REVIEW ARTICLE

UPI JOURNAL OF CHEMICAL AND LIFE SCIENCES (UPI-JCLS)
ISSN: 2581-4648 (An International online Peer Reviewed Open Access Journal)
www.uniquepubinternational.com Published by Unique Pub International (UPI)

ROLE OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE AND PHARMACEUTICAL SECTOR

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Received: 04 May 2025 Revised: 11 June 2025 Accepted: 07 JULY 2025

Abstract

Artificial Intelligence (AI) has emerged as a transformative tool in various fields, including pharmacy and healthcare. It enables intelligent modelling for knowledge representation, problem-solving, and decision-making. AI has played a crucial role in pharmacy, particularly in drug discovery, drug delivery formulation development, pharmacology, and hospital pharmacy. Advanced AI techniques, such as Artificial Neural Networks (ANNs), Deep Neural Networks (DNNs), and Recurrent Neural Networks (RNNs), have been extensively applied in these domains. Notably, AI-driven approaches like Quantitative Structure-Property Relationship (QSPR) and Quantitative Structure-Activity Relationship (QSAR) have demonstrated significant potential in drug discovery, while de novo design facilitates the invention of novel drug molecules with optimal properties. AI is revolutionizing healthcare research and service delivery by enabling efficient data analysis, improving disease diagnosis, advancing digital therapeutics, and personalizing treatment strategies. With its ability to predict and forecast epidemics and pandemics, AI has been successfully applied to diseases such as seasonal influenza, Zika, Ebola, Tuberculosis, and COVID-19. Technologies like deep learning, Bayesian nonparametric models, natural language processing, and wearable devices contribute significantly to clinical trial design, patient identification, and real-time monitoring. The Indian pharmaceutical sector has emerged as a global leader in generic drug and vaccine production. However, challenges persist across various stages, from early research and development to market deployment.

Keywords: Artificial intelligence, pharmacy, pharmacist

INTRODUCTION

AI is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in a similar way to the human attention process [1] Typically, this process entails gathering data, creating effective mechanisms for using that data, and demonstrating clear orarough conclusion and oneself corrections/adjustments [2] . This technology in pharmacy practice has witnessed rapid development over the years, providing the advantages of time and cost savings, as well as simplifying various pharmaceutical tasks [3]. Some of the current studies elaborate on the utilization of AI in healthcare and other sectors. The AI technologies in the healthcare industry include machine learning (ML), natural language processing (NLP), physical robots, robotic process automation, etc. In recent times, AI has extended its influence into pharmaceutical and healthcare domains, covering a wide range of functions such as drug discovery and design, enhancing product development, improving manufacturing processes, ensuring proper drug adherence and dosing, forecasting treatment outcomes, identifying candidates for clinical trials, managing rare diseases and personalized medicine, conducting medical imaging, detecting outbreaks of pandemic diseases, and so on.

AI GENERAL OVERVIEW

Artificial Intelligence (AI) refers to the exhibition of human-like behaviors or intelligence by computers or machines. It is a field of computer science that specializes in creating intelligent machines that can perform tasks associated with human beings, such as learning, reasoning, problem-solving, perception, and language. AI is applied in various areas, including digital computers, robots, and self-driving cars.

There are different types of AI, including narrow or weak AI, which performs specific tasks, and general or strong AI, which aims to outperform humans in all cognitive tasks. Machine learning, machine perception, and computer vision are aspects of AI that enable machines to learn from data, identify problems, and make decisions with minimal human

intervention. While AI has many benefits, there are also concerns about its safety and potential dangers, including the risk of super-intelligent machines controlling humans [4].

THE HISTORY OF ARTIFICIAL INTELLIGENCE

After playing a significant role in defining the area devoted to the creation of intelligent machines, John Mc Carthy, an American computer scientist pioneer and inventor, was called the "Father of Artificial Intelligence [5]

Maturation of AI (1943-1952)

Year 1943: The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed model of artificial neurons.

Year 1949: Donald Herb demonstrates and updating rule for modifying the connection strength between neurons. His rule is now called Hebbian learning.

