CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

SJIF Impact Factor: 7.187

https://zenodo.org/records/10469858

https://www.iajps.com/volumes/volume11-january-2024/01-issue-01-january-24/

Available online at: http://www.iajps.com *Review Article*

A REVIEW ARTICLE ON ARTIFICIAL INTELLIGENCE IN PHARMA INDUSTRY AND HEALTH CARE SECTOR

J. Jahnavi, Dr. K. Umasankar

Department of pharmaceutics, Krishna Teja Pharmacy college, located at chadalawada Nagar, Renigunta Road, Tirupati, Andhra Pradesh, India.

Abstract:

Artificial Intelligence is the pharma's &healthcare upcoming frontier in life science. Present digitalization of medicine &availability of [electronic health records] EHRs motivated the healthcare personnel to employ AI. Nowadays AI is needs in increasing production to gain the quality outcome. Current AI tendency in pharma field on several [artificial neural networks] ANNs such as [deep neural network] DNNs nor [recurrent neural network] RNNs & on [process analytical technology] PAT, [computational fluid dynamics] CFD &many more. As in healthcare AI have a tremendous role in storage of information & data management like patient case records, sale details, medicine holdings &so on. AI is checked or used on various healthcares, pharma industries & also included in disease identifying. Usage of A.I in pharmaceutical industry has accelerated. And by the usage of these A.I technologies can spare the time & money while supplying finer acknowledge on various process parameters & formulations. But at a time robot manufacturers has struggling with various challenges for their efforts to build themselves in pharmaceutical applications. A.I with robotics has a lot of advantages and disadvantages.

Keywords*: Artificial Intelligence, Natural language processing, Personalized treatment, Telemedicine, Clinical trials, Hospital and community pharmacy.*

Corresponding author:

J. Jahnavi,

Department of pharmaceutics,

Krishna Teja Pharmacy college, located at chadalawada Nagar,

Renigunta Road, Tirupati, Andhra Pradesh, India

QR code

Please cite this article in press J. Jahnavi et al., ***A Review Article On Artificial Intelligence In Pharma Industry And Health Care Sector****, Indo Am. J. P. Sci, 2024; 11 (01).*

INTRODUCTION:

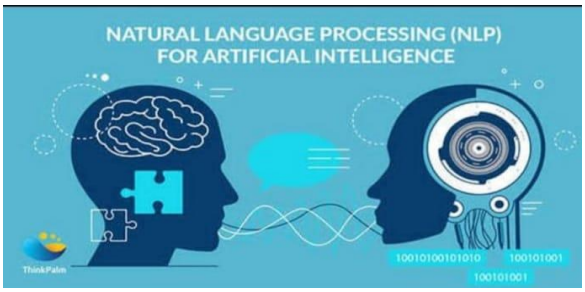
Artificial Intelligence is a sector of computer science which deals with problem solving, interpreting information and combination of several intelligence processes and conduct, expanded by algorithms, computational models and by a bunch of rules that sustain the machine to imitate the logical affairs of human beings like learning, problem solving [1,2]. AI shows enormous impact on making decision in clinical, disease treatment and automation comparable to humans; AI machines have decisive thinking capability [6]. Present -time health care automation in several medical areas has spread to the numerous pioneering startups in the world, which support good health and longer lives [4]. AI helps with the dosage modification can be carried out based on features of individual patient [1]. It has a prospering automation which discovers application in numerous perspectives of life and industry. Current times the pharmaceutical industries come up on novel and innovative ways to apply strong automation to work out the larger issues facing by pharma. AI in pharmaceutical industry connects with computerized algorithms to accomplish charge which traditionally call upon human intelligence [2].

Currently AI has grows an essential role in the industry for appropriate applications in numerous technical and research range. The algorithms in pharma sector also includes Deep neural networks(DNNs),recurrent neural networks (RNNs), Artificial neural networks(ANN), Natural language processing, health data analysis so on [2]. Neutral networks in AI, are reinforced by biological neural networks which exhibits an input and output feedback later processing the data admitted. Artificial neural networks (ANN) have multiple attached units for processing the data. DNNs are alike to ANN thusly there are multiple layers of information processing segments. RNNs process the information in an order according to what the output data of prior analysis is processed as input information for the upcoming phase of analysis [6]. Most of the similar troubles of AI methodology in healthcare system are regulatory compliance requirements, provider adoption, and patients as well as lack of data interchange [4]. At the same time, AI has the ability to revolutionize healthcare by enhancing the speed and accuracy of diagnosis and screening for diseases, assisting with clinical care, strengthening health research and supporting diverse public health interventions. AI can furthermore used to search scientific literatures for appropriate studies and to unite various types of information for suppose to assist drug discovery [4].

