A Book
on

Artificial intelligence in Business, Management and Pharmaceutical Technology

Edited by :
Prof. (Dr.) Bindu Sharma
Prof. (Dr.) Shalini Sharma

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Artificial Intelligence in Business, Management and Pharmaceutical Technology

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Artificial Intelligence in Business, Management and Pharmaceutical Technology

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PREFACE

This book is based on the research work presented in the International Conference "Artificial Intelligence in Business, Management and Pharmaceutical Technology" held on February 18 & 19, 2023, highlighting the use and impact of Artificial Intelligence in the fields of Business, Management, and Pharmacy. Today, AI has penetrated in almost every sphere and become an important tool to gain expertise and excellence at the workplace.

The research work presented in the International Conference has given insight to leverage AI to develop analytical capabilities, critical thinking, and decision-making.

The book includes more than 15 research articles that provide a practical understanding of the concepts and application of AI and cover a wide range of problems, issues, and challenges related to the application of AI in Business, Management, and Pharmaceutical Sciences.

We express our sincere gratitude to Sh. Mahendra Aggarwal, Chairman and Mr. Akhil Aggarwal, Vice-Chairman, Sunder Deep Group of Institutions, for his encouragement and support in this endeavor. We also appreciate the contribution of the faculty members of SDCMT and SDPC who have taken a keen interest in the compilation of this book.

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This book is based on the articles received in the International Conference on "Artificial Intelligence in Business, Management, and Pharmaceutical Technology" held at Sunder Deep Group of Institutions, Dasna, Uttar Pradesh on February 18 and 19, 2023. We are grateful to the participants of the conference including the faculty and students from various universities who have contributed to this book.

We thank our Hon'ble Chairman Sh. Mahendra Aggarwal and Vice-Chairman Mr. Akhil Aggarwal who has guided and supported us to make this effort a success.

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Finally, we would like to acknowledge with gratitude, love, and support our SDCMT and SDPC families.

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ROLE OF ARTIFICIAL INTELLIGENCE IN DRUG DEVELOPMENT

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ABSTRACT
Artificial intelligence (AI) is a branch of the computer science that deals with the problem-solving by the aid of symbolized programming; i.e., it consumes less time and gives faster results. In the field of the pharmaceutical sector, artificial intelligence (AI) has recently grown to be a sizzling topic. It has greatly evolved in science of problems - solving with the huge applications in research, marketing, health care, pharmacy and engineering. The machine learning (ML), is increasing demand across drug discovery and its development by yielding impressive results. The development of a novel drug in a pharmaceutical industry is quite difficult and lengthy procedure that normally takes several years and involves significant costs due to an increased attrition rate. As a result, there is an essential requirement to enhance the process of development of a novel drug utilizing innovative technology like artificial intelligence (AI). AI enables machines and computers to execute human-like tasks and make decisions as attempting to solve a specific challenge. Problem is solved on the basic of learning phase gained during memorization and adaptability, in addition to the generalisation, expertise obtained by training machines to deal with new obstacles. This review paper focuses on the major role of AI in several areas of the pharmaceutical industries, including clinical trials, drug development, manufacturing, drug analysis, quality assurance, and drug pharmacokinetic prediction. By using AI, these areas of the pharmaceutical industry can accomplish their goals faster and with less effort from humans, which reduces their burden.

Keywords: Artificial Intelligence, Drug Discovery, Drug Development, Innovative technology, Pharmaceutical Industry

INTRODUCTION
Artificial intelligence (AI) is the ability of a computer or robot to do tasks that ordinarily require human judgement and discretion. A new pharmaceutical molecule is introduced into medical use through the process of drug development.AI has already been applied at several stages of the process of drug discovery, among many other things, to find new targets, learn more about disease processes, and create new diagnostic markers (Keerthana *et al*., 2022).There has been a significant increase in the amount of money that pharmaceutical companies are investing in equipment, software, and services, particularly in the creation and collection of datasets for AI research in areas like deep computing and machine learning. AI now has a big impact on drug research, and many businesses have created internal initiatives or partnered with AI companies. Currently, some businesses are using AI to reclaim pharmaceuticals, find novel applications for already-approved medications, and identify late-stage drug. In its broadest sense, drug development, is a method of introducing a novel drug molecule into clinical practise.

It covers all phases, from early-stage basic research to identify a promising molecular target to extensive Phase III clinical trials that support the successful launch of the drug to the post-market surveillance and therapeutic targets studies (Johnson *et al*., 2001). During computing docking(s), AI typically creates, grades, and compares a posture to the preceding position. There are various docking systems that can be used for virtual screening, each of which has its own sampling methodology, scoring formulas, flexibility treatment for ligands and receptors, and time of CPU requirement for docking molecules to certain targets. (Keerthana *et al*., 2022).

The emergence of artificial intelligence (AI) and computational technologies allow by accelerating the development of new drugs scientists which has a significant impact on society. All in all, it makes the process of medication research and development easier while also giving patients better treatment. AI has applications in the fields of diagnostics, drug distribution, patient's adherence, and enhanced safety monitoring, in addition to drug discovery and development.

In certain situations, artificial intelligence (AI) can outperform humans at a task and help healthcare professionals to treat patients. This review covers how AI is helping the pharma industry advance and prosper.

Artificial intelligence (AI) has demonstrated its value in every industry. It established connections in the health industry and aided in achievement at every level, through drug discovery to the retail sale of medical products. AI-based patient portals have the capacity to assess symptoms and give the user individualised therapy.

Quality of the digital data used as input determines the quality of AI output. As a result, inconsistent input data limits the potential utility of AI. This review seeks to serves as a graphic and easily readable informational resource, covering everything from the concept of AI to the advantages and instruments employed in the most practical and accurate way for the improvement of healthcare (Grandhi *et al*., 2022).

Artificial intelligence (AI) has become more prevalent in a number of societal fields, most notably the pharma industry. In this evaluation, we focus on how AI is being used in a variety of pharmaceutical industry fields, such as pharmaceutical research, drug repurposing, increasing pharmaceutical economic output, and drug testing, among others. This use of AI lessens the workload of human workers while also achieving goals quickly (Paul *et al*., 2022).

With its outstanding outcomes, machine learning (ML) is becoming more and more popular in the drug development industry. The use of ML in the area of drug development is expanding, enabling study in a variety of directions. The growing number of drug companies whose business models place ML at the core shows the success of the technology (Elbadawi *et al*., 2021).

McCarthy initially referred to the idea of artificial intelligence (AI) in 1956 as "the science and engineering of building intelligent machines," even though Turing had proposed the idea about using computers to replicate people's behaviour and awareness six years before.(Gallego *et al*., 2021). A subfield of computer science called artificial consciousness is able to analyze intricate medical data. Their ability to find significant relationships within a data collection can be employed in various clinical situations for diagnosis, treatment, and outcome prediction (Khan *et al*., 2004).

The rapid advancement of artificial intelligence has caused significant changes in the way that drug research is conducted (Deng *et al*., 2022).

The modeling of human intelligence by machines is known as artificial intelligence (AI). The procedure entails gathering data, creating rules for using it, coming to approximate or firm results (Mak *et al*., 2019).

This artificial intelligence's major goal is to recognise practical information processing issues and provide an abstract explanation of how to address them. A theorem in arithmetic relates to such an account, which is referred to as a method. There are many different fields of AI (Krishnaveni *et al*., 2019; Archer & Germain., 2021).

According to Chen and his team, AI can defined as the study of complex medical data using sophisticated algorithms and software to mimic human cognition and examine the connections between preventative or curative measures and health outcomes (Chen *et al*., 2021).

AI is "a area of computer science through which we develop intelligent machines that can think like humans, interact with humans, and be capable of making decisions like humans," according to one definition (Sharma & Garg., 2021)

How Artificial Intelligence Works

Deep learning and machine learning are the methods used by AI. Statistical techniques used in machine learning have the capacity to learn without really being computer vision. They can develop techniques to succeed at a specific task thanks to the volume of data sent into the machine learning algorithm. There are three types of machine learning: monitored, unlicensed, and reinforcement learning (Grandhi *et al*., 2022; Mak & Pichika., 2019; Meskó & Görög., 2020).

Applications of AI

Evaluation, structure - property relationships, and drug design, which may be broken down into two main tasks: molecular property prediction and molecule generation, are some of the applications of AI in small-molecule drug discovery (Elbadawi *et al*., 2021) The prediction of viable synthetic routes for narcotic compounds (Fleming *et al*., 2018), pharmacological effects (Klopman *et al*., 2004), protein features along with efficiency (Menden., 2013 drug combining and drug-target connection (Nascimento *et al*., 2016), and drug repurposing are other applications of AI in the pharmaceutical industry (Mak et al *et al*., 2019). There are various applications of AI which are shown in figure 1.

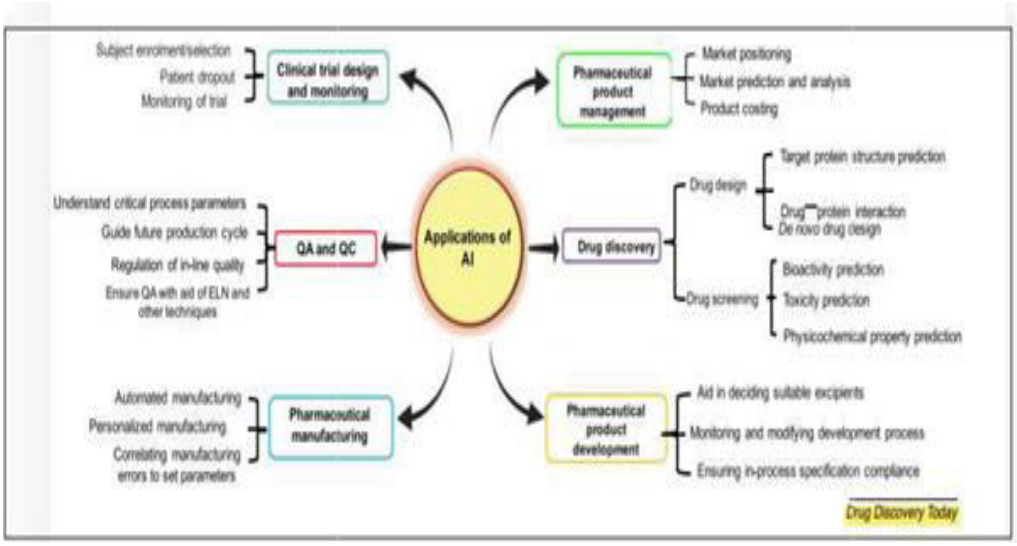

Figure 1: Applications of AI (Paul *et al*., 2022). (3)

Artificial Intelligence in Drug Discovery

A drug's discovery and development can take more than decade and cost, on average, US$2.8 billion. Even at that, nine out clearance and Phase II clinical Fleming *et al*., 2018) of 10 medicinal compounds fall short of passing regulatory studies (Paul *et al*., 2022; A´lvarez-Machancoses *et al*.,2019;

In order to find new targets, biomarkers, and molecules, scientists investigate the interactions of various molecules, genes, and proteins to determine which ones show the most potential. RWD applications can support some of these goals.AI can difference between strike and synthetic analogues, enabling quicker structural design optimization and therapeutic target confirmation (Keerthana *et al*., 2022; Mak, K. K *et al*., 2019).

AI can identify hit and drug candidates, while also accelerate therapeutic target validation and structural design optimization (Paul *et al*., 2022; Mak *et al*., 2019; Sellwood *et al*., 2018).

Along with structural and ligand-based approaches, there are many in silico techniques for molecular biological compounds from simulated chemical spaces that offer better profile analysis, quicker non-lead compound elimination, and faster therapeutic molecule selection at lower cost (Paul *et al*., 2022; Mak *et al*., 2019) Large quantities of compounds or straightforward physicochemical properties can be quickly predicted using a computational model based on the quantitative structure-activity relationship (QSAR) (Paul *et al*., 2022).

Finding new targets, compounds, and biomarkers begins with the discovery of possible therapeutic agents. To do this, studies investigated how various chemicals, genes, and proteins interact each other. They then choose which molecules have the greatest promise (Chen *et al*., 2021; Cassidy *et al*., 2020).

A computerised statistical tool called a quantitative structural activity relationship (QSAR) can be used to explain the observed variation in structural alterations brought on by replacement (Vemula *et al*., 2022).

The focus of drug discovery, design, and preclinical optimization is on 1) identifying targetable mechanisms or molecules that are responsible for a given clinical condition, and occasionally in a given population of patients, and 2) identifying, designing, and optimising a drug to modulate this altered physiology. Both of these processes are being handled using Artificial intelligence as shown in Figure no. 2 (Paul *et al*., 2021).

In during drug discovery phase, chemical substances that fit through into dynamics of a pathophysiology and possess the potential to enhance it are found (Webster *et al*., 2020).

A lot of AI has been used in drug discovery. Machine learning methods, such arbitrary forest (RF), have been employed for VS and QSAR since the early 2000s (Elbadawi *et al*., 2021; Paul *et al*., 2021; Walters et al., 2020).

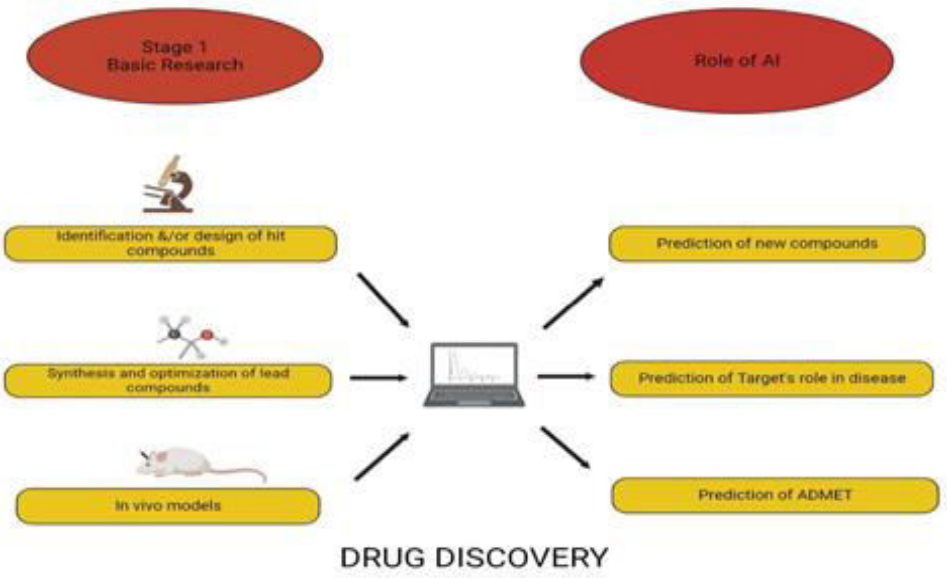

Figure 2: Role of AI in Drug discovery

Artificial Intelligence in Drug Development

The development of a novel therapeutic molecule is followed by the incorporation of the novel medicinal component into a viable dosage form with acceptable delivery characteristics. AI can replace the conventional trial-and-error approach in this situation (Chen *et al*., 2021).

The FDA defines the process of drug development as consisting of four steps that are shown below in the figure 3.

