"ARTIFICIAL INTELLIGENCE & MACHINE LEARNING IN PHARMACY & TECHNOLOGY."

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Abstract

Artificial Intelligence (AI) came as an intervention to data and number-related issues. This revolution has resulted in various technological developments in almost all sectors from engineering to architecture, education, accounting, business, health, etc. AI has gone a long way in the field of healthcare, having undertaken serious roles in data and information storage and handling – like patient health history, stocks of medicines, sales records, etc.; automated machines; computer applications and software like diagnostic equipment such as MRI radiation technology, CT diagnosis and much more have all been developed to support and ease healthcare initiatives. Inarguably, AI has revolutionized healthcare to be more effective and efficient and the pharmacy sector is not left out.

Over the last few years, much rising interest in the applications of AI technology has been revealed to study as well as interpret some significant areas of pharmacy such as drug discovery, dosage form design, polypharmacology, and hospital pharmacy. Due to the enhanced significance of AI, we felt the need to develop a comprehensive report which makes all practicing pharmacists aware of the greatest advancements which are aided by the implementation of this discipline.

Keywords: Artificial Intelligence, Drug Discovery, AI-assisted Content Generation, AI-limitations, ETC.

1.INTRODUCTION:

Artificial intelligence (AI) has ushered in swift reforms within the pharmaceutical sector in drug discovery, research and development, and patient management. AI-supported technologies, including machine learning, natural language processing (NLP), and data analytics, are now integrated into pharmacy practices to provide improved precision, greater efficiency, and greater patient safety. These capabilities of AI to sort through huge quantities of information— for instance, genomics, clinical trials, and medical literature—have hence amplified drug discovery with quicker and less expensive drug development. Furthermore, AI technologies have maximized other aspects of pharmacy practice, for example, inventory management, tailored dosing of medications, and surveillance of the safety of patients. The paper addresses a broad spectrum of uses of AI in pharmacy: ranging from the development process to clinical decision support and operational efficiencies in facilitating improved patient outcomes. The paper further addresses data privacy, compliance, and balancing between AI-driven automation and human care as self-evident challenges. AI offers a tremendous number of pharmacy perspectives, hence offering unparalleled benefits and possibilities towards enhanced efficiency AI-assisted medication review, and predictive

analytics for disease management. It also explains the contribution of machine learning algorithms towards pharmacovigilance, personalized medicine, and pharmaceutical research. Artificial intelligence is revolutionizing the pharmacy practice by improving patient care, enhancing medication management, and optimizing clinical workflows. AI-based solutions are being increasingly utilized in pharmacy to maximize

medication therapy, forecast disease outcomes, and individualize patient care. This review emphasizes the uses of AI in pharmacy such as robotic dispensing, AI-powered medication review, and predictive analytics for disease management. AI integration in pharmacy can enhance patient safety, minimize medication error, and improve the quality of care overall. Challenges, though, such as data standardization, regulatory frameworks, and workforce development need to be overcome to facilitate the successful implementation of AI in the practice of pharmacy. AI-driven drug review, and predictive analytics for disease management.

It also talks about the use of machine learning algorithms in pharmacovigilance, personalized medicine, and pharmaceutical research. Artificial

intelligence (AI) is revolutionizing the pharmacy practice by improving patient care, medication management, and automating clinical workflows. AI-driven solutions are gaining acceptance in pharmacy to maximize medication therapy, forecast disease outcomes, and individualize patient care. This review highlights applications of AI in pharmacy, such as robotic dispensing systems, AI-aided review of medications, and predictive analytics for disease management. Integration of AI in pharmacy can improve patient safety, minimize medication errors, and improve the quality of care overall. Yet, issues of data standardization, regulatory frameworks, and workforce development need to be addressed to make the introduction of AI in pharmacy practice a success. This review offers an overview of the status of AI in pharmacy today and prospects for the future.