Year 1950: The Alan Turing who was an English mathematician and pioneered machine learning in 1950. Alan Turing publishes "Computing machinery and intelligence" In which he proposed at a test. The test can check the machine ability to exhibit intelligent behaviour equivalent to human intelligence, called a Turing test.

THE BIRTH OF AI (1952-1956)

Year 1955: An Allen Newell and Herbert A. Simon created the first artificial intelligence program which was named as "Logic theorist". This program had proved 38 of 52 mathematics theorems, and find new and more elegant proofs for some theorems [5].

Year 1956: The word AI first adopted by American computer scientist John McCarthy at Dartmouth conference. For the first time, AI coined as an academic field [10, 11].

THE GOLDEN YEARS-EARLY ENTHUSIASM (1956-1974)

Year 1966: The researchers emphasized developing algorithms which can mathematical problems. Joseph Weizenbaum created the first Chabot in1966, which was named as ELIZA.

Year 1972: The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

The First AI Winer (1974-1980)

The duration between years 1974 to 1980 was the first AI winer duration. AI winer refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI research. During AI winer, an interest of publicity on AI was decreased [12]. A Boom of AI (1980-1987): Year 1980: After AI winter duration, AI came back with "Expert system." Expert system was programmed that emulate the decision-making ability of human expert. In the year 1980, the first national conference of the American association of AI was held at Stanford University.

The Second AI Winer (1987-1993)

The duration between the years 1987 to 1993 was the second AI winer duration. Again, investors and government stopped funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost-effective.

The Emergence of Intelligent agents (1993 2011)

Year 1997: In this year, IBM deep blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.

Year 2002: For the first time, AI entered the home in the form of Roomba, a vacuum cleaner. Year 2006: AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI [13,14]

Deep Learning, Bigdata and Artificial General Intelligence (2011-present)

Year 2011: In the year 2011, IBM"s Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.

Year 2012: Google has launched an Android app feature "Google now ", which was able to provide information to the user as a prediction.

Year 2014: In the year 2014, Chabot "Eugene Goostman" won a competition in the infamous "Turing test".

Year 2018: The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well. Google has demonstrated an AI program "Duplex" which a virtual assistant was and which has hairdresser appointment on call and lady on other side didn"t notice that she was talking with the machine [15].

CLASSIFICATION OF ARTIFICIAL INTELLIGENCE

AI can be classified in two different ways

1) According to calibre
2) According to the presence

A) Based on the calibre

- Weak intelligence or Artificial narrow intelligence
- Artificial general intelligence
- Artificial super intelligence

B) Based on presence

- Type1 reactive machine
- Type 2 limited memory system

- Type 3 is based on the theory of mind
- Type 4 self-awareness

A) BASED ON THEIR CALIBRE, AI SYSTEM IS CLASSIFIED AS FOLLOWS

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.

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

Artificial Super Intelligence (ASI): It is brainpower, which is more active than smart humans in drawing, mathematics, space, etc; in every field from science to art. It ranges from the computer just little than the human to a trillion times smarter than humans.

Classification Based on Presence [21]: Arend Hintze, an AI scientist classified the AI technology based on its presence and not yet present. They are as follows:

Type 1: This type of AI system is called a Reactive machine. E.g. Deep Blue, the IBM chess program which hit the chess champion, Garry Kasparov, in the 1990s. It can identify checkers on the chessboard and can make predictions; it does not have the memory to use past experiences. It was designed for narrow purposes use and is not useful in other situations. Another example is Google's AlphaGo.

Type 2: This type of AI system is called a Limited memory system. This system can use past experiences for present and future problems. In autonomous vehicles, some of the decision making functions are designed by this method only. The recorded observations are used to record the actions happening in the future, such as changing the lanes by car. The observations are not in the memory permanently.

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[8].

Type 4: These are called self-awareness. The AI systems have a sense of self and consciousness. If the machine has self-awareness, it understands the condition and uses the ideas present in others' brains. This is a non-existing AI.

