



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IX **Month of publication:** September 2026

DOI: <https://doi.org/10.22214/ijraset.2026.84922>

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A Review on Artificial Intelligence

Tarang Chaube¹, Mr. Pramod Mishra², Mr. Sujeet Pratap Singh³, Dr. Tarkeshwar P. Shukla⁴
S.C.P.M College of Pharmacy, Lucknow Road Haripur Gonda

Abstract: 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]. This process generally comprises obtaining data, developing efficient systems for the uses of obtained data, illustrating definite or approximate conclusions, self-corrections, and adjustments^[2]. In general, AI is used for analyzing machine learning to imitate the cognitive tasks of individuals^[2, 3]. AI technology is exercised to perform more accurate analyses as well as to attain useful interpretation^[3]. In this perspective, various useful statistical models, as well as computational intelligence, are combined in AI technology.

Pharm AI traces its roots back to early 2000s research at TU Dresden, where foundational work in structural bioinformatics and computational drug discovery laid the groundwork for its core technology. Building on nearly two decades of academic innovation, Pharm AI was officially founded in 2019 to bring these breakthroughs into industrial application.

Since then, Pharm AI has successfully completed over 40 projects, establishing a strong track record in AI-driven drug discovery. The company's Discovery Engine platform has been validated in in vivo settings, including both small-molecule targets and protein-protein interaction disruptors.

Pharmaceutical AI (pharma AI) uses artificial intelligence (AI) to speed up and simplify drug development. Agentic AI for pharma, generative AI, machine learning, natural language processing, and deep neural networks — which can process and analyze complex sets of data — work together to predict how drugs will behave. These technologies can recognize patterns faster than human analysts and deliver more precise results than traditional methods

Key innovations have been supported through strategic public funding, notably from the German Federal Ministry for Economic Affairs and Energy, the European Social Fund, the European Regional Development Fund, and the state budget of Saxony — contributing to advancements in screening pipeline benchmarking, information security, and AI-based target discovery.

Keywords: Artificial Intelligence, pharmaco-intelligence

I. INTRODUCTION

Pharmacy artificial intelligence (AI), or *pharmaco-intelligence*, refers to the intelligent use of information and technology to optimize medication-related processes and enhance decision-making across the pharmaceutical field, as defined by Hatem in 2024.^{1,16} This includes drug development, manufacturing, distribution, and patient care.^{1,16} One area of interest when considering pharmaco-intelligence is its use in drug discovery and development. Traditional drug development is known to be a very long, complex, and expensive process, averaging a cost of nearly \$2.6 billion and taking on average around 12 years to complete. This creates a lag time in providing potentially safer, more effective treatment options for patients with complex disease states.² Continual drug development is essential to the advancement of patient care, particularly in addressing obscure disease states that lack effective treatments. As diseases evolve, new challenges can emerge, increasing the need for innovative therapies to improve patient outcomes by treating rare disease states that either were previously untreatable or had limited therapeutic treatment options. An example of this is idiopathic pulmonary fibrosis (IPF), which will be discussed later in the article. The use of pharmaco-intelligence to expedite these processes is now being directed to improve efficacy and safety while still providing innovative treatment options. Before exploring the application of pharmaco-intelligence in drug development and its use in advancing the future of pharmacy, it is essential to understand the distinct types of AI.

The broad term *artificial intelligence* is defined as simulating human intelligence processes via the use of computer technology. This process encompasses acquiring information, developing rules for using the information, drawing conclusions, and self-correction.³

The second layer, or subfield, of AI includes *machine learning* (ML), which utilizes statistical methods for AI to learn more without the need to be specifically programmed. For ML to grow and develop, there are two fundamental approaches in which AI is trained: supervised and unsupervised learning. Supervised learning involves training from labelled data with corresponding output labels. In terms of drug development, supervised learning would include being trained to predict drug efficacy based upon available labelled data that illustrates how previous drug combinations have been successfully utilized to treat diseases.

On the other hand, unsupervised learning involves learning without explicitly labelled data, meaning that AI can learn based upon identifying patterns and relationships among seemingly random sets of data. Using drug development and pharmacy as another example, unsupervised learning could be used to find potentially previously unknown disease classifications based upon unidentified patient data.³ In simple terms, unsupervised learning allows for a more exploratory approach to find potentially hidden insights in unlabelled data.

The final subfield of AI is called *deep learning* (DL), which is a further subset of ML, utilizing deep neural networks that adapt and learn from experimental data. DL allows AI to solve complex problems by going a step farther than ML. Instead of reviewing unidentified data, DL allows for deeper analysis of unstructured data, including images and speech, without the requirement of external programming to do so. Considering integration of DL in drug development, this subset of AI can assist in identifying potential patterns among chemical structures to help predict the potential success of a new compound.³

A. AI general overview

The term AI (also known as machine intelligence) is very commonly confused and used interchangeably with robotics and automation. While robotics is simply the creation of machines that can carry out difficult repetitive tasks, AI refers to the exhibition of human-like behaviors or intelligence by any computer or machine^[7]. Traditionally, robots were not built to possess these “intelligent capabilities” even though they may be able to move or carry objects independently using a designed program and surface sensors in a process known as automation. AI, in essence, is the field of computer science that specializes in the creation of intelligent machines, developed with the ability to perform tasks that will ordinarily be associated with a human being^[8].

AI is frequently applied to the development of digital computers or computer-controlled robots with the capacity to autonomously execute intellectual and cognitive human-like processes. Such intellectual and cognitive processes include learning, reasoning, problem-solving, perception, and language. The form of AI currently in use today is referred to as narrow AI or weak AI because it is only designed to perform narrow tasks like internet search, facial and voice recognition, controlling and driving cars, and so on. However, the long-term goal of the AI community is to have machines that can autonomously outperform humans’ at all cognitive tasks. The AI that involves creating machines that can perform all human cognitive tasks will be the general AI or Strong AI (ADI)^[9].

One recent example is the machine-learning genomics screen technology used by a leading pharmaceutical company to identify and advance a new drug candidate targeting certain types of cancer. The process of identifying the target — the molecule or pathway the drug is meant to interact with — and receiving approval to move on to Investigational New Drug (IND) trials was completed in just 18 months as compared to an industry average of 42 months.

