scientists, with a 6% share of new job postings" [15].

The use of AI technology will help pharmaceutical companies work in a more efficient environment. Pharmaceutical studies are costly and unpredictable, despite initial clinical navigation and careful testing. The implementation of AI has the ability to analyze patient records through algorithms and processing methods, thereby saving time and money and enhancing clinical trial efficacy and success [16]

Cyclica is a biotechnology company that combines biophysics and AI to discover small-molecule drugs for screening against protein pharmacological targets. They have partnered with Bayer to create faster and cheaper drugs using an AI network of cloud-based technologies known as the Ligand Express [8]. AI-powered Medopad technology, developed in the United Kingdom in collaboration with Tencent Holdings, remotely monitors patients with Parkinson's disease. Doctors can complete motor function testing in three minutes to assess the severity of symptoms and schedule an appointment if necessary [9]. Healx, a promising startup, focuses on examining existing drugs to repurpose them for curing rare diseases. Using AI and ML, gathering resources, clinical trials, drug designs, multiomics data, etc., to identify a new disease target [10], the company isn’t directly focused on creating new drugs to cure these conditions. Instead, they use AI technology to examine existing drugs and repurpose them for curing rare diseases [10].

Artificial intelligence also allows for following patients and assessing compliance. Patients can test their adherence to medications by videotaping themselves swallowing a pill using a mobile phone. AiCure Company, a New York-based mobile SaaS platform, adopted this method [8]. With the rising prevalence of diabetes and cancer in China, AstraZeneca has partnered with Ali Health, an AliBaba subsidiary, to use AI technology to provide patients with faster and less expensive ambulance diagnosis pickups [16].

When matching eligible patients to clinical trials, the use of IBM Watson Technology enables coordinators to assign trials more easily. Watson helps in processing and analyzing patients' medical records and allows quicker criteria to be established [13]. Novartis is currently implementing AI and ML techniques to target drug therapy. Machine learning enables companies to identify image cells and pathologies for algorithmic and experimental trials. This will help in establishing a quicker experimental analysis worth exploring [11].

Verge Genomics is another manufacturer that develops drugs based on targeting disease genes for complex diseases such as ALS and Alzheimer's. Using AI, Verge is able to identify new drug treatments, mapping out hundreds of genes and reducing the cost of drug development [15]. Bayer and Merck & Co. were granted the breakthrough device designation from the FDA for artificial intelligence software that aims to support clinical decision-making in chronic thromboembolic pulmonary hypertension [CTEPH]. This will help radiologists assist in quicker diagnosis and better outcomes [16].

The state of artificial intelligence in business

The top companies, in terms of the number of new job postings tracked by GlobalData as of Q3 2022, were Johnson & Johnson, Evolent Health, GSK, and Intermountain Healthcare [accounting for a total of 14%]. In the US pharmaceutical industry, on the other hand, the US had the highest share of artificial intelligence-related new job postings in Q3 2022, with 73%, followed by the UK [5%] and India [3%].

Another survey in partnership with GlobalData questioned the thoughts, plans, and practices of artificial intelligence in the future among business professionals. The survey covered the importance of different aspects of AI among professionals, including its importance, awareness, replacing existing jobs with automated ones, investment costs, and the risk of cyber security [17].

The use of nanorobots in the pharmaceutical industry

The advent of micro- and nano-electromechanical systems has opened the door to the fabrication of implantable robots for use in a wide range of applications, such as the precise administration of medications or genetic material. Nanorobots with built-in or external power sources, sensors, and artificial intelligence are attracting a lot of attention because of the astonishing developments.

in nanotechnology. These smart structures make traditional therapies more effective and safer by processing information, sending signals, sensing, acting, communicating, carrying out biological activities at the cellular level, and delivering drugs more precisely [18]. Nanorobots have a lot of potential in the areas of toxin detection and theranostics. Several novel types of controlled-release drug delivery systems have been proposed for targeted therapy in a wide range of disorders, especially chronic ones, that would be of great value in personalized medicine. These include swimming microrobots for controlled delivery of drugs; transient microrobot systems for targeted drug delivery using touch- or nano-communication frameworks; and wirelessly controlled and deeply penetrable microrobots [19].