Introduction:

Artificial intelligence (AI) is transforming pharmacy practice by revolutionizing multiple aspects of pharmaceutical care and drug development.[1][2] AI technologies enable pharmacists and healthcare professionals to analyze vast amounts of patient data,

optimize medication management, and improve clinical decision-making.[3][7] Drug Discovery and Development AI accelerates drug discovery by analyzing biological data, predicting molecular properties, and identifying potential drug candidates.[2] Machine learning and deep learning algorithms help researchers develop more efficient drug development pipelines.[2] Patient Care and Medication Management AI algorithms assist pharmacists in: • Identifying potential drug interactions

• Designing individualized treatment plans • Refining medication dosages • Tracking patient medication compliance [3][5] Clinical Decision Support AI solutions assist physicians in making better clinical decisions by interpreting patient information, medical images, and diagnostic results. AI systems can forecast adverse drug events, identify potential safety concerns, and provide regulatory compliance [2][7]. Integration of AI in pharmacy is also likely to keep on increasing, and the global AI software market is also expected to grow immensely by 2025 [3]. Through application of AI technologies, pharmacies can optimize patient care, automate tasks, and increase overall healthcare delivery.

1. Literature Survey

The aim of the present article was to have a view over the topics concerning AI. The themes include AI general overview and classification, AI applications in hospitals, the pharmaceutical company, and retail drugstores and to sensitize for AI as part of pharmacy practice in the future, to prompt pharmacists to accept this advancement, and to the extent possible put in the efforts to learn the necessary skills, which will allow pharmacists to contribute towards the much-awaited advancement.To adopt the latest breakthroughs, challenges, and applications of AI- related drug discovery and pharmacy, has been thoroughly researched. AI-supported literature survey databases were vetted comprehensively, i.e., PubMed, Scopus, Web of Science, and Semantic Scholar also selected stances or sources, i.e., INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES arXiv.net and ResearchGate, were consulted in the literature search

triggered by contemporary search engines (10). AI search algorithms deployed for the retrieval of the latest literature available in all types of peer-reviewed journal articles and preprint servers

AI classification

AI may be classified in two ways [16, 17]

a) based on caliber

b) based on the presence (See table 1)

Table 1:

AI classification

Based on the caliber

Weak intelligence

Artificial narrow intelligence

Artificial general intelligence

Artificial super intelligence

Based on presence

Type 1 reactive machine

Type 2 limited memory system

Type 3 is based on the theory of mind

Type 4 self-awareness

Based on their caliber, AI system is as follows:

1. Weak intelligence or Artificial narrow intelligence (ANI): This system is designed and trained to perform a narrow task, such as facial

recognition, driving a car, playing chess, and traffic signaling. E.g.: Apple SIRI virtual personal assistance, tagging in social media.

2. Artificial General Intelligence (AGI) or Strong AI: It is also called Human-Level AI. It can simplify human intellectual abilities. Due to this, when it is exposed to an unfamiliar task, it can find the solution. AGI can perform all the things as humans.

3. Artificial Super Intelligence (ASI): It is brainpower, more active than intelligent humans in drawing, math, space, etc; in all areas from science to art. It varies from the computer just smaller than the human to a trillion times more intelligent than humans.

Arend Hintze, an AI researcher categorized the AI technology depending on its availability and not yet available. They are as follows:

Type 1: This is referred to as a Reactive machine. Example: Deep Blue, the IBM chess computer which struck chess champion Garry Kasparov during the 1990s. It is able to see checkers on the chessboard and can predict; it doesn't possess the memory to apply previous experiences. It was made for narrow purposes application and is of no use elsewhere. Another example is Google's AlphaGo.

Type 2: This AI system is referred to as a Limited memory system. This system is able to utilize previous

experiences for the current and future issues. Within autonomous vehicles, there are some of the decision-making components that are implemented by this approach alone. The observations saved are utilized to save the actions occurring in the future, like switching the lanes by vehicle. The observations are not saved in the memory forever.

Type 3: Such an AI system is referred to as "theory of mind". It implies that every human possesses their thoughts, intentions, and desires that affect what they choose to do. It is a non-exist AI.

Type 4: These are referred to as self-awareness. The AI systems possess a sense of self and consciousness. If the machine is self-aware, it knows the condition and employs the ideas within others' brains. This is a non-existent AI.