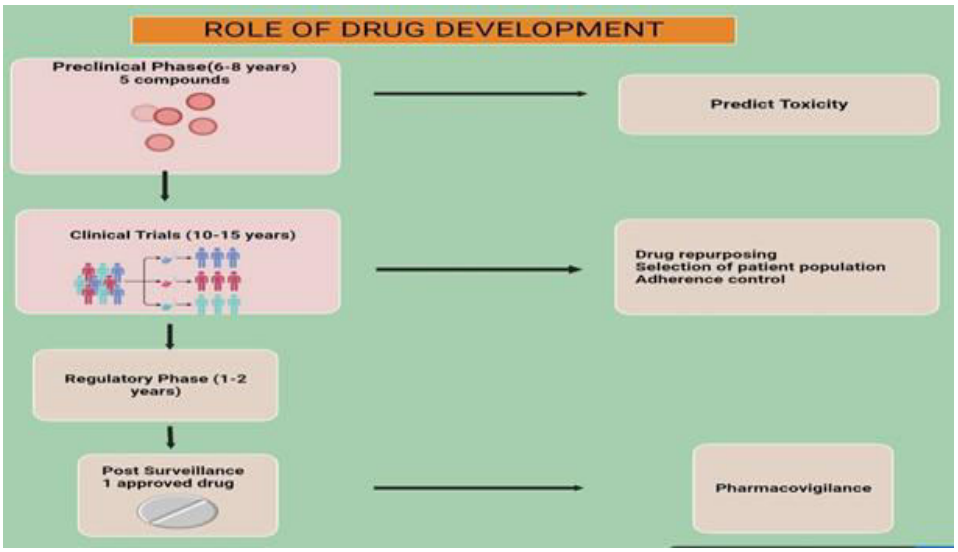

Figure 3: AI in Drug Development Process

The process of finding new therapeutic medications involves researching disease processes and the properties of molecular molecules. Clinical research includes various phases of human testing to evaluate the safety and effectiveness of the new medicine, as well as post-marketing research such as pharmacosurveillance and observational studies (Keerthana *et al*., 2022; Mak *et al*., 2019).

Finding effective new medications is a challenging and typically the most challenging step in the drug development process. This is due to the enormous extent of bioactive molecules, which is thought to contain around 1060 molecules (Mak *et al*., 2019; Segler *et al*., 2018).

The two main stages of drug development are pre-clinical testing via clinical trials and regulatory approval filing. More recently, Artificial intelligence has been incorporated into the development phases with the main purpose of enabling the collection, organisation, and analysis of "big data" in order to enhance trial regulatory approval and effectiveness (Paul *et al*., 2021).

According to FDA definition[Krishnaveni C *et al*., 2019), there are four stages: (1) drug discovery, which involves finding new therapeutic agents by understanding disease mechanisms and the characteristics of different substances and (2) preclinical research, which involves conducting research lab and animal testing to address concerns about the risk of the novel therapeutic targets, (3) clinical research, which involves conducting various elements of care trials to test a brand-new drug on human beings in order to judge its safety and effectiveness and (4) post marketing surveillance (Chen *et al*., 2021).

Feedback-driven pharmaceutical research process begins with results already gathered from a variety of sources, including increased compound and fragment screenings, computer modelling, and information found in the literature.

For *in silico* compound manufacturing and high - throughput screening models that serve as substitutes for biochemistry and biological testing of efficiency and toxicity, de novo design procedures require an understanding of organic chemistry (Mak *et al*., 2019; Yuan *et al*., 2011).

Finding novel organic compounds with biological processes is the initial step in the medication development process. This biotic activitie may result from the compound's interaction with a particular enzymes or an entire organism. A "hit" is the first chemical to exhibit activity against a specific biological target. When screening chemical libraries, computer simulations, or naturally isolated materials like plants, bacteria, and fungi, hits are frequently discovered (Mak *et al*., 2019; Zhu *et al*., 2013)

Artificial Intelligence in Pharmaceutical Product Development

The subsequent inclusion of a novel therapeutic molecule into an appropriate dosage form with the requisite delivery properties is necessary. Based on the input parameters, the Model Expert System (MES) generates decisions and suggestions for formulation development (Paul et al., 2022; Rantanen *et al*., 2015).

Artificial Intelligence in Pharmaceutical Manufacturing

The pharmaceutical business could benefit from the use of AI in manufacturing (Paul *et al*., 2022; Rantanen *et al*., 2015).

The innovative Chemputer platform, which incorporates diverse chemical codes and uses the Chemical Assembly scripting language, aids digital mechanization for the production and manufacture of molecules (Paul *et al*., 2022; Chan *et al*., 2019).

AI tools like the systematic review and tablet-classifiers are used to control the final product's quality standard and to flag any manufacturing errors in tablets (Paul *et al*., 2022; Gams *et al*., 2014).

Manufacturing of the effective drug on a big scale for commercialization is subject to a different set of regulations. It includes the creation of final drug products, active pharmaceutical ingredients (APIs), and a number from in and post-production qualities tests. Manufacturing API is either a chemical procedure for drug molecules that are synthesised or an extraction/isolation process for molecules that are naturally derived. Manufacturing of finished drug products entails creating a dosage form by combining an API with active ingredients to create a substance suitable for patient consumption (Grant *et al*., 2020).

Artificial Intelligence in Quality Control And Quality Assurance

It takes human intervention to maintain batch-to-batch uniformity and conduct manufacturing quality testing on the products (Paul *et al*., 2022; Rantanen *et al*., 2015).

The FDA revised Current Good Manufacturing Practices (cGMP) by adding a "Quality by Design" approach to comprehend the crucial process and particular standards that determine the medical product's quality of the finished (Paul *et al*., 2022; Aksu *et al*., 2013).

Challenges in Future Directions

The quality of the information contained in various RWD sources is the first significant issue. Second, rather than emphasising learning about incidental effects, the majority of the trials we found were focused primarily on prediction or categorization (Chen, Z *et al*., 2021; Pearl *et al*., 2011; Bareinboim *et al*.,2016).

Third, more evaluations of the transferability and explainability of these research are also required. In order to achieve higher success, perhaps cheaper costs, and a quicker time to market, artificial intelligence techniques and technologies are naturally applied to the difficult problems of medication creation and development.

Although the outcomes to date were more progressive than disruptive, they are nonetheless quite promising. However, several important issues that the technology, alone does not immediately address new possibilities that can improve clinical and economic performance.

CONCLUSION

The continued development of AI and its amazing tools promises to minimize the difficulties experienced by pharmaceutical firms, impacting both the process of drug development and the full lifecycle of the product. The relevance of automation will increase as a result of the use of the most advanced AI-based technologies, which will not only shorten the time it takes for items to reach the market but will also increase product quality, production process, safety, and resource efficiency. Not only can AI help with the easy and quick identification of hit

compounds, but it can also recommend possible synthesis pathways for these molecules, predict the needed chemical structure, and help with understanding drug-target interactions and its SAR. Through extensive market analysis and prediction, AI can also help establish the product's safety and the efficacy in clinical trials, as well as ensure correct positioning and pricing in the market.

ABBREVIATIONS

AI- Artificial intelligence ML- Machine learning RWD- Real world data

SAR- Structure activity relationship MES- Model Expert System

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ARTIFICIAL INTELLIGENCE SCOPE IN PHARMACOVIGILANCE

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ABSTRACT

Artificial intelligence is the ability of a machine or software to think critically and make decisions on its own, without the need for human input. Artificial intelligence has proven to be a useful tool for dealing with risky issues and operating in environments and circumstances where human workers would be put in danger. Machine learning artificial intelligence employs prior knowledge and algorithms to make predictions.

Pharmacovigilance is the study of adverse events assessment, prevention, detection and collection, evaluation of drug-related problems. The healthcare sector, in particular pharmacovigilance, understands the significance of supporting the expanding volume of data gathered from individual case safety reports (ICSRs). To handle this growth, more healthcare and skilled personnel are required to collect and analyse the data. Artificial intelligence (AI) and other assistive technologies will need to be widely utilised to stay up with the changing environment. Artificial intelligence has the potential to change how drug safety experts do their daily business and advance their professional careers. Artificial intelligence may improve qualitative and quantitative data gathering and assessment in the pharmacovigilance sector by applying machine learning techniques. Advanced medical approaches like tailored treatment that maximises the risk-benefit ratio are made possible with the help of artificial intelligence. In this review, we have succinctly covered the advantages of using AI techniques in pharmacovigilance (PV), the role of drug safety professionals using AI, the history of PV cognitive services, the role of AI in 21st-century PV, the need for AI in real-world PV, the need for AI for drug toxicity and safety in PV, and the difficulties of using AI in PV.

Keywords: Pharmacovigilance, Artificial Intelligence, Drug Safety, Pharmacology, Cognitive Service

INTRODUCTION

The study of adverse event assessment, prevention, detection, collection, and evaluation of drug-related issues is known as pharmacovigilance[1,] although the number of individual case safety reports can rise year over year, 90% of adverse occurrences (AEs) go unreported. Technology must therefore be required to maintain negative events. Artificial intelligence facilitates decision-making in challenging circumstances. To evaluate PV users' ability to make decisions, cognitive services are being created.[2] Therefore, using AI is the method to deal with AEs unreported data. Social media usage is another tactic for spreading awareness of health information. Patient narrative information is represented by electronic health records (EHRs). Using the aforementioned sources, AEs can identify and enhance the AI can reduce human labour required for transcription and data entry, allowing for more time to be spent on scientific and medically sound AE evaluations that are better for patient health. Artificial intelligence (AI) is the ability of a digital machine to accomplish tasks that need human intelligence.[3] Artificial intelligence (AI) is the use of machines to solve future problems by introducing learning technologies to the machines with the aid of historical data. The use of AI improves clinical trial success rates and assists with patient randomization. The three biggest global health burdens—diabetic retinopathy, diabetes, and cancer—have demonstrated promising results for AI in the diagnosis, mitigation, and treatment of these conditions. PV data is crucial in confirming the safety of currently available medicinal devices. After the AI incorporates the PV data, it is anticipated that the reporting will be more accurate and of higher quality. Netwell and Simon made the initial AI software discovery in 1995. John McCarthy is known as the Father of AI.

John McCarthy is known as the Father of AI. Warren McCulloch, Walter Pits, and Donald Hebb modified the strength of the connection between neurons in 1943 and presented the artificial neuron model. A mathematical problem-solving algorithm was discovered in 1966 by researchers. The expert system discovered human-expert decision-making capability in 1980. IBM's Watson was able to answer challenging quiz questions in 2011. Watson thus demonstrated that machines can comprehend natural language.

Scientists in Japan employed AI for machine learning in image learning in robots in 1972.[4] AI can be divided into three categories:

Rule-based static systems, AI-based static systems, and rule-based dynamic systems.

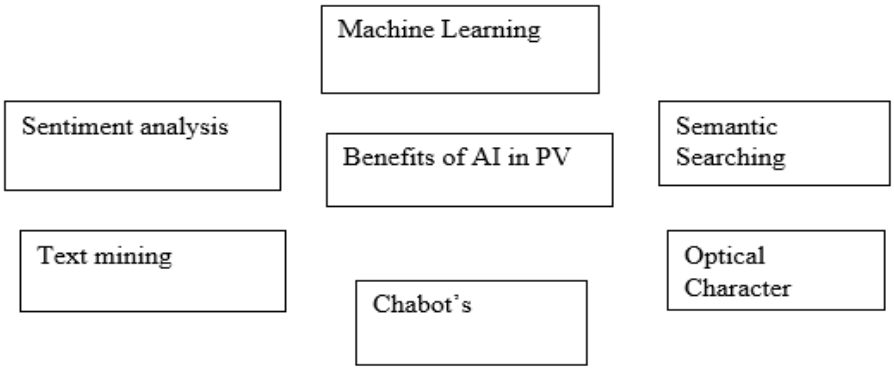
Rule-based static systems automate tasks using a pre-defined set of rules, while AI-based static systems produce results using training data (supervised ML, NLP), which is updated for later use. The PV validation framework's validation framework was based on rules, and the GMP validation framework was based on AI. The intelligent automation system has to be categorised due to the inadequate validation framework of existing technologies. Artificial intelligence is used to stimulate human intelligence based on a rule-based static system.[5]

BENEFITS OF APPLYING AI TECHNIQUES IN PV

AI used in drug discovery To extract useful information from a large dataset, AI uses sophisticated algorithms and machine learning. For instance, a dataset of RNA sequencing can be used to find genes whose expression correlates with a specific biological situation.

AI can also be used to find substances that might bind to proteins known as "undruggable targets," or proteins with unknown structures. A predicted set of compounds can be quickly identified through iterative simulations of interactions between various chemicals and tiny fragments of a protein.[6]

Benefits of Applying Artificial Intelligence Techniques in Pharmacovigilence



The computer system can comprehend and interpret human language thanks to natural language processing (NLP). Without being explicitly taught, machine learning (ML) is the branch of AI that may provide predictable results. When human intelligence is needed to address problems, a combination of NLP and ML algorithms is a cognitive service that can help. Annotated corpora with syntactic (sentence identification) and semantic (word/phrase identification) patterns are utilised to create cognitive services that are more effective.

IMPACT OF AI ON DRUG SAFETY PROFESSIONALS

Drug safety specialists need to have system-thinking abilities, leadership qualities, communication skills, and analytical assessment abilities. Drug safety experts must have taken intensive courses in soft skills. For experts in medication safety, retraining and algorithm updates are the most difficult tasks.

BACKGROUND OF PV COGNITIVE SERVICES

a) Identifying cognitive services: Safety data collection and analysis were the main goals of cognitive services

Information. It's a crucial choice how to best use the ML algorithm to cognitive services in order to assess and enter data for the ICSR process. Contextual analysis is therefore employed by researchers. In cognitive service, the task can be divided down, the interviewer can watch the tasks being performed, and then PV makes decisions. The notion of cognitive load provides various classifications of cognitive load, including the effort for working memory. There are three categories of cognitive load:

1. Intrinsic (consist characteristics of information)

2. Extraneous (how the information is present to the user)

3. Germane (construction of schemes, pattern)

Based on the above cognitive load theory and contextual analysis PV cognitive service works.

b) Development of Cognitive Service

1. Particular annotated corpus: Data for teaching cognitive skills are included in annotated corpora. Find out the value of Investigators Brochures (IB), Summary of Product Characteristics (SPC), and Prescribing Information when ICSRs are chosen. Other factors to consider include report type, country, number of reported terms, the seriousness of ICSRs, seriousness of AEs, and the severity of reported terms (PI).

2. Creating and allocating an annotated corpus: A specific corpus is created in electronic format, all manual data is converted to machine-readable form, and each item is tagged using a manual annotation procedure. Following the creation of an annotated corpus, sets are separated into training data to impart cognitive service, tuning data to raise service parameters, and testing data to provide error feedback. Creating annotated corpus prediction performance contributes to a better understanding of true performance.

c) Measuring Performance

Positive predictive value (PPV), a measure of precision, is the capacity of a cognitive service to properly identify components. However, there is a chance that even with very high precision, not all elements may be accurately preserved. Precision is what translates a service that frequently returns false negatives (FN).

When all of the findings are correctly identified, the recall is referred to as sensitivity. However, high recall carries the danger of causing false positives in the service (FP). The F1 score, which is frequently used to assess machine learning algorithms, combines precision and recall measurements. True positive and predicted positive are true positives, while true negative and real negative are true negatives.

d) Validation of Cognitive Service

AQL is applied to production sampling. A batch of items provided by the supplier were being inspected by the buyer at the time using the AQL procedure. To apply the AQL approach, one must first determine what needs to be measured. TPs are used to determine whether cognitive services produced high-quality outputs; if PV idea classification was inaccurate, TP will produce incorrect outcomes. The following phase in the AQL process is tolerance, which takes into account the lowest cognitive service quality, fault categories, and tolerance %. The suitable level, which has I, II, and III levels, is examined in the following AQL phase. Level I is utilised for distinction, and Level III is for powerful binding. The number of TPs in the annotated corpus determines the lot size, the final parameter of AQL considerations.