B. Accelerated drug discovery

Artificial intelligence is reshaping drug discovery by predicting molecular interactions, spotting promising candidates, and streamlining preclinical testing. Key applications include:

- Identifying drug candidates: AI examines biological and chemical data to help scientists understand how diseases work, predict interactions, find promising drug candidates, and uncover new ways to treat illness.
- Designing and predicting drug properties: Generative AI can create molecules with desired traits and predict ADMET properties (adsorption, distribution, metabolism, excretion, and toxicity) of promising drug candidates.

For example, one AI-focused biotechnology company is working in partnership with a pharmaceutical company to identify new drug therapies for amyotrophic lateral sclerosis (ALS). They used an AI-powered platform to identify promising drug targets and confirm their effects using models that mimic real diseases. Two of the drug targets are currently in development to make significant progress in treatment options for ALS.

C. Better clinical trial recruitment and management

Clinical trials are one of the most complex, time-consuming, and costly phases of drug development. But with AI and machine learning, researchers can accelerate many aspects of the trial process, saving companies money and time while maintaining the same or greater levels of accuracy. As AI technologies continue to evolve, they are fundamentally changing how pharmaceutical companies approach trial design, patient recruitment, and trial management to deliver more efficient and successful outcomes.

D. Smarter trial design

AI can improve clinical trial design by analyzing huge amounts of data quickly and accurately. AI-powered pharma software tools review historical trial data, regulatory submissions, and real-world evidence to:

- Optimize trial protocols
- Predict optimal dosing schedules
- Estimate sample sizes
- Recommend parameters for trial location and structure
- Identify the most relevant endpoints
- Determine ideal trial durations

AI can also simulate trial scenarios and protocols before the trial begins, increasing the likelihood of success. In one case, a clinical trial design company used AI to predict phase 2 clinical trial results with 88% accuracy.

E. Patient recruitment and retention

Traditional patient recruitment can take months or even years, with many trials failing to meet enrollment targets. AI can speed up this process by analyzing genetic markers, biomarkers, and patient history data to design more targeted inclusion and exclusion criteria. Generative AI and NLP help researchers find ideal participants by analyzing medical records, matching candidates to trials, estimating recruitment rates, and predicting dropout risks. This approach helps ensure trials enroll patients most likely to respond to treatment, improving success rates while reducing the number of participants needed to achieve statistical significance.

AI-powered platforms can make patient recruitment and retention more efficient by:

- Screening electronic health records to identify potential candidates who match specific trial criteria
- Predicting patient likelihood to complete the trial based on demographic and behavioral factors
- Optimizing site selection by analyzing population density, disease prevalence, and historical enrollment patterns
- Personalizing outreach strategies to improve patient engagement and reduce dropout rates
- Tailoring recruitment messages based on patient conversation history
- Refining follow-up strategies to keep participants engaged

For example, an AI-focused health tech company has developed a patient prescreening tool that assesses eligibility for clinical trials. The company has been able to reduce prescreening times by more than 50%.

F. Trial management and monitoring

Once trials begin, AI continues to deliver value through enhanced monitoring and management capabilities. Real-time data analysis can detect safety signals earlier, identify protocol deviations, and predict potential issues before they impact trial integrity.

AI has been used successfully in several aspects of trial management

- Automated adverse event detection through natural language processing of clinical notes
- Clinical trial risk assessment to improve safety and effectiveness
- Adaptive trial design based on emerging data patterns
- Decentralized trials to provide more flexibility for patients and perform trials on a larger scale

Digital twinning is another emerging capability with the potential to transform clinical trial management. A digital twin is a simulation that uses real patient data to create virtual patient populations. These can be used to assess safety and efficacy and may reduce the number of actual patients needed to conduct the trial.

One AI-powered biopharma company used digital twinning to test a new asthma treatment with virtual asthma patients (digital twins). The test produced results similar to the predicted outcomes of an actual Phase 1b trial, confirming that digital twinning could save time and resources during the trial phase.

G. AI Applications in Pharmacokinetics and Pharmacodynamics

AI brings a new level of speed and accuracy to pharmacokinetic and pharmacodynamic research, anticipating how drugs will interact with the human body. By using predictive analytics and advanced data modeling, AI can project how drugs will be absorbed, metabolized, and distributed, as well as how they might interact with other substances. These tools, powered by deep neural networks and machine learning algorithms, can sift through vast data sets to forecast molecular behavior, absorption rates, bioavailability, and much more.

With these capabilities, AI helps researchers anticipate how drugs will work in the body, even before human trials begin. This insight opens the door to personalized therapies shaped by each patient's genetic makeup, health profile, and environment.

Key applications include:

- Absorption prediction: Deep neural networks can predict how long it will take drugs to enter the bloodstream and whether certain interactions might slow or speed up that process.
- Distribution modeling: Machine learning and neural networks can combine large data sets to estimate how drugs are distributed throughout the body, predict drug concentrations within various tissues, and model how strongly they bind to proteins.
- Metabolism and elimination analysis: AI models can examine chemical structures and other factors to estimate how quickly a drug breaks down and leaves the body, and how stable it remains in various patient groups.
- Dosage and response: Neural networks can help researchers predict the right dose for the best effect, considering patient-specific details that might affect outcomes.
- Therapeutic effects: Machine learning tools can anticipate how drugs will perform across diverse patient populations and in combination with other therapies.
- Drug safety: AI can identify signs of potential adverse effects long before they appear in a patient's chart, making it easier to prevent harmful outcomes.

These capabilities can help bring new drugs to market faster, identify risks earlier, and enable course corrections before issues produce harmful outcomes.

H. AI's Role in Modern Pharmaceuticals

Early successes with generative AI in healthcare have sparked optimism throughout the pharmaceutical industry. This technology is already changing lives. Consider the rapid response to COVID-19 and breakthroughs in anti-cancer drug design, where AI accelerated research and improved our ability to predict outcomes.

Pharma and MedTech companies are finding many ways to tap into AI:

- Clinical trial recruitment: Generative AI simplifies the search for qualified participants. For example, life sciences AI helps researchers raise trial awareness, find participants who meet the criteria, and speed up onboarding.
- Trial site selection: Agentic AI tools act autonomously to achieve specific trial goals using artificial intelligence "agents." For example, a tool like Agentforce can review healthcare and geographic data, work with stakeholders, and suggest trial sites that align with research objectives.
- Advanced therapy management: Personalizing treatments for rare diseases often requires deep data analysis. AI helps doctors conduct that analysis, automate administrative tasks, and support personalized medicine efforts.
- Improved patient support: Assistive AI agents help patients receive the right medicine at the right time.