In artificial intelligence decision making features assist for clinical practice to review records, refers treatments and foretell the possible results to each one of the patient. In current tendency clinical research rely upon large numbers of information processing. In present scheme, numerous companies turn beneficial from AI [1]. Consequently AI diminishes the time for researchers [7]. AI is valuable to match identify and enlist appropriate studies for suitable patients in clinical research [8]. By the reinforcement of AI the toxicity potential can be forecast in clinical trials. AI has ability in alternating the strategy of medical facility but yet AI requires enhancing in such away to attain positive results [9]. AI has accomplish a great job of leveraging enabling technology automation to enhance workflow productivity and reduce operating price while promote safety, accuracy and efficiency in each pharmacy terrain [2]. Electronic dispensing provides pharmacist a lot of time to involve with a great volume of patients and also increase their health outcomes [10]. AI robotics is also frequently used in monitoring drug interactions at once administration of several drugs. But yet AI needs to be developed in deductive reasoning, commitment making as humans [11].

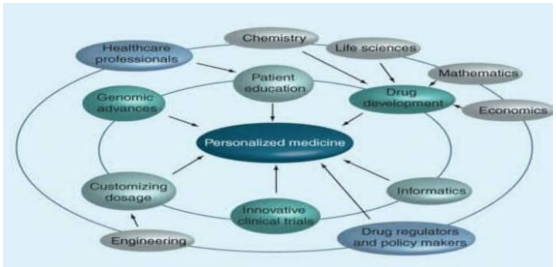
A British logician and computer pioneer Alan Matheson Turing did work on computer machinery and intelligence from 1950-1956. Later John McCarthy coined the term artificial intelligence also known as father of AI. And AI was introduced in India by professor H.N. Mahabala in 1960s. Currently China, USA, Japan, U.K and Germany are leading countries in AI research.

1. **NATURAL LANGUAGE PROCESSING**:



Natural language processing, is a subset of AI that focuses on enabling computer to understand and interpreting human language. This is a broad used technology for private assistants that are used in numerous business fields [12]. In pharma industries natural language processing is used for the clinical trial matching. Detect the right patients for clinical trials from physician's records and previous trials are time involving yet could be automated with AI program tutored on these types of records [13]. NLP during text processing, admit an alignment of disorder suitable keywords at clinical remarks relevant to the previous records. The natural language processing pipelines has been expanded to assist the medical choice making on conscientious treatment plans and monitoring severe effects [4]. As per an article by Emerj, NLP has not widely using the pharma industries like various approaches like machine vision and predicting analytics. And yet there are few applications on NLP in pharma [14]. The more commonly used formats are physician's notes, pathology reports, operational notes and electronic medical records data. Yet, NLP pipelines can also aid with the disease examination. A identified of 14 cerebral anecerysm disease- related changeable at the time executing NLP, on the basis of clinical remarks [4].

2. A.I IN PERSONALIZED TREATMENT / DIGITAL THERAPEUTICS:



Digital therapeutics is also called as digital therapy. It is a new type of medical treatment that provides evidence-basis therapeutics interventions to the patients using software programs [6]. Digital therapy is an expeditious field that has the potential to transform healthcare delivery system by providing clinically safe and effective therapies to patients. Digital therapy is personalized therapy that is tailored to the individual patient's needs. It excludes gaps in care by delivering therapies using smart phones, tablets, and familiar technologies [15]. Digital therapy gives the opportunities to become more patient centric, influence patient adherence and outcomes, better understand the patient experience of disease and generate real world data that is related to the customers [16]. The systems like artificial neural networks (ANNs), developmental computational systems can aid the healthcare workers to exploit the data. ANNs is a system, basis on the principles of the biological nervous system [6]. There is a network of interrelated computer processors known as neurons that can implement parallel computations for data processing [18]. The primary artificial neuron was enhanced by using a binary threshold function.