AI classification

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Depending upon their caliber, AI system is categorized as follows:

1. Weak intelligence or Artificial narrow intelligence (ANI): This machine is created and taught to handle a limited task, i.e., facial identification, driving an automobile, playing chess, and traffic light control. E.g.: Apple SIRI virtual personal assistant, social media tagging.

2. Artificial General Intelligence (AGI) or Strong AI: Also referred to as Human-Level AI. It can be made simpler for human intellectual capabilities. Because of this, when it is presented to a new task, it is able to discover the solution. AGI is able to do all things like humans.

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computer just little smaller than the human to a trillion times wiser than humans.

Arend Hintze, a scientist of AI categorized the AI technology according to its existence and not yet existing. They are as follows:

Type 1: It is referred to as a Reactive machine. Example: Deep Blue, the chess program developed by IBM that stunned the chess master, Garry Kasparov, during the 1990s. It is able to spot checkers on the board and can make predictions; it lacks the memory to apply past experiences. It was created for narrow purposes usage and cannot be utilized in other contexts. Another example is AlphaGo by Google.

Type 2: This system is referred to as a Limited memory system. This system can use future and current problems with past experience. In self-driven cars, part of the decision-making process is created by this method alone. The observations that are recorded are utilized to track the actions occurring in the future, i.e., changing the lanes with the car. The observations are not stored in the memory forever.

Type 3: This type of AI system is called as "theory of mind". It means that all humans have their thinking, intentions, and desires which impact the decisions they make. This is a non-exist AI.

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the machine being aware of itself, it knows the state and implements the concepts available in other people's brains. This is a non-existent AI.

Challenges Of AI In Drug Discovery :

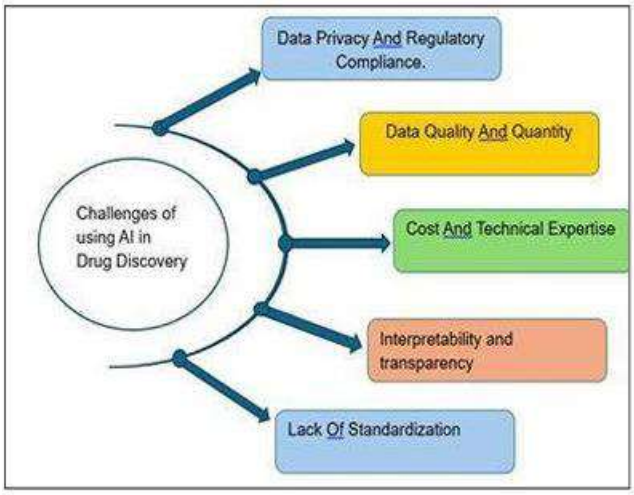

Fig -3 Challenges of AI In Drug Discovery

Applications of AI

AI has multiple applications in hospital healthcare systems for dosing form organization intended for an individual patient with the choice of suitable or accessible administration routes or treatment policies (41).

Maintenance of medical record: Organizing, storing, normalizing, and tracing data would be a very

complicated activity. Applying AI systems would simplify this. The handling of patients' medical records does indeed pose a genuine challenge. AI systems can be employed for organizing, storing, normalizing, and tracing records. This Google project- in-dirt subpoenas the criteria for an INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES 3242 | P a g

e Harshada Patil, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 4, 3237-3248 | Review crucial medical record- dig out in a short period of time. It's quite much quicker and efficient to make it a well-enhanced health care project. This project is funded by Moor Fields Eye Hospital NHS, enhancing treatment of the eye.

Treatment plan designing:

Successful AI technologies assist in designing treatment protocols. Where there is a patient who desperately requires treatment and the suitable treatment protocol cannot be determined, then controlling this scenario using AI becomes essential. Under this techno centric guidance, it will develop suitably all treatment plans based on all previous history, reports, clinical judgment, etc assists healthcare professionals to offer optimal treatment alternatives to patients . Relates

patient data and conditions to thousands of historical cases abstracted from experience accumulated over thousands of hours collaborating with the Memorial Sloan Kettering Cancer Center doctors providing both treatment alternatives to enable the oncology doctors to meet the needs of the patients. Treatments are well embodied from Memorial Sloan Kettering literature, well over 300 medical journals, and approximately 200 textbooks, nearing approximately 15 million pages of text .