I. How AI is transforming drug manufacturing

Understanding how AI works in the pharmaceutical industry can help companies improve production by bringing smarter technology to the manufacturing process. These systems help manufacturers spot problems early, run more efficiently, and maintain the high-quality standards that patients depend on.

Here are some of the ways AI can help get new treatments to patients faster:

- Digital twins: These detailed computer models mirror real manufacturing equipment, letting companies test changes and see what might happen without risking actual production.
- Predictive maintenance: AI watches equipment performance data and gives a warning when machines need attention, preventing breakdowns that can shut down production lines.
- Quality control: AI-powered systems identify quality issues faster and more reliably than traditional inspection methods.
- Inventory management: AI helps companies order the right amount of materials at the right time by studying demand patterns and supply chain trends.
- Process optimization: These systems analyze hundreds of data points to make the production process more consistent and efficient.
- Regulatory compliance: Automated tracking systems document everything that happens during manufacturing, making it easier to meet strict regulatory requirements and demonstrate compliance.

Companies can use AI tools like these to reduce production costs, speed up processes, and improve product quality. In 2023, for example, one pharmaceutical company reported to investors that they use AI to detect anomalies and recommend improvements in the manufacturing process. They hope to see a 10% increase in product yield and a 25% improvement in cycle time.

J. Overcoming Challenges of Pharma AI

Healthcare AI tools offer enormous potential for the life sciences and pharma industries, yet their insights only reach as far as the data that fuels them. If that data is incomplete, biased, or inaccurate, even the most advanced AI falls short. Recognizing these hurdles is the first step toward creating healthier outcomes for everyone.

- Data quality and integrity: Unreliable or sparse data can lead AI astray, risking patient safety and trust. Investing in careful data validation and robust quality checks helps maintain confidence in AI-driven insights.
- Potential bias: Without proper oversight, AI may unintentionally favor certain groups, raising questions about fairness and equal access to care. The life sciences community must address these issues to ensure everyone benefits equally.
- Regulatory compliance: As AI becomes central to drug development, it's raised some ethical concerns around patient consent, equitable trial enrollment, and adherence to strict manufacturing guidelines. The concern is that AI could be used to make treatment decisions and whether or not it will maintain compliance with drug manufacturing guidelines. Meeting these standards requires transparency and thoughtful governance.
- Patient privacy: Researchers must work within rules such as the Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR) to protect sensitive health information and maintain trust.

K. Addressing regulatory challenges with AI in pharma

As pharma organizations weave AI into their research and development efforts, thoughtful oversight becomes essential. A few strategies stand out:

- Address ethical considerations: Build trial designs that respect privacy, informed consent, and fairness, and that remain transparent about when and how AI guides decisions.
- Establish AI governance policies: Set clear guidelines on AI development and use, covering data validation, training practices, and compliance standards. Review FDA principles that address data handling, model fairness, and clarity around regulatory requirements.
- Choose a secure AI platform: Select trusted AI solutions designed to protect patient data, encourage diverse and equitable trial recruitment, and comply with privacy laws. For example, life sciences AI can support trial diversity and uphold patient privacy standards.

L. The Economic Impact of AI on the Pharma Industry

As pharma AI applications become more sophisticated and efficient, their economic impact is reshaping the industry. By shortening drug development timelines, enhancing analysis, and optimizing clinical trials, AI offers cost savings that can exceed \$1 billion for an average research investment — transforming not just bottom lines, but also industry-wide practices.

M. Real-world cost savings

One striking example is an AI-generated anti-fibrotic drug candidate that entered phase 1 clinical trials in 2024, just 30 months after the discovery program began. The pharma company reported that AI's ability to improve efficiency during key stages such as target discovery, drug candidate identification, and predictive drug response resulted in an accelerated pre-clinical development timeline and lower costs.

N. Other potential economic impacts of AI in pharma

- Workforce transformation: Existing roles may evolve to better use AI as a part of healthcare software. Clinical trial managers and quality control specialists, for instance, may need reskilling to incorporate AI tools into their workflows.
- Job creation: New job categories will emerge to accommodate AI-driven pharma software, including AI and machine learning specialists focused on pharma, biotech data analysts, digital health architects, and other roles.
- Reduced failure rates: Traditional drug development has an 80% to 90% failure rate. AI can significantly improve success rates by enhancing target selection and trial design, reducing development costs, and increasing ROI.
- Market expansion: AI-driven personalized medicine creates opportunities for new market segments and revenue streams, particularly in areas like oncology and rare diseases. Understanding what a healthcare CRM is and implementing it effectively can help drug companies identify healthcare providers (HCPs) in these new segments, determine whether they are likely to be interested in a new drug, and engage with HCPs by providing the right information in the right context.

For example, a platform like [Health Cloud](#) engages both patients and providers, integrates care management, and manages patient health data that may be valuable for trial assessments.

O. The Future of Pharma AI

The rapid growth of AI in life sciences is unlocking new avenues for personalized care. Combining AI with electronic health records (EHRs) and other medical software can create treatments tailored to each patient's unique needs. [AI agents](#) and [copilots](#) can gather, analyze, and refine data, improving accuracy and leading to better patient outcomes.

We're also moving toward more flexible clinical trials. AI already supports [decentralized trial models](#), making it easier to recruit, screen, and monitor patients remotely. [Some experts predict](#) a future where trials rely more on existing data, reducing the number of participants required and opening the door to faster, more cost-effective studies.

Innovations like these call for strong protocols that [respect compliance](#), security, and privacy. Trusted AI solutions such as Salesforce's [Einstein Trust Layer](#) let healthcare organizations harness AI without risking patient confidentiality.

P. Realizing the potential of AI in pharma

AI has shifted from a distant possibility to a key resource in drug development. While data integrity, regulatory compliance, and patient privacy remain concerns, AI's ability to cut the costs and speed of drug discovery makes it a cornerstone of future medicine.

Fully realizing AI's promise means choosing solutions that respect ethics and follow regulations, all while focusing on patient needs. Starting small — integrating AI into administrative tasks or patient support — can help teams gain confidence and expertise. Over time, a stronger AI foundation can pave the way for new ideas and fewer barriers to safer, faster treatments.