The multilayer feed forward perception was the most prominent model having different layers, like input layer, middle layer, and output layer. Each neuron is connected through links which having numerical weight [16].

2.1. A.I IN RADIOTHERAPY:

Automation treatment planning is a current technology. It is hugely beneficial in radiotherapy treatment planning. Automation treatment planning is systematically advanced the plan quality, consistency and error rate. The workflow of the therapy has structured into 3 types: i.e, automated rule implementation, reasoning modeling of forward knowledge in clinical practice and multi-criteria optimization [19]. Simple automated computer software with structures can execute the clinical guidelines [6]. Radiomics can provide in depth details about neoplasm with aid of several imaging biomarkers. Radiomics can be applied by predicting the outcomes and toxicity of different patient's radiation therapy [20].

2.2. A.I IN RETINA:

In vitreoretinal disease, AI has been adjusted to detect disease-related features on color fundus photographs [6]. The huge resolution imaging of the retina has provided the scope to estimate human health incredibly. By a particular photograph of the retina, highly personalized data can be extracted. The most common imaging modalities used in retina are optical coherence tomography (OCT), OCT Angiography, fundus photography, fundus auto fluorescence and others. With the high interpretation medicines, the ophthalmologist/ retinologist will define a personal therapy [21]. Each patient comes with a wealth of diagnostics information that can be applied to deep learning analysis. The most common

application of AI methods in retina is the detection of disease-related feature on color fundus photographs [22].

2.3. A.I IN CHRONIC DISEASES:

Various automatized therapies are accessible based on computer program techniques. These therapies are attentive on the behavioral and cognitive approach, which includes multiple-choice questions or joysticks [23]. Currently a latest computer interaction has been advanced .i.e, intelligent computer-assisted instruction, which has the ability to use various AI technologies like natural language understanding and expert systems [24], and by the help of AI combination therapy will be developed on the basis of patient's own autopsy. Chronic disorders need to be observed on the frequent basis by the help of AI observation can be executed using virtual medical backup. Various companies have installed such assistants which usually supply virtual coaching by text messages by the help of mobile applications. By engaging with AI in medical professionals could see improvements in early intervention and patients outcomes for those with heart disorders, cancer and diabetes [25]. Arterial fibrillations will be forecast with the usage of a combined system on the basis of deep learning. Researchers are exploring the use of AI to advance cardiovascular medicine by detecting heart disease, treating strokes and enhancing diagnostics radiology capabilities. These models can lead to personalized medicine and enable fast evaluation of medical device settings and patient-selection criteria, as well as the development of novel therapeutic agents. For instance, algorithms will use in machine learning to identify individuals at high risk for chronic diseases. Latest techniques of A.I will works upon the molecular position like molecular phenotyping, alterations, genomics and the growth/progress of digital biomarkers can also used in the handling of various disorder conditions [26].

3. **A.I IN TELEMEDICINE**:

4.

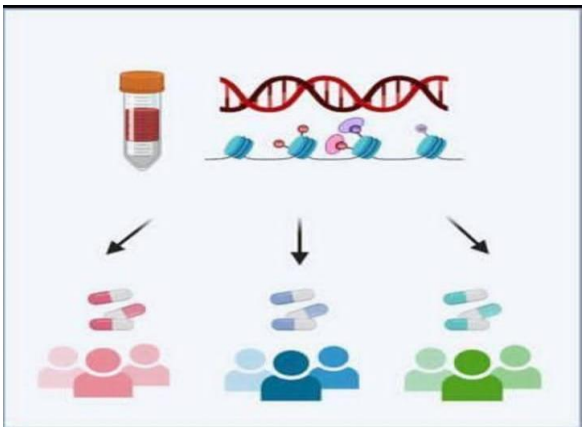
Telemedicine is the phrase which was invented in 1970s, means "Healing from afar" and mention to information communication technology helps to enhance society's health and well being by boosting access to health care information [26]. It permits physicians to supply health facility when social distancing is necessary without direct contact with the patients. The most frequently using mechanisms are video calls, mails. Telemedicine fuses convenience, comfort ability and low-cost access to information concerning health and communication technology to brace health practice via phone, mails, and with the mobile health applications [27]. According to medical news today 76% of hospitals in U.S connect with people at a distance. They do this through video conference or other automation. Patient can also get medicinal services through a portal which is secure where the doctor can access patient electronic medical record database. Telemedicine has various types like 1.Real-time video communication, 2.Remote monitoring that involves health data being reported, collected and evaluated like B.P, respiratory rates, oxygen levels, 3.Store and forward, that involves sharing and storing the medical information like MRIs, X-rays, CAT scans and so on [28]. But yet data security issues, poor user education background and deficit telemedicine features has found problems faced current days in the application of telemedicine in communication and some technology glitches, which cause troubles in smooth flow of communication, lack of patient-doctor rapport, which hinder the development of patient-doctor relationship due to the absence of physical interaction and privacy concerns [29].