E) AQL for PV Cognitive Service

PV SME (Subject Matter Experts) assess errors when developers produce results for cognitive service that have an F1 score below 75%. The PV SME analyses the TP result when the F1 score is more than 75%. If there were fewer than 150 TPs, PV SME should assess each TP individually for high-quality service; however, if there were more than 150 TPs, PV SME should randomise TPs, choose the proper AQL for a sample of TPs, and then review the findings. However, in all situations, the TP mistake must be less than 4% before the service is passed; if it is not, the developer is then sent back for additional instruction. If inconsistent ground truth prevents a cognitive service from being successfully trained, another alternative is to correct the annotated corpus or reannotate new training data. Since DD coding is a recognised global standard for prediction, who- uses it as a source of ground truth? Annotations would generate a significant difference between predictions if they were employed as ground truth. Therefore, the reviewer used metadata to compare the predictions to the actual data. Multiple seriousness parameters that describe the seriousness of AEs are combined with annotation and metadata.

F) Cognitive Service Applications of the Validation Framework

1. A cognitive service reviews, checks the accuracy of, and provides feedback to developers for improving models created by a machine learning (ML) service using a sample of fresh data.
2. Safely transfer files while protecting personally identifiable information and health information.
3. Due to an emphasis on task or data gathering and a concentration on healthcare issues, AI automation is becoming more common in PV.
4. The PV industry needs a long-term fix for an unmanageable amount of ICSRs, therefore AI offers fantastic patient advantages in the process.
5. To reduce cognitive load, 51 decision points were found to be related to data ingestion, data gathering, and data collation of ICSRs case management by AI in PV chain.
6. AI in PV utilised the AQL approach for reliable and consistent outcomes.

AI'S PART IN PV IN THE 21st CENTURY

Real-world evidence shows that AI is at least a part of the solution for many critical and life-threatening diseases, not just malignancies. PV must thus develop sure plans for other diseases. Patient-level data from individual customers is not always the same as validated data in the big data outcomes world because AI is a source that generates electronically useful healthcare data. PV operations are essential for modernising the post-marketing surveillance of biosimilars in the twenty-first century. The first AI strategy for PV is to create a new epidemiological concept based on knowledge of the distinction between the terms "generic" and "biosimilar." By creating actionable evidence on effectiveness and safety, AI will help to fill in the gaps that now exist in the PV ecosystem. Herbert Simon defined "design thinking" in the artificial sciences as the "Transformation of current conditions into preferred ones." AI-developed critical thinking is the analysis of ideas with a strong emphasis on action. At a recent conference, Dr. Donald Therese stated, "The danger is not that we will discover new information, but rather that we will become overwhelmed with our current capacity of subpar information." To effectively address the demands for PV data in the twenty-first century, this question emerges. AI is already in use in many healthcare fields, including as the building of treatment programmes and the management of drugs in electronic health records. In genomics and genetics, AI has the most influence on detecting patterns, mutations, and linking illness. However, in order for our information to be useful, it must demonstrate the analytical process used to reach a result, but access to confidential data limits this. [7]

NEED OF AI IN THE REAL-WORLD OF PV

A significant problem for professionals in PV is the growth in volume of data, the prevalence of unstructured data, and the speed of data refreshers. In a report on medication safety published 20 years ago, the US Institute of Medicine claimed that "To err is to be human" and called for a renewed emphasis on eliminating avoidable errors for patient safety. Patient safety can unquestionably be improved with the appropriate data methodologies, processes, and technologies. Unsupervised pattern recognition can find groups of AEs, like symptoms of a condition. Finding a correlation between prior properties to some extent in real-world data is made possible by supervised pattern recognition[8]

NEED OF AI FOR DRUG TOXICITY AND SAFETY IN PHARMACOVIGILENCE

Pharmacovigilace and safety standards will take into account polypharmacy, pre-clinical drug safety, and post-marketing surveillance; as a result, ML and DL will be used. From 2008 to 2017, 321 new medications were approved by the FDA. The FDA Adverse Event Reporting System (FAERS) collected 10 million AE reports during that time, of which 5.8 million were serious reports and 1.1 million were associated to fatalities. Assessing AE reports for the most recent data on drug safety after a new medicine has been licenced but before it has undergone clinical trials, confirming that it is safe, and then being sold is a PV task.

However, it is impossible to examine every drug's effect and evaluate adverse events in populations. As a result, agencies now indiscriminately access databases of AE reports and do follow-up analyses. Medication toxicity is the detection of adverse effects of drug components on people, animals, and the environment. This is a crucial phase in the design of drugs, which is why pre-clinical testing of drugs is carried out prior to entering clinical trials. Target-based prediction and QSAR are methods for evaluating toxicity. PV makes use of NLP neural nets with features like multi-task learning and attention processes. They have recently used chemoinformatics to predict ADEs using annotated datasets. GANs (Generative Adversarial Network) type of ML model is used to create a drug safety in silico molecule with its own desired chemical properties [9]

SOFTWARE

Open-source toxicity prediction tools Targe Tox and PrOCTOR are employed. The nearest protein bound to the medication is determined using TargeTox data that detect protein targets and boosting gradients that reveal toxicity scores. TargeTox can therefore produce toxicity predictions and data on protein networks.

The target-based toxicity prediction programme PrOCTOR also forecasts the score for chemical characteristics. In comparison to TargeTox, it includes many more features, including 48 variables, 50 decision trees, and outcome prediction.

To forecast toxicity, it can make use of a variety of target- and structure-based factors.[10]

ii) Post-Marketing Surveillance: The WHO-UMC system, Venulet algorithm, and Naranjo algorithm are some of the traditional approaches for evaluating and assessing AEs. Because FAERS cannot be used as mining techniques to identify AE's in post-marketing PV, AI methods are required to extract information.

iii) The diagnostic process, medication codes, ongoing lab tests, semi-structured and unstructured medical reports, and notes are all included in the third category of EHR mining.

iv) Zhao assign nine methodologies for using medications, diagnoses, and measuring variables for ADR prediction using structured HER data. The bayesian approach simulates the impact of prescription and primary care data on drug users. The ability to efficiently pre-process structure data for ML and DL algorithms is a huge benefit.[11,12]

v) Preclinical toxicity: To forecast drug toxicity and provide information on the mechanism of action, ML algorithms are used to analyse models at low levels of complexity. Consider logistic regression.
vi) Postmarket safety: A high degree of complexity DL algorithm utilised in Postmarket safety is employed for clinical decision making and safety evaluations. Cnn, RNN, etc.
Traditional used ML includes logistic regression, random forest, support vector machines which are developed currently into a deep neural network to understand how predictors affect the risk of AE[13]

Innovative methods in AIPV

Since no AE was found in any clinical trial, AE identification was done by a PV expert. AIPV aids in the collecting of qualitative and quantitative data and its evaluation by ML algorithm. The industrial revolution and the biological world are significantly impacted by AI utilised in PV. A specific patient's AE is caused by a medicine and is noted as an ICSR, with all drug data gathered and compiled by a PV expert. DL can combine the data to produce logic output [14]

The Global Drug Safety and Risk Management (GDSRM) programme of Celgene was established as an avant-garde use of the ML algorithm used in PV. Because EMR offers digital signature and encryption, it is practical to utilise as a source of information because it automates the critical thinking process based on action-oriented ideas. AI utilised in PV to reduce risk by detecting AE from previous data.[15,16]

PV with AI A person's autonomous intelligence can be divided into eight different categories, including verbal-linguistic, visual-spatial, mathematical-logical, kinaesthetic bodily, and interpersonal intelligence, according to psychologist Gardner. A broad word, AI, refers to computer science, which also encompasses ML and DL. ML comes in three flavours, including reinforcement learning, unsupervised learning, and both. ML's traditional form is called "grey literature" [17,18]

Different characteristics of ML and Non-ML

ML	Non-ML (Statistical analyses, models)
Split data for testing, signify, classification, prediction.	Signify interference, p-value, interpret relations between variables, analyze the dataset.
Design for external hyperparameter before training use not from data estimated.	Direct model parameter estimated when parametric distribution occurs in model based on Bayesian model.
Arrange big data with millions of parameters	Arrange small to moderate sizes with a limited number of parameter datasets
Represent automated feature	Represent manual feature
Performance improvement has many more chances such as running time, hyper parametric tuning	By increasing sample size, performance improves.

AI APPLICATION

By early disease diagnosis from patient electronic footprints, AI lowers the likelihood of fatality.

Cyber-attack may cause serious health issues of an individual like heart hacking stimulators, death of a person may occur. Hence, implementation of regulation framing produces safe and effective use of AI in healthcare.[19]

BENEFITS OF AI IN PV

GPS (Gamma Poison Shrinkage) is employed for the identification of spontaneous reporting signal.

Signal detection can also be done using the information component. Changes from medical experts, dentists, doctors, patients, literature reviews, and social media are sources of data gathered by cognitive services.[20, 21]

Since the thalidomide catastrophe in 1961 necessitated earlier AE identification, it takes almost two years for Australian obstetricians and germen doctors to recognise the adverse consequences of phocomelia. The WHO creates rules to stop similar catastrophes because of this.

 The spontaneous reporting system (SRS) is used to quickly identify data points electronically because they are challenging to find through manual investigation[22,23]

IMPLICATIONS OF AI IN PHARMACOVIGILANCE

The role of pharmacovigilance in healthcare is crucial and indispensable. The application of artificial intelligence (AI) in this industry, however, is still a young and developing sector. The availability of organised and curated data for training the software to detect potential medication safety hazards is one of the major obstacles to using AI.[24]

Using AI for pharmacovigilance raises privacy issues as well because data may be utilised for other reasons without the participants' consent.[25]

CONCLUSION

Artificial intelligence can be used to treat a variety of illness states and enables for the processing and analysis of massive volumes of data automation and machine learning models can optimize pharmacovigilance processes and provide a more efficient way to analyze information relevant to safety, although more research is needed to identify if this optimization has an impact on the quality of safety analyses. It is expected that its use will increase in the near future, particularly with its role in the prediction of side effects and ADRs.

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UNDERSTANDING POTENTIAL OF ARIFICIAL INTELLIGENCE IN AGRICULTURAL SECTOR TO FARMERS: A CONCEPTUAL REVIEW

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ABSTRACT

The utility of artificial Intelligence (AI) has been evident inside the agricultural boundaries currently. The arena faces numerous challenges on the way to maximize its yield which include wrong soil treatment, disorder and pest infestation, massive statistics requirements, low output, and knowledge gap between farmers and generation. The emerging concept of AI in agriculture is its pliability, high overall performance, accuracy, and price-effectiveness. This paper affords a assessment of the packages of AI in soil management, crop management, weed management and ailment management. A unique awareness is laid on the electricity and Barriers of the utility and the way in using expert structures for higher productivity. This article gives a brief evaluation of new technologies based on synthetic intelligence and the way it's far currently being utilized by research scientists and extension professionals to address issues of agricultural manufacturing and management in India. With the development in synthetic Intelligence (AI) era, farmers can monitor the nicely-being of their vegetation or the movement of their animals with out going into their farm making the farming less labour-extensive, and extra efficient. This article has referred to some AI-based intervention in Indian agriculture and highlights the function of agricultural extension in assessing the technologies.

Technological twins may even end up an important paradigm to enhance how records about farm entities is organised to help decision-making. There are also possibly to be bad impacts from AI, which include disruption to the jobs and capabilities needed from farm workers, indicating the want to don't forget the social and ethical influences of AI every time a new functionality is introduced. At the end knowledge is that challenges more deeply tends to highlight new possibilities for wonderful alternate.

Keywords: agriculture, soil management, artificial management, labour-extensive, vegetarian, technological twin

INTRODUCTION

Using AI for intelligent spraying of chemicals – Brings in cost savings

Every day, farms generate thousands of data points about temperature, soil, water usage, weather conditions, and so on. This data is used in real-time by artificial intelligence and machine learning models to gain useful insights such as determining the best time to sow seeds, determining crop choices, hybrid seed selection to increase yields, and so on.

Using AI-based robots for farm harvesting – Tackling the labor challenge

Did you ever wondered who harvests the crops from the agricultural land? In most cases, robotic machines capable of bulk harvesting with greater accuracy and speed are responsible for getting the produce on your kitchen table rather than traditional farm workers. These machines aid in increasing yield size and reducing waste from crops left in the field.

Many businesses are working to improve agricultural efficiency. There are products such as a self-picking strawberry machine1 and a vacuum apparatus that can harvest mature apples from trees. These machines use sensor fusion, machine vision, and artificial intelligence models to locate harvestable produce and assist in fruit select.

Agriculture is the second-largest sector after defence in terms of the deployment of service robots for professional use. According to the International Federation of Robotics, approximately 25,000 agricultural robots have been sold, trying to match the number used for military applications.

Using AI for predictive analytics – Enables right decision-making

Making predictions the appropriate time to sow

The difference between a prosperous year and a failed harvest is simply quick and efficient information on a simple data point of seed sowing timing. To overcome this, ICRISAT scientists used a forecasting analytics tool to determine the best time to sow the seeds for maximum yield. It also provides information on soil health and fertiliser recommendations, as well as a 7-day weather forecast.

Crop Yield Estimates and Price Forecasts

The biggest concern for many farmers is crop price volatility. Farmers are unable to plan a consistent production pattern due to volatile prices. This issue is especially prevalent in crops with short shelf lives, such as tomatoes. Companies are assessing acreage and monitoring crop health in real time using satellite imagery and weather data. Companies can detect pest and disease infestations, estimate tomato output and yield, and forecast prices using technologies such as big data, AI, and machine learning. They can advise farmers and authorities on future price patterns, sales levels, crop types to sow for greatest advantage, herbicide use, and so on.

Artificial intelligence is being used in agriculture by creative businesses. A Berlin-based agricultural technology start-up created a trilingual plant disease and parasite diagnosis and treatment app that uses images of the plant to find diseases. A handset gathers the image and compares it with a http image, which then provides a diagnosis of that specific disease that is then applied to the crop using erudite sprinkling approach. In order to address plant diseases, the programme makes use of Ai technologies. This app has been downloaded by over 7 million farmers and has assisted in the detection of over 380 agricultural diseases in field crops, fruits, and vegetables.

To give a brief, AI alleviates the shortage of resources and labour to a significant degree, and it will be an effective tool that can support institutions in dealing with the growing complexity of contemporary cultivation. It is past time for multinational businesses to invest in this area.

Can AI technology replace the information that growers mostly have? The probability is no for the time being, but in the coming days, AI will supplement and confront the way choices are made as well as improve farming techniques. Such advanced technologies are likely to result in better farming methods, yields, and a qualitative improvement in farmers' lives.

Challenges faced by farmers by using traditional methods of farming

Identifying introduced challenges in the agriculture field.

In agriculture, meteorological conditions such as rainfall, temperature, and humidity all play a role in the agricultural production lifecycle. Climate change is being caused by increased deforestation and pollution, making it difficult for farmers to make decisions about how to prepare the soil, sow seeds, and harvest.

Every cultivation necessitates a distinct type of nutrition in the soil. Soil requires three major nutrients: nitrogen (N), phosphorus (P), and potassium (K). Nutrient deficiency can result in poor crop productivity.

o Weed control is critical in agricultural production, as evidenced by the agriculture lifecycle. If not monitored, it can raise production costs and absorb nutrients from the soil, going to cause micronutrient deficiencies.