Q. Role in Determining ADMET Properties

In addition to SAR activity, the absorption, distribution, metabolism, excretion, and toxicity (ADMET) properties must be evaluated to determine the most effective delivery system of the lead compound within the body. AI may also be used to predict ADMET properties, utilizing both ML and DL to draw conclusions based upon both identified and unidentified data to discover important insights more quickly.^{2,3}

Following completion of lead optimization, the developed compound is passed on to in vitro and in vivo studies for further research and approval. AI is also leveraged in the clinical trial process by assisting in the selection of participants for the trials. Prior to AI, recruitment of participants deemed suitable for trials could be a time-consuming process, as thousands of patients were reviewed individually to ensure that they met inclusion criteria for a study. Utilizing the AI approach in recruitment allows AI to identify and predict human-relevant biomarkers of diseases being studied and facilitates the recruitment of a specified patient population in phase II and phase III clinical trials.³ The ability to rapidly review potential participants using AI helps increase the success rate in clinical trials by increasing the likelihood of selecting individuals who will respond well to the selected treatment.

If a drug fails during clinical trials for its original intended use, AI presents the opportunity to repurpose the drug for other potential therapeutic uses. During clinical trials, medication might fail for various reasons, including unexpected adverse events or lack of therapeutic efficacy. Despite the original failure, AI enables the application of the selected medication to a new disease state, which is advantageous to drug developers, as the medication is still qualified to go directly to phase II trials for a new indication—expediting the drug development process as well as reducing costs.³

R. AI in Action

One current example of the use of AI in the development of drugs to treat obscure or rare disease states is a molecule known as INS018_055, an antifibrotic small molecule inhibitor for the treatment of IPF. IPF is a disease state that currently has limited FDA-approved treatment options, making it an ideal target for drug research and development. INS018_055 resulted from the integration of the AI platform Pharma.AI. Pharma.AI serves as the foundational platform for PandaOmics, Chemistry42, and a variety of other AI initiatives.⁴

PandaOmics features an advanced, AI-driven hypothesis-generation system that allows researchers to input specific disease states and obtain a ranked list of related genes. Following this initial analysis, the system moves on to target validation, analyzing molecular targets for their potential in drug development. This process includes investigating the connections between these molecular targets and the disease, supported by relevant evidence.⁵ Throughout the entire program, PandaOmics utilizes DL and ML to enhance its analyses and predictions, including assessing the likelihood of molecular targets progressing to phase I clinical trials within the next 5 years and estimating the chances of successful transitions through subsequent trial phases tailored to the disease.⁹ Complementing this,

Chemistry42 plays a crucial role in the later stages of drug discovery, including hit identification, hit-to-lead progression, and lead optimization.¹⁰ Chemistry42 utilizes DL and ML techniques.⁴ Together, these innovative systems enhance the efficiency of drug discovery and development, facilitating targeted therapeutic interventions.

For the development of INS018_055, PandaOmics identified the target for the molecule and Chemistry42 was then utilized to design the molecular structure.⁴ The AI systems utilized in this development further illustrate the advancements that ML can offer regarding the ability of AI to learn based upon pattern recognition and unlisted data.

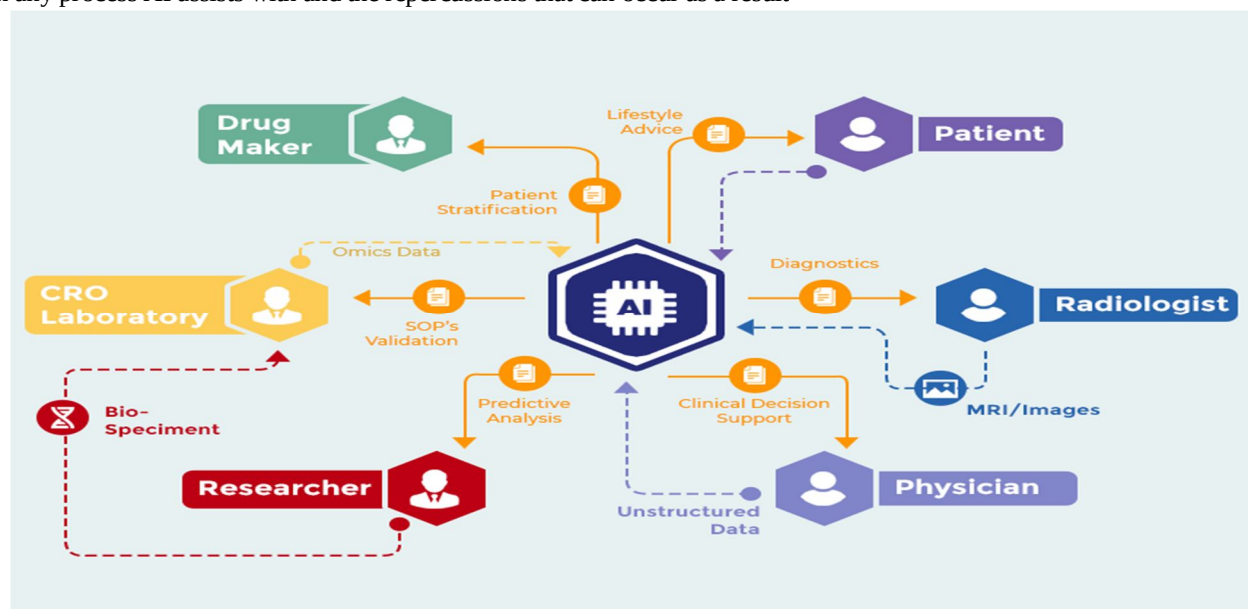
In February 2022, Insilico Medicine reported significant progress in advancing from initial development to phase I clinical trials in under 30 months, achieving this milestone at a substantially lower cost than traditional drug discovery methods—largely due to the capabilities of its Pharma.AI platforms.¹¹ The phase I trial of INS018_055 involved 80 healthy volunteers and was designed as a gold-standard clinical trial: double-blinded and placebo-controlled. This study incorporated both single and multiple ascending dose protocols aimed at assessing the compound's safety, tolerability, and pharmacokinetics, while also identifying the maximum tolerated dose in healthy subjects. Specifics of the dosing intervals and protocols have yet to be made public.⁶ Despite this, the results of the phase I trial indicated that INS018_055 was generally safe and well tolerated, with no fatalities or significant adverse effects reported throughout the study.^{12,13} This led the FDA to provide INS018_055 with the orphan drug designation in 2023.^{4,6} As of October 2024, enrollment for the phase II trial was underway at nine locations in the United States, with an anticipated completion date of February 28, 2026.⁷

S. Ethical Considerations

Despite the great advancements pharmacointelligence can bring to the field of pharmacy, it is also important to explore the limitations of its use. Some key concerns include lack of empathy, accuracy, and privacy of data, accountability, and potential bias. As previously discussed, when pharmacointelligence is utilized in the drug development process, it relies on patient data that can include laboratory tests, medications, past medical histories, and other information to make more targeted predictions regarding the success of a potential target.⁸ Ensuring that the information is handled securely and confidentially is of utmost importance to protect the privacy of the patient and comply with HIPAA guidelines.