THE ROLE OF ARTIFICIAL INTELLIGENCE.

AI in the lifecycle of Pharmaceutical Product [4].

AI plays a crucial role throughout the lifecycle of pharmaceutical products, from early research and development stages to market deployment.

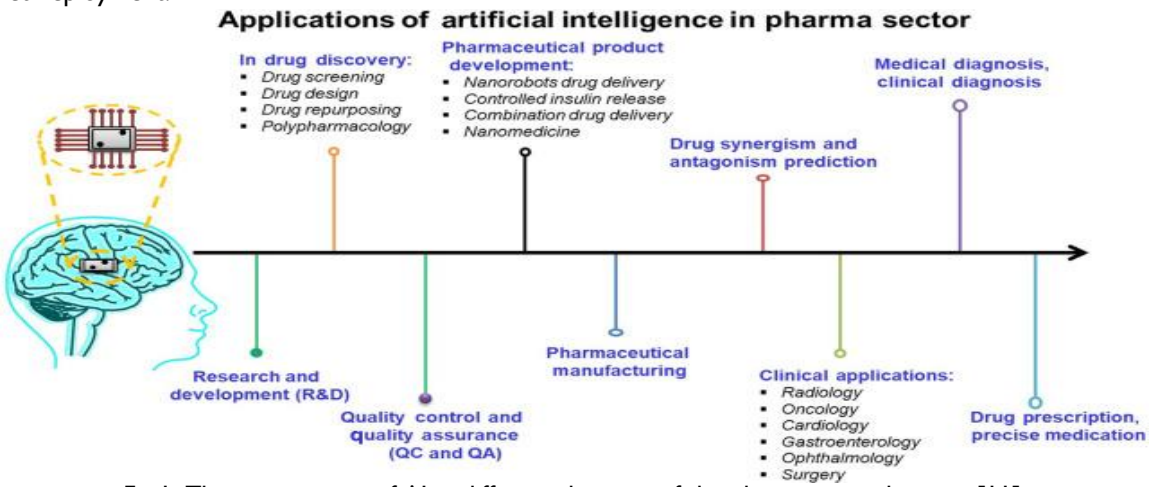

Fig.1: The intervention of AI in different divisions of the pharmaceutical sector [11]

AI IN RESEARCH AND DEVELOPMENT

The pharmaceutical industry is increasingly adopting Artificial Intelligence (AI) technology to improve research and development, drug discovery, and manufacturing processes. Top pharmaceutical companies, such as Roche, Pfizer, and Merck, are collaborating with AI vendors and investing in AI technologies to enhance decision-making, optimize innovation, and improve efficiency. According to McKinsey, AI and machine learning in the pharmaceutical industry could generate nearly $100B annually across the US healthcare system.AI is being applied in various areas, including drug design, data processing, and predicting treatment outcomes. Companies like Atom wise, in silico Medicine, and GNS Healthcare are developing AI-powered software to aid in drug discovery and development. These technologies, such as Atom Net and Pharma AI, use machine learning algorithms and generative models to predict binding properties, generate new molecular structures, and identify disease mechanisms[10]. The adoption of AI in pharmaceutical research and development is expected to accelerate the discovery of new treatments and improve success rates.

Ai in drug discovery

The traditional drug discovery process is time-consuming and labor-intensive, requiring extensive analysis to identify biologically active compounds. To accelerate this process, researchers are leveraging machine learning algorithms to predict which untested compounds are worth exploring. This approach enables computers to quickly uncover new data sets, reducing the time and cost associated with manual investigation.

Artificial intelligence (AI) is revolutionizing the pharmaceutical industry by streamlining drug development and personalizing treatment methods. AI's ability to analyze massive databases, identify drug candidates, and customize therapies is expected to transform pharmaceutical research and development. By integrating AI into the drug discovery process, researchers can develop more effective and tailored treatments, reducing the time and resources required to bring new medications to market [21].