5. A.I IN CLINICALTRIALS:

Clinical trials are a crucial part of drug discovery, but they can be lengthy and require significant investment. Unfortunately, the success rate for clinical trials that obtain approval from the FDA is only marginal [30]. There are several bottlenecks that can lead to trial failure, including insufficient participant numbers, drop-outs, side effects of the test drug, and inconsistent data. Late-phase clinical trials, such as phase-III and phase-IV, can be particularly costly if they fail, placing a significant economic burden on the sponsor [31]. These high costs can also affect therapeutic costs for patients, as biopharma companies often tie R&D costs of failed trials into the pricing of approved drugs [32].

The execution and conduct of clinical trials involve various processes such as trial design, patient recruitment/selection, site selection, monitoring, and data collection and analysis. Patient recruitment and selection can be a cumbersome process, with 80% of trials overshooting the enrollment timeline and 30% of phase-III trials being prematurely terminated due

to patient enrollment challenges. Trial monitoring in multi-centered global trials is both expensive and time-consuming. Additionally, there are significant data collection and analysis procedures involved in the duration from the "last subject last visit" to data submission to regulatory agencies [33].



Clinical trial design is a crucial aspect of interventional trials that aims to optimize, ergonomize, and economize the clinical trial conduct [34]. Bayesian nonparametric models (BNMs) have emerged as a powerful tool in clinical trial design and have found applications in various domains. These models are flexible and use a nonparametric approach, allowing the use of infinite-dimensional parameter sets with a finite subset of limited parameters. They minimize clustering and trial designing duration. Some commonly used BNMs include Dirichlet process mixture models and Markov Chain Monte Carlo (MCMC) techniques. BNMs have been successfully applied to dose selection in clinical trials involving cancer patients, immuno-oncology, and cell therapy trials. Dose selection is challenging due to patient heterogeneity, which may lead to inaccurate dose selection and selection of future target populations. BNMs consider all the variables and heterogeneity of the study subjects, making them an efficient and effective tool for dose selection in such patients [33]. Bayesian nonparametric design is used for adaptive dose selection in multiple populations. This approach facilitates the borrowing of information across multiple populations while considering their heterogeneity. It helps in accurate optimal dose selection, minimizing inaccuracies [35]. Another design that uses the Dirichlet process is modified toxicity probability interval (mTPI) designs. This design learns from emerging data, selects the dose by prior approximation, and automatically groups patients into similar clusters [36]. Artificial intelligence (AI) has indeed revolutionized clinical trials by improving efficiency and outcomes. Here are some ways AI is being used in clinical trials:

1. Patient identification and recruitment: AI can analyze medical records and social media content to identify suitable cohorts for clinical trials. It can also simplify entry criteria and alert medical staff and patients about trial opportunities.

2. Data management: AI algorithms, combined with an effective digital infrastructure, can enable the continuous stream of clinical trial data to be cleaned, aggregated, coded, stored, and managed.

3. Safety monitoring: AI can help detect adverse events and monitor patient safety during clinical trials.

4. Real-world evidence generation: AI technologies can collect and analyze real-world data to generate evidence on treatment effectiveness and safety.