Accuracy of the data provided by AI is also a concern. Recommendations and advice provided by AI is only as accurate as the data it is programmed with. There is always the potential that information provided to AI could be incomplete, incorrect, or biased, possibly skewing the recommendations that AI makes. This could result in inequities among the drug development process, such as certain populations being underrepresented or suboptimal treatment recommendations.⁸

Finally, there is always concern regarding accountability of the decisions made via pharmacointelligence. If severe or serious adverse events occur because of a recommendation made by AI, the question then becomes who is to be held accountable for these decisions.^{14,15} Regardless of each discussed limitation, it is important to always consider the effects that the absence of human touch can have on any process AI assists with and the repercussions that can occur as a result



T. AI in diagnosis and targeted genomic treatments

There are several applications of AI in hospital-based health care systems^[19, 20] 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^[21] (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^[22], 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 Center 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.
- Health support and medication assistance: In recent years, the uses of AI technology are recognized as efficient in health support services and also, for medication assistance. Molly^[24] (a start-up- designed virtual nurse) receives a pleasant voice along with a cordial face. Its aim of it is for helping patients to guide the treatment of patients as well as support them with their chronic conditions during doctor’s visits. Ai Cure^[25] is an app existing in a Smartphone webcam, which monitors patients and assists them to control their conditions. This app is useful to patients with severe medication situations and for patients who participate in clinical trials.
- 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^[27] 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”^[28], an AI technology that uses supercomputers, is useful to find out the therapies from the database of molecular structure. It hurred 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”^[29] 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 analyzed 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^[30], which contain treatment data, physician names, and hospital names. Hence, these can be retrieved easily. Publish, 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

II. AI IN PHARMACEUTICALS

AI in pharmaceuticals is the use of artificial intelligence to revolutionize drug discovery, development, and manufacturing, by analysing vast datasets to accelerate processes, improve efficiency, and personalize medicine. Key applications include identifying drug candidates, optimizing clinical trials, enhancing supply chain management, and predicting drug efficacy and toxicity.

AI in pharmacy is used to speed up drug discovery and development, improve patient care through personalized medicine, and enhance clinical and operational efficiency. It helps with tasks like analyzing large datasets, predicting adverse drug events, automating dispensing, and creating decision support systems that assist pharmacists in managing medication therapy.

1) Drug discovery and development

- AI can accelerate the discovery of new drugs by analyzing complex data to identify potential candidates.
- It optimizes clinical trials by improving patient recruitment and predicting drug effectiveness and toxicity.
- This leads to faster and more cost-effective development processes.

2) Patient care and medication management

- AI creates personalized treatment plans by analyzing a patient's medical history, current medications, and other data.
- It enhances patient safety by predicting and flagging potential adverse events, drug interactions, and medication errors.
- AI can improve medication adherence through smart technologies, wearable devices, and personalized reminders.

3) Pharmacy operations and workflow

- AI automates routine tasks like prescription verification, freeing up pharmacists to spend more time with patients.
- It optimizes inventory management, ensuring the right medications are stocked at the right times.
- AI-powered clinical decision support systems provide pharmacists with real-time information and recommendations, augmenting their expertise.

4) Education and research

- AI tools can provide students with real-time analysis of drug interactions and therapeutic responses.
- It helps pharmacists with research by summarizing documents and extracting relevant data from large bodies of text.
- Pharmacy informaticists are increasingly needed to help design, implement, and maintain these AI systems.

III. AI IN PHARMACY PRACTICE IN HOSPITAL AND COMMUNITY PHARMACIES

Machine learning models allow e-mails to be personalized at a speed and accuracy greater than that of any human being. Chatbots^[43] can be used to increase the efficiency of service delivery. Chatbots are capable of mimicking interactions between customers and customer care of sale staffs. Chatbots are capable of automatically resolving customer complaints and queries and the difficult questions are transferred to human staff. In retail pharmacy, this principle can be applied. The chatbots can be programmed to mimic pharmacist-patient interaction.

Walgreen^[44] made a partnership with Medline, a telehealth firm to create an avenue to help patients interact with healthcare professionals through video chat. AI can also be useful in inventory management. As a retail pharmacist, imagine being able to predict what your patients will need in the nearest future, stocking them, and using personalized software to deliver e-mails to remind the patient of drug needs. With the use of AI-powered data analytics, a patient's future drug purchase can be predicted. Predicting the patient's drug purchase through AI will help the pharmacist to make proper stock procurement decisions.

Although, there are existing inventory management software and application that are used in retail pharmacy stock management like Mckessons; Liberty; Winpharm; PrimeRx; and WinRx, not all of them utilize AI or machine learning. For example, an AI company, Blue Yonder developed software for Otto group^[45], a German online and catalog retailer. This software can predict with 90% accuracy what will be sold by Otto in 30 days. This reduced the delivery schedule for purchased products from one week or more to one of two days by enabling direct delivery of the product from the supplier to the consumer without having to pass through the warehouse.

Intending to improve the safety of patients, the University of California San Francisco (UCSF) Medical Center uses robotic technology for the preparation and tracking of medications. According to them, the technology has prepared 3, 50, 000 medication doses without any error. The robot has proved to be far better than humans both in size as well as its ability to deliver accurate medications. The abilities of the robotic technology include the preparation of oral as well as injectable medicines which include toxic chemotherapy drugs. This has given the freedom to the pharmacists and nurses of UCSF so that they can utilize their expertise by focusing on direct patient care and working with the physicians. Within the automated system of the pharmacy, the computers first receive medication orders electronically from the physicians and pharmacists of UCSF.