PURPOSE

Agriculture is comprehensive compliance to AI in its numerous agricultural systems. The advanced analytic idea is one that uses human brain processes as a model desktop. This results in a tumultuous technology in Automation agribusiness, providing its facility in analysing, obtaining, and responding to various situations (based on the acquired learning) to improve efficiency. Farmers can be offered solutions via platforms such as conversational agents to reap benefits in the field by keeping up with recent advancements in the farming sector.

In India, Microsoft Company is currently working with 175 farmers in the state of Andhra Pradesh to provide services and solutions for land preparation, sowing, fertiliser addition, and other crop nutrient supplements.

Also with advancement of technology in this virtual environment, we individuals have compelled our cognition to its limit and are attempting to merge a functional brain with an artificial thing. This ongoing investigation gave birth to a completely new field of study known as artificial intelligence. It is the process by which a human can create a machine that is intelligent. AI is classified as a scope.

A branch of data science that can recognise its environment and thrives to gain maximum its chances of accomplishment. AI should have been capable of executing tasks based on prior knowledge. Machine learning, CNN, ANN, and machine learning are examples of domains that enhance machine work and assist in the creation of more modern technology.

IOT is described as "idea to idea communication. The three main goals of the system are interaction, mechanisation, and cost reductions. Dr. D.K. Sreekantha, Kavya.A.M discusses with an in implementation of IOT in crop production and how it can environment for people.

AI has made inroads into science and medicine, training, financial management, food production, business, stability, and a variety of other fields. AI implementation entails a computer learning experience. This brings us to the "Machine learning" comment thread of the AI field. Machine learning's primary intention is to feed the machine information accumulated from previous perceptions and statistical evidence so that it can conduct its given tasks of resolving a specific issue.

Bacall to Adopt AI in Agricultural

Artificial intelligence has enormous potential in agriculture, although there is still a lack of information when it comes to enhanced advanced technologies.

Agriculture uses machine learning technologies. Farming is heavily influenced by external factors such as soil types, climate, and parasite outbreak vulnerability. When harvesting begins, the scheduled crop raising schedule at the start of the season may not show up to be favourable because it is influenced by external factors.

The AI system requires a large amount of information to instruct the machinery and equipment and predict correctly. It is simple to collect spatial data when there is a large amount of land suitable for cultivation, but it is more difficult to collect digital information. It is also difficult to create experience and understanding rules and place them in the sorted position for a large number of variables. Various crop specific statistics could only be acquired once every year, when the crops are being produced. Since it requires awhile for the data set to grow, it takes a significant amount of effort to build a rigorous Artificial intelligence - based Ml algorithm. This is the primary reason for the use of AI in agricultural commodities such as herbicides, herbicides and pesticides, and crops.

An even more deciding factor is the high cost of many application or product for agribusiness that are widely available in the marketplace. Machine learning alternatives must be more

attainable in order for the technique to have an influence on the farming town. If AI yielded positive are available on an open network, they will be more affordable, leading to initial acceptance and effectively understanding among farmers.

LITERATURE REVIEW

1.1McKinnon.(1985) A variety of farming techniques will ultimately produce efficient crop productivity, a reason why the improved agronomic sector was created. This will additionally be determined by the kind of crop and the weather conditions of adjustment. Mackinnon and Lemmon introduced the application of Ai systems in agricultural production for the initial period in 1985. Several agrarian methods were also used, with an emphasis on alongside crop substance, biomedical, and sustainability issues with both qualitative and numerical objectives . Crop awareness has gained traction in a wide range of research fields, including botanic garden and organisms creation.

Various elements of plants, like seeds, roots, stems, peonies, leaves, and fruit and vegetables, can be used to classify and identify different species.

Leaves vegetation acceptance appears to be the greatest general method for analyzing leaves properties like as appearance, structure, and shading . Plant productivity is more important from a business standpoint, and it is strongly influenced by weather circumstances, soil properties, growing conditions, and agricultural production properties. Higher-quality agricultural commodities have a relatively high sale price and revenue. Fruits quality, firmness, and skin tone are the variables used for cultivation . Farmers can combine possible approaches and techniques to deal with the water shortage dilemma. Drought duration, amplitude, and prediction are critical factors in deciding between options . AI cultivation uses physical devices, detectors, visual acuity monitoring devices, three dimensional image analysis, and a deceiver control method.

1.2Batchelor et al. (1989) describe the soybean crop development design, SMARTSOY, in the article, and the design is SOYGRO is a brand name. The design amylase by an experience and understanding strategy, which is separated into two methods: the objectivist strategy, which indicates that it tries to recreate the procedures of technical people in to arrive at a conclusion, and the behavioral approach, which tries to recreate the findings but exclude the procedures of technical people. Pest destruction is ascertained using a structured method for estimating loss prices and budgetary control. The empiricism and humanistic perspectives coincide here so ... the second approach human immunodeficiency virus (hiv in pesticides preference and method of application.

Moreover, the comprehensive plan is ineffective in determining the pest loss price on output. This is a significant disadvantage for producing suggestions since crop productivity is estimated by immediately preceding experiences with comparable sucking pests, herbicides had to use, and agriculture results in the last. The objective is to produce suggestions for soybean oil crop production based on a computation of the loss price and the cost of repairing the flower and growing gain. Both strategies turn up at this computation.

1.3Prakash et al. (2013) A professional framework Prakash et al. created PRITHVI, a multi - paradigm system, in Rajasthan, India (2013). The framework was specially formulated for the Soybean yield. This framework gathered its skill set from agrarian deputies, journal articles, and soybean yield experts. Technique was used to examine the entire framework and recommend the producer as an analyst. PRITHVI was broken down into five blocks.

The primary goal of creating this optimization method was to assist growers in the area in raising one‘s crop yields. As a user interface subsystem, the design makes use of MATLAB.

1.4Roach et al. (1987) Scientists have created an intelligent model that recommended growers on how often to sprinkle pesticides on citrus fruits to prevent mosquito and stratospheric harm. POMME was the name assigned to the system.

In addition to the time, it recommended the growers on what to spray. In POMME, the cirtrus fruit clot illness circulation framework was used rather than predicted ones from the contagion chart. The program's results are accurate, and the framework was accepted by the specialists who tested it.

1.5Ravichandran and Koteshwari) Researchers Ravichandran and Koteshwari trialled a method that indicates utilising ANN techniques for yield estimation in mobile phones in 2016. A predicting model was created. As said before, this program's forecasting model consisted of three layers. The model's effectiveness was determined by the amount of convolution layer. To start, the ANN was developed and instructed utilising different algorithm such as Silva and Almeida's methodologies, Delta-bar-delta, Rprop, etc to pick the most suitable layout. The testing method was employed to determine the hidden layers. Because the forecasting system's accuracy is dependent on the amount of convolution layer, there should be a practical method to investigate the choice of such convolution layer. The study finds that the deeper the concealed strands in the ANN model, the further precise the forecasting. In 2016, researchers Ravichandran and Koteshwari trialled a technique that indicates using ANN methods for crop prediction in cellular telephones. A forecasting model was developed. As previously stated, the prediction algorithm for this programme was divided into three layers. The quantity of fully connected layers determined the model's efficiencies. To begin, the ANN was created and advised to pick the best layout using machine learning such as Silva and Almeida's techniques, Delta-bar-delta, Rprop, and others.

1.6Arif et al. (2012) Two ANN models were developed to measure moisture content in agricultural land with substantially fewer weather conditions. The measured and calculated moisture in the soil values were then utilized to cross - check and verify each of these concepts. To evaluate ET, the first ANN model was developed. The minimal level, normal, and air mass temperature and time were used. Data on solar radiation, precipitation, and thermal gradient were accumulated to establish the second model. These two models generated the statistics on ambient temperature was also collected. These two concepts generated reliable and precise forecasts of moisture content in agricultural land while involving the lowest amount of weather conditions, human labour, and duration.

1.7Keshtgari and Deljoo, (2012) Smart farming and WSN software merge an intriguing new research area which will significantly improve farmland production quality, accuracy water management, and therefore will result in enormous cost savings. Moreover, the convenience of implementation, building systems, and tracking make it possible for WSN devices to be acknowledged in smart farming. We are using the methodological approach to determine the best detector configuration, reducing application costs while also rendering WSN an even more attractive remedy for all kinds of crops and crop production.

1.8Wall and King (2004) Created an intelligent framework that governed sprayer vents using humidity and temperature sensing devices in the sector. Moreover, this framework omitted to take into account the challenge of water smog or agricultural sectors.

1.9Gutiérrez et al. (2014) Managed to come up with an irrigation control method that employs the GPRS device as a transmission medium. The system is integrated into a microchip router that regulates the amount of water. It was demonstrated that the water requirement were 90% larger than the traditional irrigation purposes.

1.10Kim et al. (2008) A decentralised wifi router was used to detect and control the application of water from a distant area.There is a need to shift toward new technology known as the Internet of Things in order to increase efficiency, market system, and to decrease human interference, duration, and expenses. The Web of Things (IoT) is a group of devices that transfer signals alone without participation of individuals. As a result, in the goal of achieving high efficiency, IoT collaborates with farming to achieve precision agriculture.

CONCLUSION

Agrarian surveillance is essential for minimizing human interference in discipline. Food demand is increasing on a daily basis, and without the use of advanced agronomic practices, it will be difficult to meet the rising demand. Agrarian surveillance is of primary importance because it aids in labour reduction and production increase. Artificial intelligence has been used in agricultural inputs and to assist farmers in nutrient management choice. The machine communicates among itself to ascertain which harvest is appropriate for cultivation in addition to the herbicides and pesticides that encourage substantial growth using the data set that the operator has accumulated and stipulated to the structure. Reinforcement learning has a diverse range of uses The industry has made tremendous progress. Reinforcement learning has an advantage over computer vision and adds depth to ml algorithms. Many important techniques exist to provide growers with good harvests and extensive field strategic planning. As meal constitutes the most basic need of any living thing being, this significantly enables to the nation's overall economic growth. IoT demonstrated its importance by assisting in actual data surveillance. The Internet of Things is primarily used in smart drip irrigation systems.

Even though effective use of freshwater resources is crucial, and with technological advances and the implementation of mechanisation, the water problem can be resolved. In today's world, conventional farming techniques have little impact. Water scarcity and flooding are both major issues Many flaws in this framework, combined with an urgent need to safeguard farmland, resulted in the creation of agrarian mechanisation. This report comprises a concept for designing a system utilising detectors, Cloud computing, and deep learning to computerise ancient traditions in crop production.

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ROLE OF ARTIFICIAL INTELLIGENCE IN MODERN HEALTHCARE& CHALLENGES IN ITS INTEGRATION AND GOVERNANCE

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(1) ABSTRACT

The researcher aims to identify the role of Artificial Intelligencein the modern healthcare sector along with possible challenges which can hinder the integration of Artificial Intelligence in the Healthcare Sector. Also, the researcher aims to identify the legal framework governing AI in India.

Initially, the study focuses on the concept of Artificial Intelligence having great potential for development. However, it is right to state that the integration of AI in Healthcare has alarmed the Govt. to provide for strict governance of this intelligent system for the fair and transparent use of technology. Further, the researcher addresses the ethical, social, and legal challenges in the governance of Artificial Intelligence in India. The common application of AI in the health sector involves – patient diagnosis, transcribing medical documents, improving patient and physician communication, remotely treating patients, and many more, and with this, there are speculations that the time is not far when humans will be completely replaced with robots in medical sciences. Also, one of the major benefits of the integration of AI in healthcare is that computer algorithms have achieved accuracy and are at par with human experts. In today's era, Artificial Intelligence is used comprehensively in medical sciences for the collection of extensive data from patients that could help doctors to maintain the medical history of the patients for enabling the doctors to yield better information and results. Though it is right to state that integration of Artificial Intelligence in healthcare can yield promising development much remains to be done when it comes to the legal framework for governing artificial intelligence in India. The Government, medical industries, startups, technology firms, investors, etc. need to come together to create a strong system that provides for the integration of AI in the healthcare sector in India as without the integration of the stakeholders it would be impossible to achieve the true potential of Artificial Intelligence for the humans. Hence the researcher aims to discuss how artificial intelligence is changing the landscape of medical science and to separate hype from reality thereby discussing challenges in its governance.

(2) INTRODUCTION

In today's era,Artificial Intelligence in the healthcare sector have been investigated from a multi-disciplinary perspective and therefore this sector is receiving attention from the government, researchers, physicians, tech developers, investors, and consumers in term of its innovation potential. Although the first attempt was made long back in the 1950s by physicians to improve diagnoses using computer-aided programs, the recent trends in this area show that this field is emerging and there is the rise of AI in the Healthcare sector all across the globe.The major aim of Artificial Intelligence applications is to determine the relationship between medical techniques & patient outcomes. The healthcare sector coupled with Artificial Intelligence supports physicians in diagnosis, predicting diseases, customized treatments, health service management, securing patient data, predictive medicine, clinical decision-making, etc. As a result, Artificial Intelligence is gradually changing medical practices and decision-making processes. Major hospitals, at present, are using Artificial Intelligence enabled systems to equip medical staff in patient diagnosis and treatment for a wide range of diseases.AI-supported technologies display results using a large volume of medical research data and patients' treatment records and play a significant role in the decision-making process for diagnoses of the disease and its treatment. It is also observed that Artificial Intelligence technology can diagnose

diseases more accurately and efficiently than a professional because of its prediction based on large research data and knowledge.

While Artificial Intelligence is being embraced positively, it is important to note that its application provides both new opportunities and challenges to overcome hence there is a need to provide a balanced view of the use of AI-enabled devices to value the application of Artificial Intelligence in the healthcare industry. Some noteworthy challenges involved in Artificial Intelligence enabled devices comprise data infringement, privacy infringement, cybersecurity, data ownership, data sharing with various organizations, infringement of medical ethics, medical errors, risk of system failure, etc. Moreover, AI-based technologies and their application in the healthcare industry are still dubious for their universal absence which alarms the need to analyze the use of AI-enabled devices and their application in the healthcare industryto decide the future course of action.

(3) Recent Trends in Healthcare Sector in India

According to the research reports, "India produces only about 50,000 doctors a year which is not enough to meet the minimum standards. To get to the World Health Organization's recommendation of a doctor-patient ratio of 1:1000, India will need 2.3 million doctors by 2030." Hence, it is proposed that the adoption of AI in the healthcare industry can bring about a significant change and help in reshaping the Indian healthcare market. Therefore, it is right to state that Artificial Intelligence is an emerging & promising sector in the Indian healthcare industry. The competence of Artificial Intelligence will enable the healthcare industry to deal with an uneven ratio of doctor-patient in India. Further, the adoption of Artificial Intelligence will help provide quality healthcare services in rural areas and educate doctors and nurses to deal with complex medical mechanisms more efficiently. Therefore, the adoption of AI can help reshape the Indian healthcare industry significantly. Global health emergencies like the Novel Coronavirus pandemicbrought about a big spotlight on the healthcare industries of countries around the globe and called for a structural shift towards digital healthcare. The pandemic made every country realize that it's high time for them, including India, to reboot their healthcare sector to enable the use of AI to enable devices in the sector and to support health startups. With this structural shift, the Indian startup ecosystem has experienced significant growth in recent years and is among the top list of the nation to have achieved millions of funding for tech startups focused on innovation and service. The Indian Government has also been stepping up to put efforts to close the gaps between the healthcare sector and technology with the "Digital India" initiative. The government has started the Digital India program to make India a knowledge-based economy and a society that is empowered by technology by ensuring digital access, empowerment, and closing the digital divide. According to the reports of the Department of Industrial Policy & Promotion Indian healthcare sector is the fastest-growing sector of the country and is expected to generate 40 million jobs by 2030.