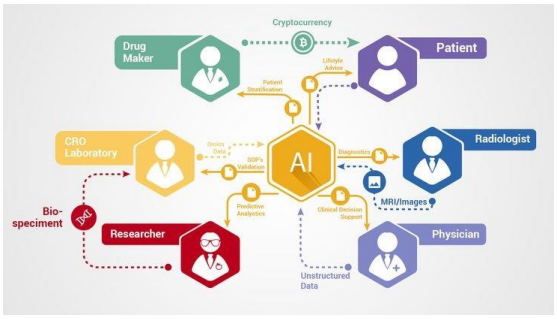
5. Trial design optimization: AI can assist in designing more efficient and adaptive clinical trials, leading to faster results and reduced costs.

6. Drug repurposing: AI algorithms can identify potential new uses for existing drugs by analyzing large datasets.

These are just a few examples of how AI is transforming clinical trials. The use of AI in this field is rapidly evolving, offering new opportunities for improving patient care and advanced medical research.

5. A.I IN HOSPITAL AND COMMUNITY PHARMACIES:

Artificial Intelligence has the potential to enhance the efficiency, accuracy and quality of services provided by hospital and community pharmacies, benefiting both healthcare providers and patients. However, it's essential to ensure that A.I systems are properly regulated and monitored to maintain patient safety and data privacy.



A.I has the capacity to transform both hospital and community pharmacies in multiple ways:

1. Medication management: A.I can enhance the efficiency of medication management for pharmacists by automating tasks like verifying prescriptions and checking for drug interactions, thereby reducing the likelihood of errors.

2. Inventory management: A.I can enhance inventory management by predicting drug demand, minimizing wastage, and ensuring the availability of essential medications, thus optimizing the drug inventory.

3. Drug Dispensing: Robots and AI-driven automated systems can precisely and rapidly dispense medications, enhancing both the speed and accuracy of prescription fulfillment in drug dispensing.

4. Patient counseling: AI-driven virtual assistants or chat bots can offer patients information regarding their medications, dosage instructions, and potential side effects, thereby enhancing patient education in the context of counseling.

5. Drug Interaction Alerts: AI systems can identify potential drug interactions and notify pharmacists, thus mitigating the risk of adverse reactions.

6. Predictive Analytics: AI can assess patient data, forecast health trends, and suggest preventive measures or interventions, enabling pharmacists to customize their services according to individual patient requirements.

7. Telepharmacy: AI can facilitate remote monitoring and consultations, expanding the ability of pharmacists to assist patients in underserved regions or those with limited mobility.

8. Fraud Detection: AI can aid in the detection of prescription fraud and abuse, safeguarding the integrity of pharmaceutical services.

9. Drug Discovery: In research environment, AI can expedite drug discovery processes, aiding in the identification of novel medications and treatment options.

10. Administration Tasks: AI can simplify administrative duties such as billing and record-keeping, allowing pharmacists to allocate more of their attention to patient care.

(AI) has found several applications in the field of hospital pharmacy. Some of these applications include:

1. **Maintaining clinical records**: The collection, storage, normalization, and tracing of patient data can be complicated tasks. A.I is like as the Google Deep Mind health project, which has been evolved to aid in digging medical history in limited period of time. Sudipta et.al said that, this project has confirmed useful in developing and expending healthcare services. Moorfields Eye Hospital NHS is aided by this project for enhancement of eye treatment.
2. **Therapy plan designing**: AI automation can help support in design efficient therapy. Whenever faced crucial patient conditions were picking an appropriate therapy plan turn challenging, AI systems can also play a vital role in managing the situation. These systems consider historical information, reports, and healthcare knowledge to recommend therapy plans. For instance, IBM Watson has launched a program to assist oncologists in treatment plans.
3. **Assisting in repetitive tasks**: AI technology can aid in studying X-ray imaging, radiology, ECHO, ECG, and further diagnostic methods for disease detection and recognition. Medical sieve is an example for cognitive assistant with good analytical and reasoning abilities. Start-ups combining deep learning with medical data are working towards enhancing patient conditions. Specialized computer programs are available for every part of the body to help in the diagnosis of particular diseases. Deep learning techniques can be selected for several imaging analysis, including X-ray, CT scan, ECHO, ECG, etc.
4. **Health support and medication assistance**: current years, the uses of AI automation are recognized efficient in health assist services and also, for the medication assistances. Sudipta Das et.al said that, Molly (a start-up designed virtual nurse) acquires a pleasant sound along with a cordial face. Its aim is to support patients to guide the treatment of patients as well as helping them with prolonged (chronic) condition between the doctor's visits. A.I Cure is an app, which existing in mobile phone's webcam, monitors patients and help them to control their conditions.
5. **AI helps to people in health care system**: It is capable of gathering and comparing the information from social awareness algorithms. The enormous data recorded in healthcare system involves the medical records of the patients along with the treatment records profile from the birth, habits along with life-styles of the patients.