After this, individual doses of pills are picked, packaged, and dispensed by the robotics. This is followed by machines assembling the doses onto a bar-coded plastic ring. The thin plastic ring contains all medications that have to take by a patient within a period of 12h. Adding to the capabilities of the automated system is their ability to prepare sterile preparations that are meant for chemotherapy along with filling intravascular syringes with the right medications^[46].

IV. DISCUSSION

The primary aim of health-related AI applications is to analyze relationships between prevention or treatment techniques and patient outcomes. AI programs have been developed and applied to practices such as diagnosis processes, treatment protocol development^[47], drug development^[1], personalized medicine^[48], and patient monitoring and care^[49], among others. As the quality of care offered for patients continues to grow in prominence, here are some ways pharmacies can leverage the continued technology explosion to impact value-based outcomes. As the most accessible and affordable healthcare stakeholder, pharmacies can become health management centers instead of only medication fulfillment locations. Technology can help provide more personalized healthcare offerings including advice, guidance, and an expanded suite of services (e.g., immunizations, screenings, MTM, disease state management). Health trackers and wearable will be able to provide real-time capture of data that can enable pharmacy to follow up with at-risk patients on their conditions and monitor their quality of improvement^[50].

AI can be of real help in analyzing data and presenting results that would support decision making, saving human effort, time, and money, and thus helps save lives. Medical and technological advancements that have helped the healthcare-related development of AI include the overall evolution of computers, resulting in faster data collection and more powerful data processing, Growth in the availability of health-related data from personal and healthcare-related devices and records, and the development of pharmacogenomics and gene databases, Expansion and industry adoption of electronic health records and natural language processing and other advancements in computing that have enabled machines to replicate human certain processes^[51].

In the physician space, AI from technology companies like Microsoft is breaking into the healthcare industry by assisting doctors in finding the right treatments among the many options for cancer. Capturing data from various databases relating to the condition, AI is helping physicians identify and choose the right drugs for the right patients^[52, 53]. In the pharma space, AI is working with researchers to support the decision-making processes for existing drugs and expanded treatments for other conditions, as well as expediting the clinical trials process by finding the right patients from several data sources^[1, 54, 55]. Pharma is even working to predict with certain accuracy when and where epidemic outbreaks might occur, using AI learning based on a history of previous outbreaks and other media sources.

In the hospital space, AI is being used to prevent medical errors and reduce hospital readmissions. By analyzing patient data from medical and medication errors, readmission root causes, and other internal and external databases, AI will one day identify and prevent high-risk patients from developing complications, and provide prospective care guidance, and diagnostic support, among many other clinical applications. Additionally, AI will be useful in workflow optimization and efficiency, helping eliminate redundancy in cost from duplicate or unnecessary procedures^[56, 57].

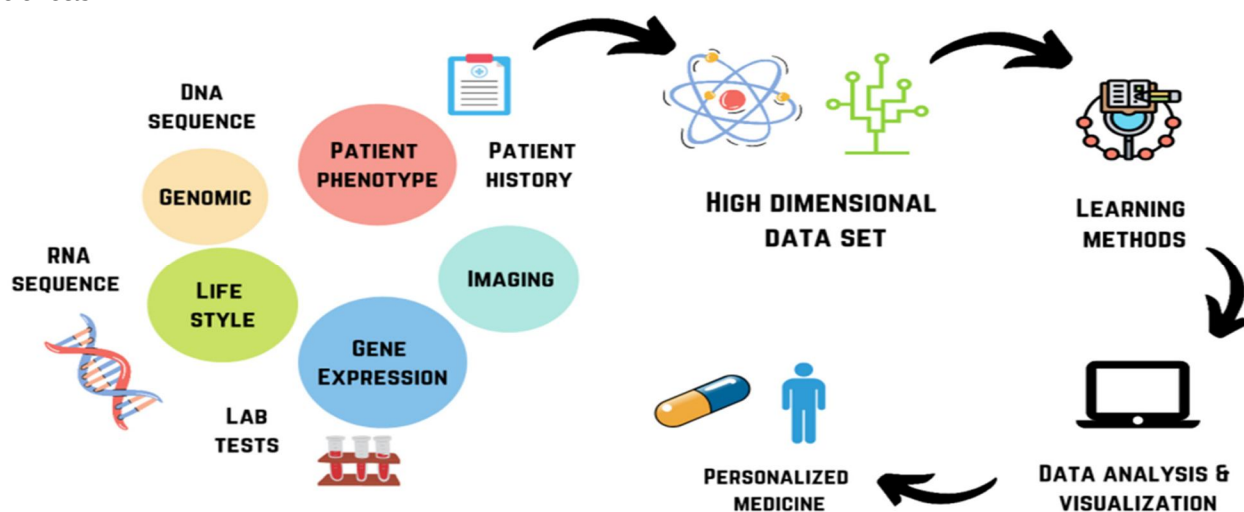
In pharmacy today, we already have an early form of AI in place. It's called our pharmacy management system, housing patient utilization, and drug data, as well as potentially identifying drug-related problems through clinical decision support screening. The next generation in pharmacy technology is the introduction of a technology-based information expert system to identify timely drug-related problems based on patient data captured from the pharmacy system and other external data systems. Consistent with workflow robotics, this would leave less of the work on the pharmacist to shoulder the responsibility of identifying serious drug-related problems^[58, 59].

A. Implications for pharmacists and their practice

AI can strongly influence and shift pharmacists' focus from the dispensing of medications toward providing a broader range of patient-care services. The pharmacist can leverage AI to help people get the most from their medicines and keep them healthier. Most importantly, AI provides pharmacy an opportunity for more collaboration across many different entities serving the same patient. For the patient, in addition to potentially better healthcare services offered by their professionals, AI may be a useful tool for providing guidance on how and where to obtain the most cost-effective healthcare and how best to communicate with healthcare professionals; optimizing the value of data from wearable; providing everyday lifestyle guidance; integrating diet and exercise; and supporting treatment compliance and adherence.