The Govt. of India is working hard towards the integration of Artificial Intelligence & Healthcare in India to provide opportunities to solve its long-existing challenges in terms of proving significant medical facilities to a massive population. Further, the Government has also taken initiative toward the digitalization of health infrastructure. For Example – Digital Health Locker, Ayushman Bharat Scheme, etc.The integration of Artificial Intelligence in the health sector has resulted in great collaboration between the Govt. & Technical Establishment and traditional medical service providers. For Example – The collaboration of NITI Aayog with, Microsoft & startups, MOU signed between Maharashtra Govt. & NITI Aayog to establish International Centre for Transformational Artificial Intelligence etc.

(4) Role of Artificial Intelligence in the Healthcare Sector

With the advancement of Artificial Intelligence in the healthcare sector of the country, a rapid change in terms of opportunities and employment has been seen. AI and robotics have

revolutionized the world by opening remarkable opportunities in the healthcare sector. Everyday, professionalsinthe healthcare industry, researchers, and even patients generate vast data with the help of AI to enable devices to improve health, therapies, and medical practices. Hence, it is right to state that Artificial Intelligence has bought a revolutionary change in the healthcare industry. However, the work done by humans can not be replaced completely by AI-enabled devices because of the possibility of electronic errors and the risk of machine failure.

The major aim of Artificial Intelligence applications is to

- Diagnosis & decision making
- Early detection & keeping well
- AI-assisted medical diagnoses
- AI-assisted robotic surgery
- Medical image analysis
- Medical risk prediction
- Clinical trials
- Drug discovery
- Medical data security
- Automated workflow assistance
- Fraud detection
- Virtual nursing assistants
- Research & Training etc.

The healthcare sector coupled with Artificial Intelligence supports physicians in diagnosis, predicting diseases, customized treatments, health service management, securing patient data, predictive medicine, clinical decision-making, etc. As a result, Artificial Intelligence is gradually changing medical practices and decision-making processes. Major hospitals, at present, are using Artificial Intelligence enabled systems to equip medical staff in patient diagnosis and treatment for a wide range of diseases. AI-supported technologies display results using the large volume of medical research data and patients' treatment records and play a significant role in the decision-making process for diagnoses of the disease and its treatment. It is also observed that Artificial Intelligence technology can diagnose diseases more accurately and efficiently than a professional because of its prediction based on large research data and knowledge.

Artificial Intelligence (AI) has the potential to transform healthcare in various ways. It can turn large amounts of patient data into actionable information, improve public health surveillance, accelerate health responses, and produce leaner, faster, and more targeted research and development.More specifically, AI in healthcare can support physicians; automate clinical documentation and image analysis, as well as assist with virtual observation, diagnosis, and patient outreach. Access to quality healthcare in developing countries, particularly in rural areas, is often a challenge that AI technologies have the potential to alleviate. In India, rural populations may lack even basic healthcare facilities. Health technologies can help resolve these disparities and reach underserved populations. India is in a unique position to be a leader in the AI and healthcare space, with large amounts of data and a growing start-up community specializing in harnessing AI to diagnose disease.

(5) Challenges in the integration of AI into healthcare and its governance

The healthcare industry in India is made up of various segments, including hospitals, pharmaceuticals, diagnostics, medical equipment and supplies, medical insurance, and telemedicine. The application ofArtificial Intelligence is becoming widespread in the healthcare sector for its efficiency in early-stage disease diagnosis and its possible treatment but its nature is restricted in a sense of its inability to perform major attributes of human nature. Moreover, one of the major requirements of Artificial Intelligence integration into the healthcare sector is public health data but the said data itself is one of the potential risk factors. The AI-enabled devices require a large amount of data to give accurate results and therefore the integration of Artificial Intelligence into Healthcare cannot be considered an end and the efficiency of professional human physicians to detect possible mistakes of AI-enabled devices cannot be replaced. Artificial Intelligence should be integrated to support the healthcare sector in decision-making and not automate the decision-making process. That is to say that AI-enabled devices should not be developed to replace primary healthcare. Challenges and risks involved in the integration of AI in Healthcare exist around the globe as digitization practices are defective and not standardized. The data are readily available for Artificial Intelligence companies likely to be aberrant. Certain noteworthy challenges involved in the integration of AI& Health sector remain constant i.e., data infringement, privacy infringement, cybersecurity, data ownership, data sharing with various organizations, infringement of medical ethics, medical errors, risk of system failure, etc. Moreover, AI-based technologies and their application in the healthcare industry are still dubious for their universal absence which alarms the need to analyze the use of AI-enabled devices and their application in the healthcare industry to decide the future course of action.

Potential concerns around the integration of Artificial Intelligence into Healthcare include

- Lack of technological infrastructure in India
- Infringement of Doctor-Patient confidentiality
- Infringement of Medical Ethics
- Data & Privacy Infringement
- Algorithm error & unfair outcomes
- Cybersecurity
- Data Ownership
- Lack of Accountability

In India, there are gigantic challenges for the health sector in the integration of Artificial Intelligence in terms of accessibility, affordability, and quality. On the positive side, India has the best hospitals in the world resulting in the growth of the medical tourism sector whereas on the other hand, unavailability and shortage of qualified medical professionals, particularly in the rural areas, disturb the actual potential of the health sector in India. Although the said shortcoming can be overcome by the integration of Artificial Intelligence in the Health sector the lack of legal framework for the governance of AIalarms the need to analyze the use of AI-enabled devices and their application in the healthcare industry to decide the future course of action.

While there is considerable literature emerging on various aspects of AI, governance of AI is a significantly underdeveloped area. The new applications of AI offer opportunities for increasing economic efficiency and quality of life, but they also generate unexpected and unintended consequences and pose new forms of risks that need to be addressed. To enhance the benefits of

AI while minimizing the adverse risks, governments worldwide need to understand better the scope and depth of the risks posed and develop regulatory and governance processes and structures to address these challenges.While the technology can yield positive impacts for humanity, AI applications can also generate unexpected and unintended consequences and pose new forms of risks that need to be effectively managed by governments. As AI systems learn from data in addition to program rules, unanticipated situations that the system has not been trained to handle and uncertainties in human-machine interactions can lead AI systems to display unexpected behaviours that pose safety hazards for its users.

(6) CONCLUSION

At present,there are no laws governing the regulation of AI in India and therefore despite the well-acknowledged potential of AI there are significant challenges that hamper its adoption. Responsibility and liability for harm resulting from the use of AI applications remain ambiguous under many legal frameworks. Further, The autonomous nature of AI systems presents issues around the potential loss of human autonomy and control over decision-making, which can yield ethically questionable outcomes. To enhance the benefits of AI while minimizing the adverse risks they pose, governments worldwide need to understand better the scope and depth of the risks posed.While there are increasing speculations about its danger and its benefit, there is little empirical research to substantiate them. However,challenges and risks involved in the integration of AI in Healthcare exist around the globe as digitization practices are defective and not standardized. The data readily available for Artificial Intelligence companies is likely to be aberrant and therefore for the effective integration of AI in the Healthcare sector the Govt. is making attempts to create digital platforms for the collection of data. However, the lack of a legal framework for the governance of AI in India still poses challenges to its integration intothe healthcare sector. The major challenges involved are in terms of data, privacy infringement, accountability, cybersecurity, etc. The application of Artificial Intelligence in the Healthcare sector in its developing stage requires an adequate amount of financial support along with a legal framework to decide the future course of action in this area. A major hindrance in the development of Artificial Intelligence involves challenges faced by various stakeholders due tolack of proper legal framework, lack of financial support, patient data & privacy infringement, lack of knowledge as to the operation of new technological tools, etc. Though the future of Artificial Intelligence in healthcare is bright & promising yet much remains to be done when it comes to the governance of Artificial Intelligence in today's era. The healthcare industry needs to come together to agree on the standardization of the data infrastructure, it needs to create a strong system to protect confidentiality & handle consent of data from patients. Without these radical changes, it would be challenging to achieve the true promise of AI to help humans.

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A REVIEW ARTICLE ON ARTIFICIAL INTELLIGENCE: ROLE, CURRENT TRENDS AND FUTURE ASPECTS IN THE PHARMACEUTICAL INDUSTRY

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ABSTRACT
The study of artificial intelligence (AI) focuses on how computers imitate human mental processes and learn from data. AI is redefining the way that healthcare will be provided in the future by enhancing learning capacity and offering a comprehensive decision-support system. The application of AI in pharmaceutical technology has grown over time, and it can help save time and money while also improving our understanding of the connections between various formulations and process variables. Executives in the pharmaceutical industry are looking for methods to use AI in the healthcare sector. Leading pharmaceutical businesses to work with AI vendors and use AI technology in their manufacturing processes for research, development, and general medication discovery. Its application in the pharmaceutical sector has advanced from science fiction to reality during the past several years. Pharma businesses are employing predictive analytics technologies and implementing more automated, effective processes that incorporate data-driven decisions. This kind of advanced data analytics will eventually combine machine learning and artificial intelligence. This review focuses on the function, present trends, and future implications of artificial intelligence tools in the pharmaceutical industry. These tools can increase the success rate of new drugs by conducting quality control and ensuring good standards, driving increased automation of daily fundamental workflows, resolving supply chain issues along the production line, reducing material waste, enhancing the manufacturing reuse value, able to perform predictive maintenance and decreasing operational costs.

Keywords: Artificial Intelligence, Tools in AI, Pharmaceutical industry, Pharmaceutical technology, Health care

INTRODUCTION
A field of computer science called artificial intelligence (AI) focuses on using symbolic programming to solve problems. It has significantly developed into a problem-solving science with broad applications in business, medicine, and engineering [1]. The major goal is to recognize practical information processing issues and provide an abstract explanation of how to address them. A theorem in mathematics relates to such an account, which is referred to as a method. In the study of artificial intelligence, algorithms are created and used to analyze and understand data. Numerous branches of statistical and machine learning, analytical thinking, clustering, and similarity-based techniques are all included in this field [2]. AI is a rapidly developing technology with numerous uses in both business and daily life. The pharmaceutical industry has recently found new and inventive methods to apply this potent technology to assist address some of the most important concerns confronting the pharmaceutical industry at the present. In the pharmaceutical industry, artificial intelligence refers to the utilization of machine learning for tasks that normally require human intellect. The usage of artificial intelligence in the pharmaceutical and biotechnology sectors has revolutionized how researchers create new medicines, treat diseases, and more during the last five years [3,9].

Utilizing technical breakthroughs, the pharmaceutical industry can speed up innovation. One of the most current technical developments that arise to mind is artificial intelligence, the creation of computer systems that can carry out tasks that would typically need human

intelligence, like speech recognition, visual perception, decision-making, and language translation.

According to an IBM estimate, the total amount of data in the healthcare industry was 161 billion GB as of 2011. Due to the enormous amount of data that is available in this field, artificial intelligence can really assist in data analysis and result presentation that will aid in decision-making, save time, money, and human effort, and ultimately save lives. Epidemic breakout forecast; utilizing artificial intelligence, one may examine the social media activity, research the history of the outbreak, and predict where and when the epidemic will occur with a high level of precision. In addition to the previously mentioned use cases, there is a wide range of alternatives, including customizing the course of therapy; developing new tools for patients and doctors; etc. Research on clinical trials: use predictive analytics to find trial participants through social media and medical visits. [3]

In pharmaceutical companies, artificial intelligence (AI) refers to the application of automated algorithms to a range of tasks that typically need human intelligence. Recently, scientists' methods for discovering new therapeutic targets, repositioning and repurposing drugs, developing novel compounds, conducting clinical trials, and performing all other tasks related to the lifespan of medical products have changed as a result of the application of AI in the pharmaceutical and biotechnology industries. One of the main factors influencing interest in AI is the need to lower the cost of producing new medications. A study from the Massachusetts Institute of Technology found that just 13.8% of drugs successfully complete clinical trials. A company may expect to spend USD 1.3 to complete the entire clinical trial process and acquire Food and Drug Administration (FDA) approval. [4]

Benefits of Artificial Intelligence [4-6]

- Effective use of incomplete data sets, quick data analysis, flexibility in accommodating preferences and limits, and the capacity to produce rules that make sense.
- Shorter time to market, innovative product development, greater customer reaction, increased confidence, and are some of the factors that contribute to improved product quality and performance at a cheap cost.
- If properly coded, AI would have a lower mistake rate than humans. They would be extremely quick, accurate, and precise.
- They will not be impacted by hostile settings, enabling them to carry out risky duties, explore space, and withstand issues that would harm or kill us.
- Assume what a user will type, inquire about, look up, and do. They can readily serve as helpers and suggest or order a variety of things. The smartphone is one illustration of this.
- Capable of detecting fraud in card-based systems, as well as potential future systems.
- AI used to play numerous video games. Also, the records are managed and organized by using AI.
- They can make reasoned decisions with few or no errors since they can think clearly and without emotion.
- Has the ability to evaluate individuals for medical reasons, including assessing emotional and physical hazards.
- It can provide information about side effects and medical procedure simulations.
- Robotic surgery, including radiosurgery, will allow for precision that humans cannot.

- Although storage is abundant, access and retrieval might not result in links in memory as well as they might in humans.
- They would never be able to experience human creativity, or at least it would seem that way given our technology sensibilities.

Limitations of Artificial Intelligence [6]

- Electronic documents that need to be streamlined must first be cleaned up because they are disorganized and dispersed over several databases.
- Medical data is confidential and not legally accessible, according to data governance. It is crucial to have public approval.
- Pharmaceutical businesses are renowned for being conservative and resistant to change. To provide the greatest care possible, we must eradicate prejudice.
- It cost high due to the complex equipment designs, repairs, maintenance, and frequent updating of software.
- Robots cannot decide if there is any unknown situation occurs. At that moment, they either fabricate a report or collapse.
- If machines take the place of people in all occupations, unemployment would increase significantly.

Current Trends and Tools in Artificial Intelligence:

Two factors account for this increase in popularity:

(1)A large amount of textual data in RWD, particularly in EHRs, and In reality, text mining is a perfect method because more than 80% of the clinical evidence in EHR is reported in the free text [7].

(2)Rapid development of NLP techniques, particularly those new deep attempts to learn models with cutting-edge performance [8].

Various tools and technologies are used as a part of current trends in artificial intelligence which are now implemented in many fields. Some of the technologies involved are:

Robot pharmacy: The robot has been shown to be significantly superior to humans in terms of size and its capacity to administer precise drugs. The manufacture of hazardous chemotherapy drugs for oral and injectable use is one of the capabilities of robotic technology. The UCSF Medical Center uses robotic technology for the manufacture and monitoring of pharmaceuticals with the aim of enhancing patient safety. They claim that the technology has accurately prepared 3,50,000 doses of medication. The UCSF pharmacists and nurses now have more freedom to focus on providing direct patient care and collaborating with the doctors, allowing them to make the most of their knowledge [9].

The computerized facility also includes two non-refrigerated pharmacy warehouses and a frozen pharmacy warehouse for the storage and withdrawal of supplies and pharmaceuticals, as well as an inventory management system that maintains track of every product. These buildings are all completely automated. [10,11]

MEDi Robot: Medicine and engineering designing intelligence are abbreviated as MEDi. The community health sciences professor at the University of Calgary in Alberta, Tanya Beran, served as the project leader for the creation of the pain management robot. After working in hospitals where children scream during medical procedures, she had the notion. Though the robot cannot think, plan, or reason, it can be made to appear to have AI by first

establishing a rapport with the kids and then explaining what to expect during a medical treatment [12-13].