Ai in pharmaceutical manufacturing

The integration of Artificial Intelligence (AI) in India's industrial sector has significant potential to enhance performance, competitiveness, and efficiency. AI-driven applications, such as predictive maintenance, can reduce downtime and improve equipment effectiveness, while machine learning algorithms can optimize production schedules, inventory management, and quality control. The use of AI in conjunction with robotic automation and smart manufacturing systems enables efficient data integration, timely decision-making and improved flexibility [23].

The integration of AI in pharmaceutical quality control and assurance has significantly enhanced the identification of flaws and deviations, predictive modeling, and real-time monitoring. Machine learning techniques analyze historical data patterns to facilitate early diagnosis and prevention of quality concerns. AI algorithms optimize procedures, improving operational effectiveness and reducing manufacturing expenses, while computer vision systems ensure strict adherence to quality standards and detect errors undetectable to human inspectors.

AI in Pharmaceutical Product Management

AI technologies enable pharmaceutical companies to strategically position their products by analysing market trends, competitor activities, and consumer preferences. Predictive analytics powered by AI can enhance market forecasting, anticipating demand fluctuations and optimizing production accordingly, thereby mitigating potential economic risks. Furthermore, in the realm of product costing, AI facilitates a more precise estimation of expenses involved in drug development, manufacturing, and distribution. This can lead to more informed pricing strategies, ensuring competitiveness in the market while maintaining economic sustainability [24].

APPLICATIONS OF AI IN PHARMACY

a. Research development
b. Drug development
c. Diagnosis
d. Disease prevention
e. Epidemic prediction
f. Remote monitoring
g. Manufacturing
h. Marketing
i. Rare diseases and personalized medicine
j. Processing biomedical and clinical data
k. Identifying clinical trail candidates

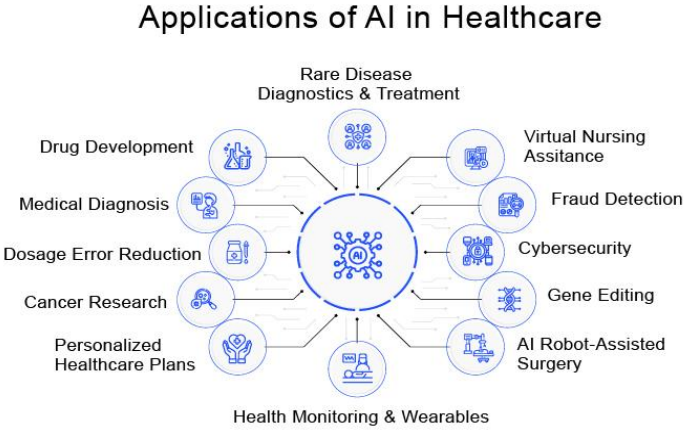

Fig.2: Applications of Ai [25]

Diagnosis and targeted genomic treatments. There are several applications of AI in hospital-based health care systems [17,18] in organizing dosage forms for individualized patients and selecting suitable or available administration routes or treatment policies.

Maintaining of medical records

Maintenance of the medical records of patients is a complicated task. The collection, storage normalizing, and tracing of data are made easy by implementing the AI system. Google Deep Mind health project [19] (developed by Google) assists to excavate the medical records in a short period. Hence, this project is a useful one for better and faster health care. The Moor fields Eye hospital NHS is assisted by this project for the improvement of eye treatment.

Treatment plan designing

The designing of effective treatment plans is possible with the help of AI technology. When any critical condition of a patient arises and the selection of a suitable treatment plan becomes difficult, then the AI system is necessary to control the situation. All the previous data and reports, clinical expertise, etc., are considered in the designing of the treatment plan as suggested by this technology. IBM Watson for Oncology[20], the software as a service, is a cognitive computing decision support system that analyzes patient data against thousands of historical cases and insights gleaned from working thousands of hours with Memorial Sloan Kettering Cancer Centre physicians and provides treatment options to help oncology clinicians make informed decisions. These treatment options are supported by literature curated by Memorial Sloan Kettering, and over 300 medical journals and 200 textbooks, resulting in almost 15 million pages of text [22].