Challenges and future prospects

State-of-the-art and high-performance approaches and improvements in computer science have improved drug screening strategies and advanced drug delivery platforms such as feedback-controlled, programmable, and microchip-based devices. However, various problems remain. Size of the drug reservoir, distribution efficiency, biocompatibility, supplying optimum drug concentrations, long-term operability, or dangers associated with improper design are challenging concerns [20, 21]. Safe biomaterials and drug delivery systems that have predictable drug release profiles give patients longer-lasting and more consistent drug concentrations, which makes them more likely to stick with their treatment plan. The use of a miniature actuator increases the medication reservoir without increasing device volume [22]. Fully functional nanorobots for theranostics and targeted medication delivery are challenging to make [23, 24]. This requires a deeper understanding of biological processes, the interactions of nanorobots within the body, their movement in liquid environments, the application of appropriate algorithms for controlling against environmental perturbations, the design of cores capable of recognizing cells and molecular cues, size reduction, an appropriate power supply, propulsion, actuation, sensing, system integration, navigation control, and relabeling. In designing nanorobots, tumor heterogeneity, noise, and uncertainty should be considered. Inappropriate nanorobot therapeutic activity does not eradicate tumors and can cause harm. Challenges remain concerning capsule robots, including suitable power backup, locomotion, space for drug reservoirs, anchoring mechanisms, control over drug release profiles, incorporation of bi-directional communication systems, telemetry, image sensing, capacity of drug storage, theranostic activity, controlled drug release, clinical efficiency of delivered drugs, safety issues, and high costs. Successful AI-based techniques result in stable, functional, biocompatible drug delivery systems with accurate dosage, targeted distribution, and few safety concerns. Researchers can apply ANNs, which are highly adaptive nonlinear optimization algorithms, and other machine learning approaches such as genetic programming, fuzzy logic, or decision trees to current drug discovery [25]. ANNs have gained popularity in many scientific fields, including the pharmaceutical industry, due to their ability to model nonlinear data, solve complex problems, analyze large and multivariate data sets, make predictions, model and optimize formulation processes, design-controlled drug delivery systems, and simulate protein-protein or small molecule-protein interactions. Despite the benefits of AI tools, such as rapid and continuous performance of a variety of tasks [e.g., designing bionanorobots and controlled drug delivery], AI strategies can be associated with several problems, such as high costs of maintenance and repair, frequent upgrading of software, lost code recovery, system reinstating, a lack of common sense, creativity, judgment, or an appropriate response to the changing environment, and a reflection of data inaccuracy in the ANN models that may not clarify variable correlation. Developing a reliable ANN model requires a vast amount of data and a large sample size. ANNs can model complicated datasets and predict clinical treatment responses, but selecting appropriate algorithms or datasets might be difficult. Machine learning-based models can speed up drug discovery, rational drug design, target prediction, and the development of safer drugs. However, to cut down on false negative or positive predictions, it is important to combine experimental methods with in silico simulations and make machine learning models that can be understood [26].

The availability of high-quality, up-to-date data is another challenge associated with AI, since the two go hand in hand with large data collection and processing. Noise in the training data can affect the accuracy of the models created from it, as predictive models are the foundation of AI. Drug manufacturers could take action by instituting strict policies on the quality and handling of data. Another is group work, which can increase the availability of high-quality shared data resources. For more precise forecasting, they should include both successful and unsuccessful drug development attempts. Additionally, researchers can combine these massive datasets to enhance the performance of the associated algorithms by utilizing them as feature data, training data, and validation data. Combining several data sources strengthens and refines these algorithms' results.

Conclusion

Drug development takes a long time and involves costs; therefore, new methods and approaches need to be used. Massive amounts of multivariate data present tremendous opportunities for AI technologies to analyze, solve, classify, model, accelerate, and discover biomarkers, drug targets, potential drug candidates, their pharmacological properties, relationships between the formulation of drugs, and more. AI-powered platforms that match patients with the best clinical trials could greatly reduce mistakes, make the process more cost-effective, and also help create new therapies with the features that people want. Analyzing large-scale molecular information and data links facilitates the development of more efficient medications or delivery systems, revealing novel insights into the molecular mechanisms of diseases and variables impacting cell or tissue function. In this way, AI would play a significant role in both the drug discovery process and personalized treatment.

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