The technology for facial recognition used in MEDIi was developed internally by Aldebaran Robotics. It can speak 20 different languages and is very flexible in various scenarios. The robot retails for $9000, but once the applications required for the robot to assist in medical procedures are installed, the price jumps to between $15,000 and $30,000. The robot was first designed to alleviate pain, but over time its applications have evolved to include comfort during surgeries, physical therapy, and fundraising. [13]

Erica Robot: A researcher at Osaka University named Hiroshi Ishiguro created the new care robot Erica in Japan. It was created in cooperation with Kyoto University, the Advanced Telecommunications Research Institute International, and the Japan Science and Technology Agency (ATR). It has a mix of European and Asian facial traits and speaks Japanese [14]. It enjoys animated movies, longs to go to Southeast Asia, and yearns for a chatty life companion, just like any other typical human. The robot was created with the ability to understand and respond to inquiries with human-like facial expressions, but it cannot freely move. Ishiguro altered the traits of 30 attractive women and utilized the average to create Erica, the "most beautiful and intellectual" android [15].

TUG robots: These robots are called Aethon TUG and are made to autonomously move around the hospital and transport large items like trash and linen as well as prescriptions, meals, specimens, and resources. It features two versions, including swap base platforms that may be used to transport racks, bins, and carts, as well as fixed and secured carts. For the delivery of drugs, delicate items, and laboratory specimens, stationary carts are used. The TUG is a particularly adaptable and usable resource because it can offer many sorts of carts or racks [16].

Berg: One of the leading companies using AI in its numerous processes is Berg, a biotech company with headquarters in Boston. It has an AI-based drug discovery platform with a sizable patient database that is used to locate and validate the many disease-causing biomarkers before choosing treatments based on the information gathered. The company's mission is to use artificial intelligence (AI) to accelerate medication discovery and lower costs by eliminating the guesswork that is involved in the drug development process [16].

Applications of Artificial Intelligence in the Pharmaceutical Industry [2, 17-23]

1. Drug Discovery Process, Design, and Product Development

In the pharmaceutical sector, the use of AI is increasing for drug research and development. AI plays a significant role in the identification and validation of pharmacological targets, from the production of small molecules to the identification of novel drug development. It is frequently used to accurately and efficiently identify biomarkers and develop multi-target drugs. A significant advantage for the pharmaceutical business is the reduction in medication development time when AI is used during drug testing. Drug developers will also be benefited from artificial intelligence in the pharmaceutical sector because it will allow them to conduct clinical trials more quickly and introduce their products to the market sooner. It results in a quicker and less expensive development procedure, as well as the availability of cutting-edge pharmaceuticals for improving patient care without side effects. For instance, pharmaceutical researchers can find and validate novel cancer medicines. By using the data such as electronic medical records (EMR) and other omic data. The optimal formulas for designing and developing medications, created by AI systems using ML and other data analytics algorithms that extract data from EMR will effectively treat tumors.

Another example of a multivariate optimization problem is the development of medicinal products. Variables used in the formulation and process optimization are involved. The ability of artificial neural networks to generalize is one of their most advantageous traits. These characteristics make them excellent for addressing issues in the field of pharmaceutical product development formulation optimization.

2. Research & Development

Globally, pharmaceutical firms utilize cutting-edge AI-powered tools and ML algorithms to speed the drug discovery, development, and innovation process. These technological tools are made to find intricate patterns in vast datasets. Therefore, issues related to the research and development process can be solved with AI in pharmaceutical firms. It is quite advantageous to be able to analyze the patterns of different diseases and figure out which combination formulations are most effective in treating disease symptoms. Pharma companies can invest in the research and development of medicines that are more likely to successfully treat a type of disease or medical problem.

3. Disease Prevention

Pharmaceutical companies can employ artificial intelligence to create medications for very rare disorders including Parkinson's, Alzheimer's, and dementia.

According to Global Genes, there are not enough medications available to quickly treat and cure about 95% of uncommon diseases. The pharmaceutical sector will undergo a full transformation as a result of the usage of AI, which will guarantee the most cutting-edge models for the early detection of dangerous diseases and better patient outcomes.

4. Next-Level Diagnosis

Advanced machine learning systems can be used by doctors to collect, analyze, and evaluate patient health care data. Deep learning and machine learning are being used by healthcare practitioners all over the world to keep patient data safely in the cloud or other centralized storage system which is called Electronic Medical Records (EMR).

Doctors may consult these medical data when they need to comprehend the impact of a certain genetic problem on a patient's health as well as how medicine cures it. EMR data can be used by machine learning systems to produce real-time estimates for disease diagnosis and to suggest the best treatment option for the patient.

Since ML technologies can quickly collect and analyze information, they can aid in speeding the diagnostic procedure and potentially save millions of lives.

5. Epidemic Prediction

Pharma firms and the healthcare sector use ML and AI technologies to track and evaluate the global spread of illnesses. Utilizing data gathered from numerous sources, these contemporary technologies analyze a number of environmental, biological, and geographic elements on the population health of distinct geographic locations and derive data insights to lessen the effects of epidemics in the future. For developing nations lacking the financial and medical infrastructure necessary to stop the spread of disease, artificial intelligence and machine learning models are especially helpful.

The ML-based malaria epidemic prediction model is a good illustration of this; it acts as a warning system for malaria epidemics and aids healthcare professionals in taking the appropriate countermeasures.

6. Drug Repurposing

Repurposing medications appears to be amongst the most practical applications of AI-based technology for pharma businesses on a tight budget.

Many biopharmaceutical companies choose to repurpose existing medications or late-stage drug prospects for use in new therapeutic areas since it reduces the possibility of unforeseen toxicity or adverse effects in human trials and probably requires less R&D investment.

7. Identifying Clinical Trial Candidates

Identifying patients to take part in the studies is another way that artificial intelligence is used in the pharmaceutical sector, in addition to helping to make sense of clinical trial data.

Using strong predictive analytics, AI can scan genetic data to find the right patient population for a trial and choose the best sample size can scan genetic data to find the right patient population for a trial and choose the best sample size using advanced predictive analytics.

Some AI systems can interpret complex data, including doctor's notes, intake forms, and intake forms, as well as free-form text that patients enter into clinical trial applications.

8. Marketing

Sales are the driving force in the pharmaceutical industry, and AI can be a useful tool in pharma marketing. Pharma firms can investigate and create distinctive marketing tactics with AI that promise strong sales and brand recognition.

AI can assist in mapping the customer journey, enabling businesses to determine which marketing strategy influenced customers to make a purchase. Pharma businesses can therefore concentrate more on the marketing tactics that provide the highest conversions and revenue growth.

AI systems may evaluate and compare the outcomes of previous marketing campaigns to determine which ones continued to be the most successful. This saves time and money while also enabling businesses to design their current marketing strategies accordingly.

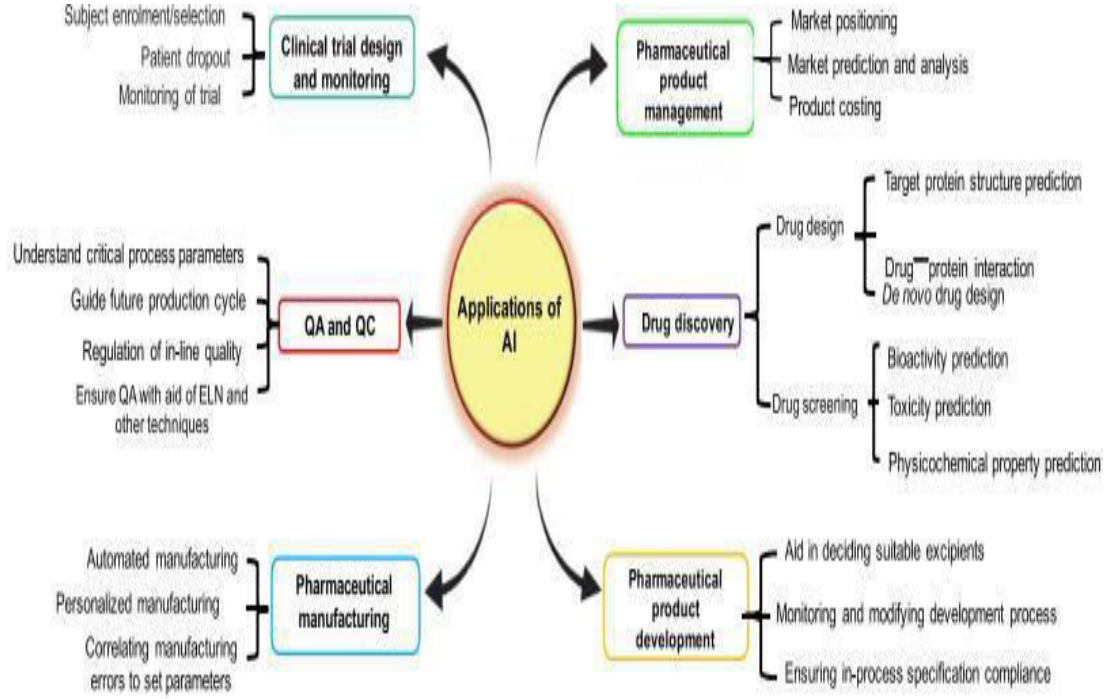

Figure 1: Applications of Artificial Intelligence [23]

Table 1: Artificial intelligence (AI) and pharmaceutical companies Partnerships [25]

S. No.	Area of collaboration in Drug Development	Artificial intelligence	Pharma Companies
1.	To target personalized medicine using medicine learning and large- scale genome sequencing	Bina	Roche
2.	To track real-time data via smartphones and other wearable technologies	Xbird	Bayer Pharma
3.	Drug repurposing	Biovista	Astellas Pharma
4.	To discover novel and selective small molecule	Ex-Scientia	GlaxoSmithKline
5.	To announce the mechanism of AI-based patient monitoring platform can improve adherence	Aicure	Abbvie
6.	To identify novel biological targets and pathway	In-silico medicine	GlaxoSmithKline
7.	To identify new treatments for psychiatric diseases	Ex-Scientia	Sumitomo Dainippon Pharma

Future Aspects of Artificial Intelligence in the Pharmaceutical Industry [21, 27-30]

The pharmaceutical industry's recent uptick in using AI capabilities is not slowing down. By 2025, over half of all healthcare organizations worldwide intend to develop AI strategies and widely use the technology. Particularly, international pharmaceutical and drug development corporations will put more money into finding fresh treatments for cancer and chronic disorders. As a result, businesses are using AI more and more to manage chronic diseases better, cut expenses, and improve patient health. Future applications of AI will focus on important chronic diseases like cancer, diabetes, kidney disease, and idiopathic pulmonary fibrosis.

By enhancing candidate selection procedures for clinical trials, AI will also have an impact on the future of medicines. AI helps ensure adoption by giving trial opportunities to the most qualified applicants by quickly evaluating patients and choosing the top individuals for a particular study. The technology also aids in removing aspects that can impair clinical studies, hence minimizing the need to make up for such elements with a big trial population. AI will still be used by businesses to improve patient screening and diagnosis. AI can be used by professionals to glean more useful information from pre-existing data, such as MRI pictures and mammograms.

Drug research and production will continue to benefit from AI and machine learning. Additionally, when AI technologies become more widely available over time, they will blend naturally into the manufacturing and pharmaceutical processes. AI will be utilized in the future.

CONCLUSION

The most technologically advanced machine ever created is the human body. When it comes to doing any given task, the human brain is actively working to create something that is much more effective than a human being, and it has been incredibly successful in doing so to some extent. The robotic pharmacy, pull robot, and Watson for cancer are a few examples of AI solutions that have significantly changed the industry. As it expands, the infrastructure required by the healthcare sector will need to be increasingly sophisticated and technologically advanced. Artificial intelligence is the design and application of algorithms for the learning, understanding, and interpretation of data. The use of artificial intelligence (AI) and other cutting-edge technologies will cause the pharmaceutical industry to undergo significant transformation in the years to come as organizations grasp the strategic importance of incorporating these breakthroughs to achieve a competitive edge. As they incorporate these new technologies throughout the pharmaceutical development and deployment pipeline to increase efficiency, the top pharmaceutical companies will undoubtedly expand their investments, acquisitions, and alliances.

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ROLE OF ARTIFICIAL INTELLIGENCE IN DESIGN, DEVELOPMENT AND ANTI-MICROBIAL RESISTANCE OF ANTIBIOTICS

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ABSTRACT

Development of an antibiotic is a very lengthy and highly expensive process since only preclinical, pharmacokinetic, pharmacodynamic and toxicological studies include a multiple of in silico, in vitro, in vivo experimentations that traditionally last several years. This has led to a series of pathogens developing antibiotic resistant, , which poses severe threats to public health systems while also driving up the costs of hospitalization and treatment. The future of antibiotics requires innovation in a field that has relied on highly traditional methods of discovery and development. This will require substantial changes in policy, quantitative understanding of the societal value of these drugs, and investment in alternatives to traditional antibiotics. Artificial intelligence (AI) is a branch of science and engineering that focuses on the computational understanding of intelligent behavior. Many human professions, including clinical diagnosis and prognosis, are greatly useful from AI. A large number of researches are being carried out to improve the current available AI technology to make the pharmacy profession more efficient. Clinical trials output prediction through the AI/ML integrated models could further decrease the clinical trials cost by also improving the success rate. In this review paper, we briefly report some studies on design, development and antimicrobial resistance (AMR) of antibiotics using artificial intelligence.

Keywords: AI, Clinical trials, ML, AMR

Artificial intelligence (AI) is described in the context of health as the application of algorithms and software to complement human awareness or attention during the analysis of intricate medical data. Machine intelligence, another name for artificial intelligence, is a tool for analyzing massive volumes of organized and unstructured data to produce wise and correct conclusions. A more accurate definition of artificial intelligence (AI) is the ability of computers to draw judgments without clear-cut human input.

Artificial intelligence (AI) is described in the context of health as the application of algorithms and software to complement human awareness or attention during the analysis of intricate medical data.

THE WAVES OF AI

FIRST WAVE- (c.1970-1990)

The initial wave of artificial intelligence research gave us "knowledge engineering" optimization tools that effectively handled practical issues. Reasoning is strong but lacks the capacity to learn or generalize.

- GOFAL-Good Old Fashioned Al.
- Symbolic, heuristic, rule based.
- Handcrafted knowledge, —expert systems.

SECOND WAVE- (c.2000s-present)

The second phase of artificial intelligence gave rise to machine learning programmes. These employ statistical analysis to address challenging pattern recognition issues. Second-wave artificial intelligence algorithms see and learn, frequently on par with human perception and learning, unlike their first-wave counterparts. Second-wave artificial intelligence is strong,

but in order to effectively perform its analysis, it needs well-organized, regularly coded, and full data sets. The third wave of artificial intelligence is now overcoming this restriction.

Good at picking up information and observing, but little capacity for logic or generalization.

- Statistical learning, deep neural nets, CNNs, RNNs.
- Advanced text, speech, language and vision processing.

THIRD WAVE- (est.2020s-2030s)
The third phase of artificial intelligence development has begun. Third-wave AI systems are capable of analyzing enormous data sets, finding patterns, and producing algorithms to explain them. The context of various data pieces is normalized by these systems, which also provide original, fresh theories more quickly and accurately than human researchers.

FOURTH WAVE- (est.2030s to -)
- Able to handle any intellectual task.
- Capable of carrying out any mental work that a person can.
- AGI-Artificial general intelligence. Possibly leading to ASI (Artificial Super intelligence) and the ―Technological Singularity.

Classification of Artificial Intelligence
AI may be categorized in two distinct ways: based on quality and presence.