Helping with repetitive work:

Artificial intelligence helps in detection and diagnosis for small repetitive work such as screening X-ray images, radiology, ECHO, ECG, etc. Medical Sieve (an algorithm proposed by IBM) is a "cognitive assistant" or skilled analyst and reasoner . Health conditions of patients with deep medical learning are to be improved. Then there is a software program designed for that area of the body that is utilized in specific diseases. Any type of imaging analysis might be an option with deep learning, such as X-ray, CT and MRI . INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES

providing support for health and assistance for drugs. Molly is just one of the virtual nurses designed by a start-up; she is friendly and has a face and voice that are pleasant. The aim is that patients can be guided through their treatment . The same guidance of treatment through consultation with a doctor also applies to chronic patients with the same level of support from Molly. AI Cure is an application that monitors patients, employing a smartphone camera. so that they are able to manage their conditions more effectively. It is beneficial to patients who have hard-to-manage medications and those who are participating in clinical trial studies Precision of medicine:

AI sees its advantages where there are applications such as genomic research and genetic engineering, with visible outcomes. Deep Genomics, an AI platform, will replace trying and memorize the genetic codes by heart, since the genetic Drug development:

Developing or inventing a drug takes a long time, usually over a decade, and costs several billions of rupees. "Atomwise": gene therapy discovered through Windows of supercomputers to find therapy from a database of molecular structures

3243 | P a g e Harshada Patil, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 4, 3237-3248 | Review . Throw a virtual screen software on effective and safe therapeutic therapy against Ebola with available drugs. It identified two drugs initially linked to an Ebola infection. In less than a day, it performed its analysis, while manual analyses would run for months or even years . A Boston biopharma firm harvests big data regarding patient management in the context of holding back data to search for triggers that enable certain patients to prosper in their disease. They made use of biological data from patients that included AI technology to determine variances between an environment of health and a pathology-conducive environment. This is advantageous to drug discovery and design, health care part, and treating conditions .AI assisting individuals in the Health care system: Open AI Framework: 2016-the open AI ecosystem promise is among the top ten promising innovation technologies. Good technology compiles and compares social

awareness algorithms data . The medical companies

maintain mass data on patients-from a child's treatment record to today, all might be said to be available to the patients, and then the entire data is going to have to be scanned through and ultimately will make a suggestion for life

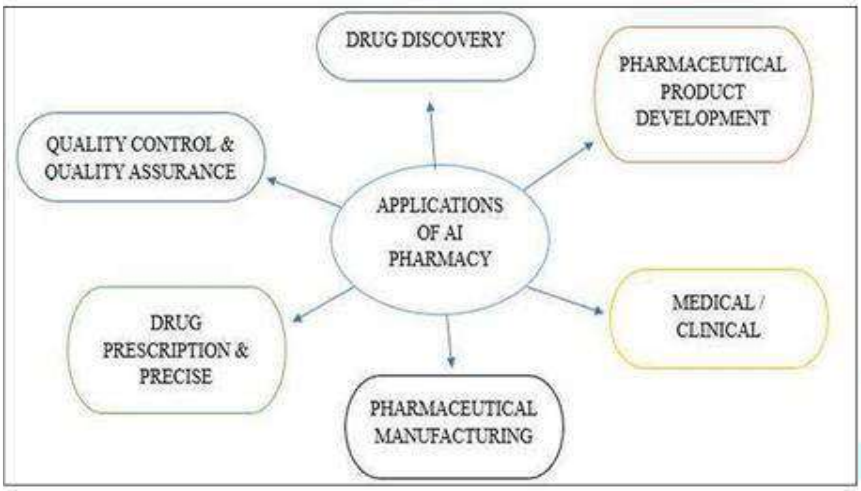

Fig-4 Application of AI in Pharmacy

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