CLASSIFICATION:

1**. Artificial narrow intelligence**:

ANI is the familiar class of A.I that gets available in the market. This type of A.I are developed to work out the individual problems and to accomplish

singular assignment incredibly. It is the exclusive sort of A.I that present nowadays.

2. **Artificial General Intelligence:**

AGI is yet a thesis notion. This state's that A.I has human-level logical functions, beyond broad range of departments like image processing, language processing, computational functions and reasoning and many more.

3. **Artificial Super Intelligence:**

The world is virtually passing into the science invention enclave. Apart from ASI viewed as rational development among AGI. This ASI possibly will qualify to exceed every one of the human potentiality. That embrace making of decision, better art making, and also involve in making relationships develop.

Principles of AI Ethics:

The development of safe, ethical, responsible, trusted, and acceptable AI has converged on a set of guiding principles:

- Transparency
- Impartiality
- Accountability
- Reliability
- Security and Privacy
- Social benefits

Elements of Artificial Intelligence:

- Learning from new information and experiences.
- Using logical reasoning.
- Solving problems.
- Adapting to new problems.
- Producing high accurate solutions.
- Language understanding.

Advantages:

- AI provides the pharmaceutical industry with the capability to address previously insuperable challenges that couldn't be resolved through conventional data analysis methods.
- AI can execute specific tasks with greater precision, leading to cost savings and heightened productivity.
- AI exhibits significantly lower error rates than humans, showcasing remarkable precision, accuracy, and speed if coded correctly.
- AI provides invaluable insights that will substantially enhance the results of clinical trials.
- It enhances the effectiveness of antivirus detection systems and encourages the development the development of new artificial intelligence algorithms.
- In the future, robotic radio surgery and other surgical techniques may attain a level of precision beyond human capabilities.
- AI transforming drug discovery through the utilities of deep learning and natural language processing to comprehend and analyze extensive bioscience information.

Disadvantages:

- AI primarily lacks a human touch as it lacks the capacity for independent thought and can only operate based on predefined algorithms and progress.
- It possesses the capability to influence the younger generation negatively.
- The replacement of humans by robots in all fields could ultimately result in widespread unemployment.
- Many people fear that machines, if in the wrong hands, could easily cause destruction.
- Partially evidenced by the widespread use of smart phones and other technologies, humans are becoming increasingly reliant on AI, potentially diminishing their cognitive abilities.
- The introduction of AI leads to substantial financial expenditures. Elaborate machine design, upkeep, and repairs incur significant costs. The R&D division requires an extended duration to design a single AI machine.
- AI in the form of robots has the potential to surpass humans, potentially leading to concerns of subjugation.

Applications of Artificial Intelligence in pharma industry and Healthcare sector:

IN PHARMACEUTICAL INDUSTRY:

1. **Drug Discovery and Development:**
   - In the realm of drug discovery and development, the task involves the identification of promising drug candidates
   - AI has ability to forecast potential drug interactions and adverse effects.
   - AI has ability to speed up the drug discovery process in pharmaceutical industry.
2. **Clinical trials:**
   - Optimizing patient enrollment and eligibility standards.
   - Monitoring trial data in real time.
3. **Genomics and Personalized Medicine:**
   - Analyzing genetic information to create personalized treatment strategies.

- Discovering genetic indicators for diseases.

IN HEALTHCARE SECTOR:

1. **Disease Diagnosis and Medical Imaging:**
   - Analyzing radiology images to detect at an early stage.
   - Examining pathology slides.
   - Identifying irregularities in medical images.
2. **Drug Prescription and Medication Management:**
   - Automated verification of drug interactions in prescriptions.
   - Monitoring medication adherence.
3. **Remote Patient Monitoring:**
   - Wearable devices for patient data in real time.
   - Continuous monitoring and alerting for chronic illnesses.
4. **Natural Language Processing (NLP):**
   - Deriving insights from clinical notes and patient medical history.
   - Chatbots for engaging with and assisting patients.
5. **Healthcare Operations:**
   - Optimizing resource allocation in healthcare facilities.
   - Managing the supply chain.
6. **Telemedicine:**
   - Virtual appointments and assessment.
   - Monitoring patients from a distance.