According To Their Caliber**:**

1. Artificial Narrow Intelligence (ANI)
2. Artificial General Intelligence (AGI)
3. Artificial Super Intelligence (ASI)

According To Their Presence: Type 1: Purely reactive

Type 2: Limited memory Type 3: Theory of mind Type 4: Self-aware

The following categories of AI exist based on their Capabilities.

Type I. Artificial Narrow Intelligence (ANI)
Weak AI or Artificial Narrow Intelligence (ANI): It only does a limited range of tasks, such as facial recognition, driving, playing chess, and traffic signaling.

Type II: Artificial General Intelligence (AGI)
Strong AI or Artificial General Intelligence (AGI) It carries out all tasks like a person and is referred to as human-level AI. It can simplify human intelligence and do challenging tasks.

Type III: Artificial Super Intelligence (ASI)
Artificial Super Intelligence (ASI): It is far more active than humans and is wiser than them in terms of sketching, math, and space.etc.

The following categories of AI exist based on their Presence.

Type1: Purely reactive:
It is one of the most important and necessary types of AI. It directly detects its environment or circumstance and acts in response to what it sees. It doesn't have a concept of what the rest of the world is like. It is unable to construct memories or draw on previous experiences in order to influence current decisions. It just focuses on one thing.

Type 2: Limited memory:
This type, which is higher on the Al evolutionary ladder, considers bits of past information and incorporates them into its pre-programmed world representations. It only has enough memory or experience to make sound decisions and carry them out.

Type 3: Theory of mind:
Type 3 is capable of comprehending thoughts and emotions, which has an impact on human behavior. This sort of AI, which can understand feelings, motives, intents, and expectations as well as interact socially, has yet to be developed, but it is expected to be the next generation of intelligent robots.

Type 4: Self-aware:
These forms of Al are capable of forming self-representations. They are an extension of Type 3's "theory of mind," in that they are conscious of their own internal states. They can foresee others' feelings and generate inferences and abstractions. These are the machines of the future. They are extremely clever, sentient, and aware.

Antibiotics
The term antibiotic was coined from the word “antibiosis” which literally means, against life‟. In the past, antibiotics were considered to be organic compounds produced by one microorganism which are toxic to other microorganisms. As a result of this notion, an antibiotic was originally, broadly defined as a substance, and produced by one microorganism or of biological origin which at low concentrations can inhibit the growth of, or are lethal to other microorganisms. However, this definition has been modified in modern times, to include antimicrobials that are also produced partly or wholly through synthetic means. Whilst some antibiotics are able to completely kill other bacteria, some are only able to inhibit their growth. Those that kill bacteria are termed bactericidal while those that inhibit bacterial growth are termed Although antibiotic generally refers to antibacterial, antibiotic compounds are differentiated as antibacterial, anti-fungal and anti-viral to reflect the group of microorganisms they Penicillin was the first antibiotic discovered in September 1928 by an English Bacteriologist, late Sir Alexander Fleming who accidentally obtained the antibiotic from a soil inhabiting fungus Penicillium notatum but its discovery was first reported in 1929 and clinical trials first conducted on humans in 1940 therefore predicated on the overall intended benefit, taking into consideration the attendant side effects. For this reason, it is pertinent to understand the mechanism of action of every identified antibiotic before introduction into our health care delivery system, and recent molecular biological approaches have played very significant roles to elucidate our understanding in this regard. Hence this paper aimed to review the classification of antibiotics and their mode of action with emphasis on molecular perspectives.

Antibiotics Mode of Action
The antimicrobial potency of most classes of antibiotic care directed at some unique feature of the bacterial structure or their metabolic processes. The mechanism of antibiotic actions is as follows:

- Inhibition of cell wall synthesis
- Breakdown of cell membrane structure or function
- Inhibition of the structure and function of nucleic acids
- Inhibition of protein synthesis
- Blockage of key metabolic pathways

Types of Antibiotics

There are various classes or groups of antibiotics, which depend on their chemical structure. Some classes of antibiotics include the following:

Class	Examples
Penicillins	amoxicillin (Amoxil)
Macrolides	azithromycin (Zithromax) and erythromycin (Ery-Tab)
Cephalosporins	cephalexin (Keflex) and cefdinir (Omnicef)
Fluoroquinolones	ciprofloxacin (Cipro) and levofloxacin (Levaquin)
Beta-lactams with increased activity	amoxicillin/clavulanate (Augmentin)
Urinary anti-infectives	nitrofurantoin (Macrobid)
Lincosamides	clindamycin (Cleocin)

Antibiotic Resistance

Antibiotic resistance (AR) is a naturally occurring phenomenon consisting mostly of acquired adaptative mechanisms. These mechanisms aid bacteria to overcome and survive the aggression caused by antibiotics. AR represents an important problem in present times due to several factors. Bacteria possess a collection of genes that grant them resistance to external aggressions. The resistance genes' inheritance model and transcription levels define the bacterial resistome**.** Bacteria often develop resistance to antibiotics, but even before antibiotics have been used, they developed resistance to other aggressors.

Mechanism of Antibiotic Resistance

Resistance mechanisms counter the drug along its path from entry through accumulation and target binding to downstream toxicity (clockwise along the top arc). The outermost line of defense is prevention of the bare entry of the drug into the cell (Spatial exclusion ⊣ Entry). A change in the chemical composition or thickness of the bacterial cell envelope can impede the diffusion of antibiotics into the cell (Permeability). Additionally, cell membranes often contain drug dedicated or general pumps (Efflux pump). The next line of defense prevents drug accumulation by chemically targeting the drug (Drug modification ⊣ Accumulation): designated enzymes modify drug molecules (Substitution reaction) or hydrolyze them (Degradation). These reactions can either occur within the cell, or preemptively outside the cell if the enzymes are secreted. Even if drugs do accumulate unmodified in the bacterial cytoplasm, binding and inhibiting their target can be hampered by a change in the target (Target modification ⊣ Binding): chemical modification of the target itself (Residue substitution), binding of the target by a protective factor (Target protection), or change in target abundance (Expression level). Notably, while for some drugs over expression of the target increases resistance, for others it is reduced expression that can confer resistance. Ultimately, the last line of defense can be avoiding the toxic effect of target binding (Bypass ⊣ Toxicity), by circumventing the need for the chemical reaction in which the target is involved, or by changing the chemical composition and functionality of the cell (Metabolic shunt).

Artificial Intelligence in Antibiotic Discovery, Design and Development

Antibiotic development is a slow, expensive, and failure-prone process that can span over 10 years and cost hundreds of millions of dollars. Between 2014 and 2019, only 14 new antibiotics were developed and approved 5. In a survey of nearly 186,000 clinical trials for over 21,000 compounds, the probability of success for new drugs that treat infectious diseases was 25.2%. For orphan drugs, i.e., those that treat rare infectious diseases, this probability dropped to only 19.1%. This risk of failure drives corporations to pursue research and development with a higher guarantee of return on investment, opening the way for academia to initiate early stages of antibiotic design and optimization. The continuous

development of artificial intelligence brings a new perspective to the field of antibiotic discovery.

It can take up to 10–12 years for drugs to reach the market, including antibiotics. The first period of the drug development process usually ranges from 2–4 years. In this period, new active substances are investigated from a chemical point of view. Only a few manage to pass this step before being tested in animal studies to discover any toxicological effects. AI can shorten the preclinical phase by rapidly generating many substances based on algorithms created by ML techniques. These algorithms predict the antibiotic efficacy for each generated molecule by analyzing large sets of data, making the whole early drug discovery process much faster.

When it comes to machine learning, this type of technology consists of various computational methods that are based on previous experience. The computers operate with so-called "raw data" in order to extract patterns and construct algorithms. The efficiency and value of such an algorithm is closely correlated to the quality and sample size of the data that is used in the process. Thus, it can be used in order to improve the performance of certain programs or to make predictions, while using the advantage of computational power and the ability to rapidly process large quantities of information.

The traditional experimental methods of discovering new antibiotics or improving existing ones are now being influenced by algorithms that were created by machine learning and neural networks, which allow larger in silico exploration and study. The main Artificial Intelligence technologies that are used in the analyzed studies are described in this review.

Da Cunha et al. combined machine learning, spectroscopy and the antibiotic mechanisms of action and potency via high-throughput Fourier-transform infrared spectroscopy. This technique is based on the detection of certain metabolic fingerprints in order to assess the growth inhibition that is generated by the specific antibiotic, together with its mechanism of action. By analyzing specific antibiotics belonging to certain classes, it successfully predicted the mechanisms of action of different antibiotics belonging to the same class. Moreover, it was also capable of estimating antibiotic potency, which was measured by the metabolic fingerprints that were detected by Fourier-transform infrared spectroscopy, reflecting the cell alterations that were induced by the antibiotic.

Zoffman et al. also used machine learning by analyzing and searching through the Roche compound library, eliminating known antibiotics and other substances from other past antibiotic projects, prioritizing the remaining compounds based on novelty, potency, chemical structure, and the availability of purified powder material. These were further tested against four Gram-negative bacteria in order to assess their antibacterial activity. Moreover, the study aimed to show certain compound-induced phenotypic changes in relation to the lowest effective dose and the minimal inhibitory concentration, and to determine the mechanisms of action for novel compounds. Machine learning was used to determine and capture the specific bacterial phenotypic fingerprints in relation to certain mechanisms of action of different compounds, showing that compounds with the same mechanism of action induced similar phenotypic fingerprints. When it comes to novel compounds, these bacterial phenotypic fingerprints can be used to better establish the relationship between the structure and activity of certain antibacterial agents.

A deep learning approach towards novel antibiotic discovery was proposed by Stokes et al., by searching and formulating predictions using various databases. After training and optimizing the model, it was used in order to identify potential antimicrobial molecules from the Drug Repurposing Hub. This database consists of a large number of molecules that are being tested in various stages of research, in order to find new applications for them. Finally,

99 molecules were identified and further empirically tested for antimicrobial inhibition; 51 of these compounds showed a strong inhibitory effect on a strain of E. coli. During the clinical phase of investigation, the structural similarities of molecules from the training dataset and the predicted toxicity were also taken into consideration using a deep neural network in order

to select the compounds with low structural similarity and the lowest toxicities. The algorithm showed that halicin displayed strong growth inhibitory activity against E. coli, even on cells that persisted after treatment with ampicillin. Being potent against multiple strains of antibiotic-resistant E. coli, the growth inhibitory potential of halicin was also tested on other pathogens, such as M. tuberculosis, carbapenem-resistant Enterobacteriaceae (CRE), A. baumannii and P. aeruginosa; it showed promising results, possessing strong inhibitory properties against CRE and A. baumannii, while also proving to be bactericidal against M. tuberculosis, but lacking efficiency against P. aeruginosa. Halicin presents a complex and particular mechanism of action. It has been proven to sequester iron inside the bacteria, thereby disrupting its ability to maintain a normal electrochemical membrane gradient, thus inhibiting metabolism and resulting in cell death. Additionally, halicin is a c-Jun N-terminal kinase (JNK) inhibitor.

Not only can machine learning be used in order to predict and discover novel antibiotics, but also to search a large amount of data, followed by the selection of certain compounds that meet the required criteria. Parvaiz et al. used machine learning in order to conduct a large search for compounds possessing the beta-lactamase inhibition quality. Of these 700,000 compounds, 74 were identified, after which they were subjected to empirical validation, revealing that eleven compounds were recognized as enhancers, while seven were inhibitors of CMY-10, which is a plasmid-encoded class C beta-lactamase. One compound presented great promise, being regarded as both a β-lactam enhancer and β-lactamase inhibitor. Moreover, machine learning facilitated the search for structurally similar compounds, after which 28 more were identified, all of them exhibiting β-lactamase inhibition potential and antibacterial activity.

Neural Networks and Antimicrobial Compounds

Inspired by the architecture and structure of the human brain, new AI technologies called neural networks have started to emerge. They consist of interconnected processing units and are based on pattern recognition technology. Moreover, the network learns from examples to perform certain tasks, even though it does not need a preset rule system, functioning instead through the constant adjustment of results in order to reach a target value.

Word embedding is a technique that is used in natural language processing in which words from a vocabulary are represented as vectors by using a significant number of words to form the pieces of the text as an input. Bacteriocins are proteic or peptidic toxins that are produced by some bacteria in order to kill other bacteria or viruses that may endanger them, which represents one of the most promising perspectives on novel antibiotic discovery. Among their mechanisms of action, pore-forming and permeabilization of bacteria, nuclease activity and DNA disruption, or inhibition of peptidoglycan formation are the most frequent.

Hamid et al. selected a word-embedding representation for each trigram from a protein sequence, and then used a Recurrent Neural Network (RNN), which is a subsequent type of artificial neural network, to distinguish between bacteriocin and non-bacteriocin sequences. The results showed that the novel technique can predict, with a statistically significant probability, six bacteriocins in Lactobacillus that were yet unknown, and the authors concluded that their RNN-based algorithm is the best automated method for the classification of bacteriocins compared to the current automated AI-based algorithms for biological sequence classification.

An artificial neural network (ANN) was used by Badura et al. to predict the antimicrobial properties and the biological and chemical effects of quaternary ammonium salts against E. coli. The study was based on the transformation of chemical information into three-dimensional models of imidazole chlorides and the generation of molecular descriptors via computational chemistry methods. The result was a high classification accuracy (95%, regression model: learning set R = 0.87, testing set R = 0.91, validation set R = 0.89), demonstrating that ANN-based systems can be successfully used to find efficient antimicrobial compounds.

Discovery of Antibiotic Peptides

ML is also used in the discovery of antibiotic peptides. Peptides with antimicrobial activity are also widely distributed in different lifeforms where they play an essential role as part of the innate immune system. The most known mammalian AMPs are cathelicidins and defensins, acting as human host defense peptides (HDPs). They are secreted in different parts of the organism such as the skin, eyes, respiratory tract, lung, and intestine. Their main role is to act fast by being part of the innate immune system and provide a broad-spectrum protection against invading pathogens. Microorganisms like bacteria and fungi also produce AMPs which help them fight against each other. AMPs are simple peptides without a complex 3D structure like large proteins, however their cost of production is expensive, at about USD 100–1000 for 1 mg of AMP, and they are only produced in lab conditions for experiments.

The most widely known mechanism through which AMPs kill microbes is osmotic shock, which occurs either through the formation of pores, or paving as carpet on the membrane surface to weaken membrane integrity.

Unlike most conventional antibiotics, which have specific functional or structural targets, AMPs act directly on the microorganisms, often causing cell lysis, or modulate the host immunity to enhance defense against microorganisms. Moreover, they act faster than conventional antibiotics, have a narrower active concentration window for killing, and do not typically damage the DNA of their targets, though there have been studies describing how AMPs inhibit critical intracellular functions by binding to DNA, RNA, or intracellular proteins. As a result, they do not induce resistance to the extent that is observed with conventional antibiotics. Nevertheless, if bacteria are exposed to AMPs for extended periods of time, they can and do develop resistance even to peptide-based drugs, including the last- resort and life-saving drug, colistin.

The quantitative structure-activity relationship (QSAR) method, combined with ML techniques, was successfully used in 2009 by a group with the objective to discover new AMPs with antibacterial propertie. Their algorithm managed to predict and rank antimicrobial activity of 100,000 virtual peptides, with 94% of the 50 highest ranking peptides later being proved as being highly active against strains of multidrug- resistant Pseudomonas aeruginosa (P. aeruginosa), methicillin-resistant Staphylococcus aureus (MRSA), extended-spectrum β-lactamase-producing E. coli and Klebsiella pneumoniae (K. pneumoniae), as well as vancomycin-resistant Enterococcus faecalis and Enterococcus faecium (VRE) . QSAR is a computational modeling method that finds relationships between the structural properties and biological effects of compounds. This method helps in antibiotic discovery by prioritizing the relevant active molecules to be further tested in animal studies, saving time and money. The QSAR method shows a high potential when it comes to antibiotic discovery, especially when it is combined with ensemble methods which can improve predictability.