B. Core applications

- 1) **Drug Discovery:** AI analyses large biological and chemical datasets to identify disease targets, design novel molecules, and predict a drug candidate's properties, which significantly speeds up the discovery process.
- 2) **Clinical Trials:** AI is used to optimize trial design, improve participant recruitment by analysing patient data, and monitor trials more effectively for safety and efficacy.
- 3) **Personalized Medicine:** AI analyses individual patient data to create customized treatment plans, aiming for better outcomes and fewer adverse reactions.
- 4) **Manufacturing and Supply Chain:** AI optimizes supply chain logistics by forecasting demand and managing inventory, while in manufacturing, it helps monitor equipment for predictive maintenance and ensures product quality.
- 5) **Pharmacovigilance:** AI analyses data to detect adverse drug reactions, improving patient safety by enabling earlier detection of side effects



V. BENEFITS AND CHALLENGES

A. Benefits

AI can substantially reduce development costs and time, leading to faster market entry for new medicines. It also creates opportunities for new therapeutic solutions and personalized treatments.

B. Challenges

Adoption can be slower in pharma due to strict regulations. Other challenges include the "black box" nature of some AI models, the potential for algorithmic bias that could lead to unequal outcomes, and the need for transparency in AI decision-making. The future

- AI is expected to continue transforming the pharmaceutical industry, leading to more efficient and widespread drug discoveries.
- Companies are increasingly partnering with AI firms to accelerate research and development.
- While AI-generated drugs have not yet received FDA approval, some are entering clinical trials, showing progress in this area.

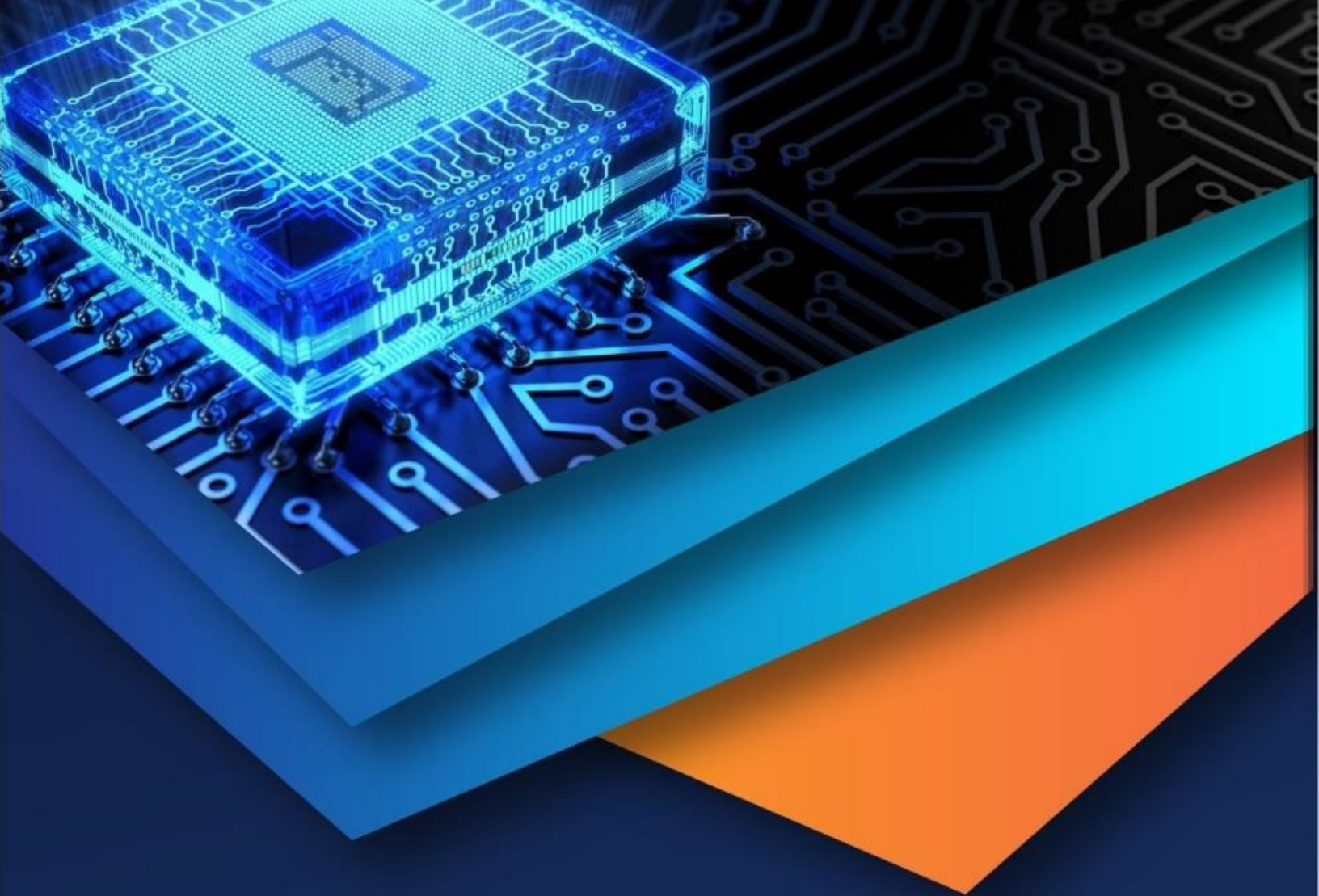
VI. CONCLUSION

AI involves the combination of human knowledge and resources with Artificial Intelligence. As research into AI continues, with many interesting applications of it in progress, one may consider it a necessary evil even for those that see it as an enemy. Therefore, it is strongly recommended that pharmacists should acquire the relevant hard skills that promote AI augmentation. Education about and exposure to AI is necessary throughout all domains of pharmacy practice. Pharmacy students should be introduced to the essentials of data science and fundamentals of AI through a health informatics curriculum during their PharmD education. Pharmacists must also be allowed to develop an understanding of AI through continuing education. Data science courses or pharmacy residencies with a focus on AI topics should be made available for pharmacists seeking more hands-on involvement in AI development, governance, and use.

As these technologies rapidly evolve, the pharmacy education system must remain agile to ensure our profession is equipped to steward these transformations of care.