These AI applications not only boost efficiency but also hold the potential to enhance patient outcomes, lower healthcare expenses, and stimulate innovation in the pharmaceutical and healthcare industries.

CONCLUSION:

Artificial Intelligence plays a central role; the core focus of a novel initiative is the development of computational models of intelligence. AI has become a game-changing factor in both the pharmacy and healthcare domains. Through the applications of natural language processing, AI-driven solutions are improving the effectiveness of healthcare providers and elevating the patient experience. Personalized treatment plans, by AI are revolutionizing patient care. Machine learning algorithms analyze vast datasets to tailor therapies to individual needs, optimizing outcomes and minimizing adverse effects. Telemedicine has seen a significant remote patient consultations and monitoring. Patient can receive real-time healthcare guidance, and doctors can access critical patient data, leading to timely interventions and reducing the burden on physical healthcare facilities. AI is accelerating clinical trial processes by identifying suitable candidates, predicting potential drug interactions and streamlining data analysis. This not only expedites the development of new treatment but also ensures their safety and efficacy. In sum, AI with its remarkable applications in NLP, Personalized treatment, telemedicine, and clinical trials, is poised to continue reshaping the pharmacy and healthcare sectors. As AI technologies advance, the industry can anticipate even more efficient, accessible, and patient-centric healthcare services in the near future.

REFERENCES:

1. Sanjeeb Kumar Sahoo, Nihar Ranjan Kar. Applications of Artificial Intelligence in Pharmaceutical Industry and Healthcare Sector. Journal of Fundamental & Comparative Research.2022 Dec;2277-7067
2. Prerna V Surye.,et al., A Review on Artificial Intelligence in Pharmacy. International Journal of Pharmaceutical Research and Applications.2023 March, pp:1938-1946
3. Muhammad Ahmer Raza., et al., Artificial Intelligence in Pharmacy: An Overview of Innovations. Pharmacy Practice & Practice-Based Research.2022, pp: 1312-4839
4. Sudipto Datta.,et al., Application of Artificial Intelligence in Modern Healthcare System. Intech open.2019
5. Tamanna Sharma, Abhinav Mankoo., et al., Artificial Intelligence in Advanced Pharmacy. International Journal of Science & Research Archive,2021,02(01),047-054
6. Subrat Kumar Bhattamisra, et al., Artificial Intelligence in Pharmaceutical and Healthcare Research.2023, https://www.mdpi.com/journal/bdcc.
7. Artificial Intelligence in healthcare,Academy of Royal Medical Colleges,2019
8. Jiang F, Jiang Y., et al., Artificial Intelligence in Healthcare: past, present and future. Stroke Vasc Neurol.2017;2(4):230-43
9. Agrawal P. Artificial Intelligence in drug discovery and development. J Pharmacovigil.2018;6(2)
10. Das, S., R. Dey, and A.K Nayak, Artificial intelligence in pharmacy. INDIAN JOURNAL OF PHARMACEUTICAL EDUCATION AND RESEARCH, 2021. 55(2): P.304-318.
11. Russell, S., D. Dewey, and M. Tegmark, research priorities for robust and beneficial Artificial Intelligence: an open letter. AI Magazine, 2015.36(4)
12. Christopher DM, Hinrich S. Foundations of Statistical Natural Language Processing. Cambridge, London, England: The MIT Press; 1999