Assisting in repetitive tasks

AI technology also assists in some repetitive tasks, such as examining the X-ray imaging, radiology, ECHO, ECG, etc., for the detection and identification of diseases or disorders. Medical Sieve[23] (an algorithm launched by IBM) is a cognitive assistant" having good analytical and reasoning abilities. A medical start-up is necessary for the improvement of the patient's condition by combining deep learning with medical data. A specialized computer program is available for each body part and used in specific disease conditions. Deep learning can be employed for almost all types of imaging analyses, such as X-ray, CT scan, ECHO, ECG, etc.

Accuracy of medicine

AI shows a good impact on genomics and genetic development. Deep Genomics[26], an AI system is useful for observing patterns in the genetic information and medical records to identify the mutations and linkages to diseases. This system informs doctors about the events happening within a cell when DNA is altered by genetic variation. An algorithm is designed by the father of the human genome project, Craig Venter[24] that gives information on patients' physical characteristics based on their DNA. "Human Longevity" AI technology is useful to identify the exact location of cancer and vascular diseases in their early stage.

Drug creation

The development or creation of pharmaceuticals takes more than a decade and consumes billions of rupees. "Atom wise" [23], an AI technology that uses supercomputers, is useful to find out the therapies from the database of molecular structure. It hurled a virtual search program for safe and effective therapy for the Ebola virus with the existing drugs. The technology identified two drugs that caused Ebola infection. This analysis was completed within one day compared to months to years with manual analysis. A Biopharma company in Boston developed big data for the management of patients. It reserves data to find the reasons why some patients survive diseases. They used patients' biological data and AI technology to find out the difference between healthy and disease-friendly atmospheric conditions. It helps in the discovery and design of drugs, healthcare, and problem-solving Applications.

AI helps people in the health care system

The "open AI ecosystem" [21] was one of the top 10 promising technologies in 2016. It is useful to collect and compare the data from social awareness algorithms. In the healthcare system, vast information is recorded which includes patient medical history and treatment data from childhood to that age. This enormous data can be analysed by the ecosystems and gives suggestions about the lifestyle and habits of the patient.

Healthcare system analysis

In the healthcare system, if all the data is computerized then retrieval of data is easy. Netherland maintains 97% of invoices in digital format [22], which contain treatment data, physician names, and hospital names. Hence, these can be retrieved easily. Zorg Prisma Publiek, a local company analyses the invoices with the help of IBM Watson cloud technology. If any mishap occurs, it recognizes it immediately and takes the correct action. Because of this, it improves and avoids patient hospitalization.

Strategies to overcome challenges to AI adoption in a pharmacy setting

To overcome the barriers to AI implementation in pharmacy, effective strategies such as AI education and training programs are essential. The pharmaceutical industry faces significant hurdles, including financial limitations, workforce proficiency, data security concerns, and regulatory complexities. Addressing these challenges requires collaborative efforts, allocating resources to education, infrastructure, and workforce development, and establishing clear guidelines for ethical AI use. Additionally, pharmacies must implement robust data protection measures, such as privacy-enhancing technologies, to safeguard patient privacy, and address pharmacists' concerns about AI to facilitate a smooth transition [24].

CONCLUSION

The integration of Artificial Intelligence (AI) in pharmacy and healthcare is transformative.AI accelerates drug discovery, enhances patient care, and improves manufacturing processes.AI driven approaches support clinical decision-making, disease diagnosis, and treatment optimization .Technologies like computer-aided drug design and QSAR/QSPR modelling revolutionize drug development.AI adoption faces challenges, but its benefits outweigh limitations. Integrating AI education into pharmacy curricula is essential .Investing in infrastructure and fostering collaboration is crucial. Embracing AI is necessary for navigating the future of pharmaceutical research.AI will pave the way for personalized treatment strategies and improved patient outcomes.

AUTHOR CONTRIBUTIONS

All authors are contributed equally

FINANCIAL SUPPORT

None

DECLARATION OF COMPETING INTEREST

The Authors have no Conflicts of Interest to Declare.

ACKNOWLEDGEMENTS

None

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