REFERENCES

- [1] Mak, K.-K. and Pichika M.R., Artificial intelligence in drug development: present status and future prospects. *Drug discovery today*, 2019. 24(3): p. 773-780. [DOI] [PubMed] [Google Scholar]
- [2] Das, S., Dey R., and Nayak A.K., Artificial Intelligence in Pharmacy. *INDIAN JOURNAL OF PHARMACEUTICAL EDUCATION AND RESEARCH*, 2021. 55(2): p. 304-318. [Google Scholar]
- [3] Russell, S., Dewey D., and Tegmark M., Research priorities for robust and beneficial artificial intelligence: an open letter. *AI Magazine*, 2015. 36(4). [Google Scholar]
- [4] Dasta, J., Application of artificial intelligence to pharmacy and medicine. *Hospital pharmacy*, 1992. 27(4): p. 312-5, 319. [PubMed] [Google Scholar]
- [5] Deopujari, S., et al. , Algoman: Gearing up for the “Net Generation” and Era of Artificial Intelligence, One Step at a Time. *The Indian Journal of Pediatrics*, 2019. 86(12): p. 1079-1080. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [6] Dasta, J.F., Application of artificial intelligence to pharmacy and medicine. *Hosp Pharm*, 1992. 27(4): p. 312-5, 319-22. [PubMed] [Google Scholar]
- [7] Honavar, V., Artificial intelligence: An overview. *Artificial Intelligence Research Laboratory*, 2006: p. 1-14. [Google Scholar]
- [8] Lopes, V. and Alexandre L.A., An overview of blockchain integration with robotics and artificial intelligence. *arXiv preprint arXiv:1810.00329*, 2018. [Google Scholar]
- [9] Kawal, F., A Tour to the World of Artificial Intelligence. *CYBERNOMICS*, 2020. 2(5): p. 33-35. [Google Scholar]
- [10] SIRI. [cited 2022 20 May]; Available from: <https://www.techtarget.com/searchmobilecomputing/definition/Siri>.
- [11] What Is Alexa? [cited 2022 20 May]; Available from: <https://itchronicles.com/artificial-intelligence/is-alexa-an-ai/#:~:text=What%20Is%20Alexa%3F,Echo%20and%20Dot%20smart%20speakers>.
- [12] How Google's Self-Driving Car Will Change Everything. [cited 2022 20 May]; Available from: <https://www.eescorporation.com/do-self-driving-cars-use-ai/>.
- [13] Das, S., et al. , Applications of artificial intelligence in machine learning: review and prospect. *International Journal of Computer Applications*, 2015. 115(9). [Google Scholar]
- [14] Heudin, J.-C. Artificial life and evolutionary computing in machine perception. in *Proceedings of Conference on Computer Architectures for Machine Perception*. 1995. IEEE. [Google Scholar]
- [15] State Of AI And Machine Learning In 2019.; Available from: <https://www.forbes.com/sites/louiscolumbus/2019/09/08/state-of-ai-and-machine-learning-in-2019/?sh=133dd64c1a8d>.
- [16] Mulholland, M., et al. , A comparison of classification in artificial intelligence, induction versus a self-organising neural networks. *Chemometrics and Intelligent Laboratory Systems*, 1995. 30(1): p. 117-128. [Google Scholar]
- [17] Shakya, S., Analysis of artificial intelligence based image classification techniques. *Journal of Innovative Image Processing (JIIP)*, 2020. 2(01): p. 44-54. [Google Scholar]
- [18] Arend Hintze. Understanding the four types of AI. [cited 2022. 13 June]; Available from: <https://theconversation.com/understanding-the-four-types-of-ai-from-reactive-robots-to-self-aware-beings-67616>.
- [19] Ganapathy, K., Abdul S.S., and Nursetyo A.A., Artificial intelligence in neurosciences: A clinician's perspective. *Neurology India*, 2018. 66(4): p. 934. [DOI] [PubMed] [Google Scholar]
- [20] Manikiran, S. and Prasanthi N., Artificial Intelligence: Milestones and Role in Pharma and Healthcare Sector. *Pharma times*, 2019. 51: p. 9-56. [Google Scholar]
- [21] Deep Mind's health team. [cited 2022 13 June]; Available from: <https://www.deepmind.com/blog/deepminds-health-team-joins-google-health>.
- [22] IBM Watson for Oncology.; Available from: https://www.ibm.com/common/ssi/cgi-bin/ssialias?appName=skmwww&htmlfid=897%2FENUS5725-W51&infotype=DD&subtype=SM&mhsr=ibmsearch_a&mhq=IBM%20WATSON%20ONcology#:~:text=IBM%20Watson%20for%20Oncology%2C%20software,Center%20physicians%20and%20other%20analysts.
- [23] IBM. Medical Sieve.. [cited 2022 13 June]; Available from: https://researcher.watson.ibm.com/researcher/view_group.php?id=4384.
- [24] MOLLY, THE VIRTUAL NURSE. [cited 2022 13 June]; Available from: <http://adigaskell.org/2015/03/20/meet-molly-the-virtual-nurse/>.
- [25] AiCure. THE RIGHT DOSE FOR THE RIGHT PATIENT. [cited 2022 13 June]; Available from: <https://aicure.com/>.
- [26] Deep Genomics. Programming RNA Therapies Any Gene, Any Genetic Condition. [cited 2022 13 June]; Available from: <https://www.deepgenomics.com/>.
- [27] Shampo, M.A. and Kyle R.A., J. Craig Venter--The Human Genome Project. *Mayo Clinic proceedings*, 2011. 86(4): p. e26-e27. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [28] Atomwise. Artificial Intelligence for Drug Discovery.; Available from: <https://www.atomwise.com/>.
- [29] Open AI Ecosystem.; Available from: <https://www.scientificamerican.com/article/open-ai-ecosystem-ports-a-personal-assistant-for-everyone/>.
- [30] eInvoicing in The Netherlands.; Available from: <https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/eInvoicing+in+The+Netherlands>.
- [31] Fleming, N., How artificial intelligence is changing drug discovery. *Nature*, 2018. 557(7706): p. S55-S55. [DOI] [PubMed] [Google Scholar]
- [32] Okafo, G., Adapting drug discovery to artificial intelligence. *Drug Target Rev*, 2018: p. 50-52. [Google Scholar]
- [33] Ferrero, E., Dunham I., and Sanseau P., In silico prediction of novel therapeutic targets using gene-disease association data. *Journal of translational medicine*, 2017. 15(1): p. 1-16. [DOI] [PMC free article] [PubMed] [Google Scholar]
- [34] Katsila, T., et al. , Computational approaches in target identification and drug discovery. *Computational and structural biotechnology journal*, 2016. 14: p. 177-184. [DOI] [PMC free article] [PubMed] [Google Scholar]



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