13. Afzal N, Sohn S, Abram S, et al. Mining peripheral arterial disease cases from narrative clinical notes using natural language processing. Journal of vascular Surgery. 2071;65:1753-1761
14. Castro VM, Dligach D, Finan S, et al. et al. Large-scale identification of patients with cerebral aneurysms using natural language processing. Neurology. 2017;88:164-168
15. Ramesh, A.N.; Kambhampati, C.; Monson, J.R.; Drew, P.J. Artificial Intelligence in medicine. *Ann. R. Coll. Surg. Engl*. 2004, 86, 334
16. Hanson III, C.W.; Marshall, B.E. Artificial Intelligence Applications in the intensive care unit. *Crit. Care Med.*2001,29,427-435
17. Hopfield, J.J. Artificial neural networks. *IEEE Circuits Syst. Mag.* 1988, 4,3-10
18. Jain, A.; Mao, J.; Mohiuddin, K. Artificial neural networks: A tutorial. Computer1996, 29, 31-44.
19. Moore, K.L. Automated radiotherapy treatment planning. In Seminars in Radiation Oncology; WB Saunders: Philadelphia, PA, USA, 2019; Volume 29, pp. 209-218.
20. Arimura, H.; Soufi M.; Kamezawa, H.; Ninomiya, K.; Yamada, M . Radiomics with artificial intelligence for precision medicine in radiation therapy. J. Radiat. Res. 2019,60 150-157.
21. Schmidt- Erfurth, U.; Sadeghipour, A.; Gerendas, B, S.; Waldstein, S .M.; Bogunovic, H. Artificial intelligence in retina. Prog. Retin. Eye Res. 2081,67, 1-29.
22. Troulis, M.; Everett, P.; Seldin, E.; Kikinis, R.; Kaban, L. Development of a three-dimensional treatment planning system based on computer tomographic data. Int. J. Oral Maxillofac. Surg. 2002, 31, 349-357.
23. Posner, M.I.; Rothbart, M.K. Research on Attention Network as a Model for the Integration of the Integration of Psychological Science. Annu. Rev. Psychol. 2007, 58, 1-23.
24. Haag, M.; Maylein, L.; Leven, F.J.; Tonshoff, B.; Haux, R. Web-based training: A new paradigm in computer-assisted instruction in medicine. Int. J. Med. Inform. 1999, 53, 79-90.
25. Ellahham, S. Artificial Intelligence: The Future for Diabetes Care. Am. J. Med.2020, 133, 895-900.
26. Telemedicine : Centers for Medicare & Medicaid service;. Available : https:// www.Medicaid.gov/ Medicaid/ benefits/ telemedicine/ index . Html
27. Keesara S, Jonas A, Schulman K. Covid-19 and health care's digital revolution. N Engl J Med 2020;382:e82.
28. Zundel KM. Telemedicine: history, applications, and impact on librarianship. Bull Med Libr Assoc 1996;84: 71-9.
29. Hurst EJ. Evolutions in telemedicine: from smoke signals to mobile health solution. J Hosp Librariansh 2016;16:174-85.
30. Huss, R. The High Price of Failed Clinical Trial: Time to Rethink the Model. Clinical Leader,3 October 2016. Available online: http:// www.clinicalleader.com/doc/ the-high-price-of-failed-clinical-trails-time-to-rethink-the-model-0001
31. Goldsack, J. Synthetic Control Arms Can Save Time and Money in Clinical Trials. 2019. Available online: https:// www.statnews.com/2019/02/05/synthetic-control-arms-clinical-trial/
32. Unger, J.M.; Vaidya, R.; Hershman, D.L.; Minasian, L.M.; E Fleury, M. Systematic Review and Meta- Analysis of the Magnitude of Structural, Clinical, and Physician and Patient Barriers to Cancer Trial Participation. Gynecol. Oncol. 2019,111,245-255.
33. Kolluri,S.; Lin, R,; Zhang, Y.; Zhang, W. Machine Learning and Artificial Intelligence in Pharmaceutical Research and Development: A Review. AAPS J. 2022, 24,19.
34. Harrer, S.; Shan, P.; Antony ,B.; Hu,J. Artificial Intelligence for Clinical Trial Design. Trends Pharmacol. Sci. 2019,40,577-591.
35. Li, M.; Lin, R.;Lin, J.; Bunn, V.; Zhao, H. Bayesian Semi- parametric Desigh (BSD) for adaptive dose-finding with multiple strata. J. Biopharm. Stat. 2020, 30, 806-820.
36. Lin,R.; Lin, J.; Li, P. Design considerations for phase I/II dose finding clinical trial in Immuno-oncology and cell therapy. Contemp. Clin. Trials 2020, 96, 106083.