Generally, a molecule able to inhibit many different strains of the same bacterium will have a lower propensity than a molecule that inhibits a few strains. By following this thread, new QSAR approaches, such as the multi-tasking model for quantitative structure-biological effect

relationships (mtk-QSAR), also called multi-target (mt-QSAR), are used to integrate different kinds of chemical and biological data, allowing the assessment of multiple biological activities against diverse biological systems. By screening large amounts of data, the descriptors can show which pattern is often associated with the desired conditions (for instance high antimicrobial activity against multiple Gram-negative bacteria and low cytotoxicity to human cells). In the end, known peptides are prioritized based on their similarity with these descriptors and other peptides can also be generated with the established set of rules. Only the combination of certain amino acids and the topological distances between them are essential for improving the antibacterial activity. In the study conducted by Kleandrova et al., the study group generated a library formed by 10 peptides, all which exhibited high antibacterial activity against Gram-negative bacteria based on the molecular descriptors which they used to screen a data set containing 3592 peptides.

To this extent, the use of in silico models based on perturbation theory concepts and machine learning technologies (PTML) could measure the probability of a drug being active under certain conditions (protein, cell line, organism). The combination between PTML and mtc-QSAR models showed promising results in discovering multi-strain inhibitors.

NN-based algorithms are also used to identify and describe the bioactivity of each peptide sequence. For using recurrent neural networks (RNNs), representation methods together with architecture for each representation must be used to analyze the sequence of amino acids. Vectors are commonly used to describe essential properties of AMPs. They are used to represent the order of amino acids in AMPs, for example by representing peptides as sequences of vectors, describing the presence of one of the 20 essential amino acids in the sequence. Alternatively, 1D vector have been considered, where each amino acid in the sequence is codified by a number from 0 to 19. More recently, peptides have been reproduced with the aid of the word2vect denomination. However, sequential representation does not consider the interactions between amino acids and the atoms within each amino acid. Essential properties of AMPs must be included, such as amino acid composition or composition–transition–distribution, to make the vectors more descriptive

Artificial Intelligence and Antibiotic Resistance

Antibiotic resistance (AR) is a naturally occurring phenomenon with the capacity to render useless all known antibiotics in the fight against bacterial infections. Although bacterial resistance appeared before any human life form, this process has accelerated in the past years. Important causes of AR in modern times could be the over-prescription of antibiotics, the presence of faulty infection-prevention strategies, pollution in overcrowded areas, or the use of antibiotics in agriculture and farming, together with a decreased interest from the pharmaceutical industry in researching and testing new antibiotics. The last cause is primarily due to the high costs of developing antibiotics.

Antimicrobial resistance (AMR) is anticipated to cause around 10 million deaths per year by 2050, and the economic impact of AMR is expected to approach USD 100 billion during the same period. It is imperative that required efforts to implement new regulations and revive research efforts to manage the AMR epidemic are carried out to address this crisis.

Due to the recent AMR emergence, the world is in desperate need of some relief, and to this end, the Food and Drug Administration of the United States has proposed regulations that would specify the types, quantities, and frequencies of adequate antibiotic use. A complete prohibition on the use of antibiotics in cattle feed was recommended by the European Union in 2006. Japanese and Chinese policymakers, in contrast to their counterparts in Europe and the United States, have concentrated on proposals that are more compelling in nature. In 2016, the Chinese government announced the National Action Plan to Contain Antimicrobial Resistance

(NAPACAR). However, despite increased awareness of antimicrobial resistance (AMR), the general situation is deteriorating, and we must continue to create antimicrobial peptides (AMPs), antibiotic combinations, and monitoring systems to effectively control AMR.

Artificial intelligence (AI) has demonstrated substantial competence in the field of AMR control in recent years. For example, artificial intelligence applications based on sequencing have been used to explore AMR. Furthermore, the collection of clinical data for the development of clinical decision support systems could assist clinicians in monitoring trends in antimicrobial resistance to promote antibiotics' sensible applications.

Currently, two approaches for diagnosing AMR are commonly utilized. One is called the whole-genome sequencing for antimicrobial susceptibility testing (WGS-AST) and the other one is antibiotic susceptibility testing (AST). The latter is the traditional approach for quantifying antimicrobial resistance levels, but it is not efficient, nor does it explain the mechanism of antimicrobial resistance. It is possible to diagnose AMR with high accuracy and consistency using WGS-AST; however, to extract information properly, large, and high-dimensional datasets are required. As a result, artificial intelligence technologies are being used to improve upon existing methodologies in the previously discussed ways. **Table 1** shows the application of AI in efforts to control high AMR rates with their advantages and disadvantages.

Table 1: AI application strategies against AMR

AI Applications for AMR	Concepts	Advantages	Drawbacks
AI health industry and antibiotics			
Antimicrobial peptides	A natural class of small host defense peptides, found in all classes of biological species.	• Low chances of AMR development • Multiple action mechanisms Ease of synthesis with machine/deep learning	• Highly toxic • Expensive in large-scale production • Un-preferable widespread use • The onset of allergic reactions
New antibiotics	Discovery of new and structurally different antibiotics from the ones already known using AI.	• Broad-spectrum and targeted bioactivity • Reduced production time Cost-effective	• Challenge of training libraries according to required pharmacokinetic properties of drugs Challenge of most appropriate approach selection, minimizing toxicity, and lead compound discovery
AI, infectious diseases, and pediatric practices			
Appropriate antibiotic prescription	Appropriate therapy selection, dose, and correct administration route	• Automatic support for decisions and review of antimicrobial prescriptions • Automatic feedback input and relevant improvement Directed operation	• Biasness in operation • Little labor Need for health funds
Prediction of antibiotic resistance	ML techniques to predict early AMR or the probability of a microbial	• Genomic exploitation to predict the phenotype Ability to support	• Lack of genotypes and genome data in NCBI or other databases Challenge of large data

	agent becoming resistant	clinician's decision	integration
The severity of infection prediction	Machine/deep learning tools for infectious pathology recognition and appropriate management	• The efficiency of distinguishing infectious and noninfectious diseases • Decision support provision Mortality reduction	• Challenge of accurate data collection Insufficient relevant laboratory information

Assistance Strategies of AI in AMR

Early detection of infectious diseases, the differentiation between infectious and noninfectious pathologies, and correct therapy of consequences are all important aspects of combating antibiotic resistance. In this global issue, AI can play a very vital role. The preparation of antibiograms and then the development of personalized machine learning (ML)-based AMR prediction models could be very useful AI techniques for high-peak risk infectious bugs and their trends in the susceptibility patterns. Using this strategy, Yelin et al. conducted a study to examine a 10-year longitudinal dataset of over 0.7 million community- acquired UTIs and identified a significant association between AMR and demographic characteristics, previous history of urine cultures, and the previous history of using the antibiotics by the patients. After examinations, they developed an ML-based AMR prediction model and described the high potential bugs for UTIs and their AMR patterns.

Strategies to Overcome Antibiotic Resistance

As part of their research, Getsal et al. used a combination of tools to undertake antibiotic susceptibility—namely, screening flow cytometer antimicrobial susceptibility testing and assisted machine learning were used to improve current AST methods. This type of artificial intelligence technology produces a dependable output in less than 3 h. A fully developed IR-spectrometer approach has also emerged in recent years that integrate infrared (IR) spectroscopy with artificial neural networks to minimize the amount of time required to perform AST from 24 h to 30 min. Pakistan, Burkina Faso, Malawi, Nepal, Bangladesh, and Zimbabwe are among the nations where the typhoid vaccine is being used, with the prospect of other countries being included during the project.

The antibiotic-resistant gene-sequencing models can predict antibiotic resistance categories with excellent precision (>0.97) and recall (>0.90), according to the results of an assessment of the deep and machine learning models across 30 categories of antibiotic resistance. Compared with the traditional best-hit strategy, the models demonstrated a significant benefit by consistently producing negligible false-negative results and, thus, greater total recall (>0.9). Given how neural networks underpin DeepARG models, it is reasonable to predict that the outputs of the DeepARG systems will improve even further if additional data are gathered for under-tapped categories of ARGs. DeepARG-DB, a newly constructed ARG database, contains ARGs that have been predicted with a strong confidence level and subjected to intensive manual examination, significantly increasing the scope of current ARG repositories. In general, a combination of antibiotic abuse along with ineffective infection control and prevention contributes to antibiotic resistance development. Actions can be taken at all societal levels to mitigate the effects and prevent the growth of antigovernment sentiment.

Marco et al. fully offline mobile application (the App hereafter) capable of analyzing disk diffusion ASTs and yielding interpreted results, operating entirely on a smart phone. The need of such an application was identified by Medicines Sans Frontiers (MSF), who often operates in low and middle income countries (LMIC) where AST is difficult or impossible to implement. The MSF Foundation brought together the people and skills needed for this

application to be developed, truly believing that the App can have a great impact on the fields where MSF operates and the global fight against AMR. The App combines original algorithms, using machine learning (ML) and image processing, with a rule-based expert system, for automatic AST analysis. It embeds a clinically tested third-party expert system which could compensate for a lack of microbiology expertise. The user is guided throughout the whole analysis and can interact at any step with the user-friendly graphical interface of the application to verify and possibly correct the automatic measurements if needed. The whole analysis takes place on the same smart phone used to acquire the picture of the AST. Since it does not require any hardware other than a basic Android smart phone, and because it works completely offline (without internet connection), the App is suited for resource-limited settings. Therefore, the App could help fill the digital gap, increase patients' access to AST worldwide and possibly facilitate the collection of epidemiological data on antimicrobial resistances, the lack of which is recognized today as a major health danger. In fact, the main aim of this application is to facilitate the adoption of the disk diffusion AST in resources-limited hospitals and laboratories where this test is not available yet. The App pursues this objective by partially alleviating the need of expert human resources, making the reading more reliable, and providing interpreted results. Therefore this application does not want to compete with high-end commercial systems, which can count on dedicated hardware. Nevertheless, in order to be reliable, it is fundamental that the App fulfills the minimum viable performance requirements

CONCLUSION

Continuous improvement of AI technologies has opened the way to new perspectives of drug development, providing the necessary tools to efficiently treat drug-resistant bacteria. Researchers are discovering gaps and breaches in surveillance and methodical data collection. Based on these data, it is urged that surveillance practices must be formalized, and specific efforts must be taken to prevent AMR in the region. Furthermore, the world needs to change the way it consumes antibiotics. Without a change in public behavior, medical expeditions to find newer antibiotics will not be fruitful. The adoption of new behaviors should include measures to minimize the transmission of infectious diseases, such as immunization, hand washing, and excellent food hygiene.

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ARTIFICIAL INTELLIGENCE IN BUSINESS MANAGEMENT: TRENDS AND CHALLENGES IN HUMAN RESOURCE MANAGEMENT

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ABSTRACT
Artificial intelligence has recently made a significant impact in the logistics field, with significant growth and applications in a variety of domains, including business and management, government and the public sector, science, and technology. AI tools have attracted attention in literature and business organizations by making supply chain management easier and using advances in machine learning. AI is intelligence shown by machines. Every day, we observe the tremendous advancement of internet and mobile technologies, medicines, algorithmic development, health facilities, digital applications, and so on, which tends to speed up mechanical and electronic engineering systems. However, AI technologies have great potential for problem-solving as they are similar to human logic and reasoning, but there are still issues with their practical use and a lack of technology about strategically using AI to uplift business morale. There are two basic reasons for using AI: problems in strategic decision-making and new issues in cyber threats.

Keywords: Artificial intelligence, problem-solving, machine learning, mechanical and engineering system, business management.

INTRODUCTION
The father of artificial intelligence, John McCarthy, who first coined the term in 1956, expresses a definition for AI that says that "artificial intelligence is the science and engineering of making smart machines, particularly intelligent computer programs."

The robots working in industries, self-driving cars, fitness watches, and online tutorials are examples of artificial intelligence technological innovations. By reshaping strategies and business models, AI has become an integral part of every business operation and a key strategic component of the plan.

Organizations like Facebook and Google gather a lot of information from clients and need to study and analyze it, which can easily be done with the help of artificial intelligence. AI also helps in determining the cost model used to measure the success factors of any organization. Therefore, AI has become the reason for increasing the level of competition in all places like firms, government, international business, education, etc. AI's aid in logistics helps lower shipping costs for effective business management.

The known fact is that the disruption process requires a review of the business strategy, and the leaders are reformulating their strategic plans for the acquisition of AI technologies (Davenport, 2018). From a managerial viewpoint, the literature about AI addresses the management of information, decision-making, knowledge management, and skills. Previously, AI technologies associated with companies created barriers to acquiring business value through the use of this type of technology. It is important to conceptualize the current research about the connection between AI, organizational strategy, and the decision-making process. The correlation between AI and organizational strategy to create business value should be analyzed by implementing the literature review. Borges et al. (2020) The business runs in the long run, which involves a changing environment, and that has to be tackled by the decision-making process, so Trunk et al. (2020) analyze the connection between AI and decision-making under the changing circumstances by implementing the literature review. Through the correlation between AI and decision-making, businesses show the possibility of existing studies and also describe how

humans can adopt AI for decision-making in dynamic environments. Analytics in business and management is rapidly evolving. The combination of AI and data analytics enables managers to learn more about their customers than they do themselves.

Many successful companies are using AI integration in the marketing field, including:

Amazon:
Online retail follows both a consumer- and business-oriented approach. AI products and services and other professional AI services are built on consumer products. For example, Amazon Echo, Alexa, Polly, and so on.

Amazon Echo brings AI into the home through its intelligent voice server. The company has three primary services of Alexa for AWS: Lex, a business version of Alexa; Polly, which turns text into speech; and Rekognition, an image recognition service.

Apple:
It is another giant industry. Apple executives have mentioned AI integration several times in the past and how it can be a big step for the company. This probably shows why the companies have acquired AI startups over the last few years and have continued to improve innovative products like Siri and create ML.

OBJECTIVES OF THE STUDY

The inferences obtained in this study will provide a better understanding of the innovations, current use of AI technology, the impact of AI on business models, and trends and opportunities of artificial intelligence in the human resources sector.

The above analysis provides the answer to the following questions:

- How is artificial intelligence related to business models? Why is AI important for businesses?
- What are the trends and challenges of AI in the HR sector? How does artificial intelligence influence all sectors across the globe?
- Is the growth of artificial intelligence disrupting the human resources of the organization? What is the dark side of artificial intelligence?

LITERATURE REVIEW

ARTIFICIAL INTELLIGENCE

Artificial intelligence refers to machines performing various functions that are usually related to human minds, such as learning, interacting, and problem-solving. AI gives rise to a contemporary learning system that can learn, adapt, and act autonomously. AI is a system that can interpret the data, learn the necessary content from such data, and use it in such a way that specific tasks and goals can be achieved flexibly. (Kaplan &Haenlein, 2019b, p. 17)

Opportunities for AI in HR

Approximately 45 articles were discovered while searching through 13,136 relevant studies on AI, robotics, and other technological advancements in HRM settings, and these were published in top HRM, international business (IB), general management (GM), and information management (IM) journals.

AI is increasingly adopted in the workplace due to its potential to increase value for consumers, employees, and organizations and help manage and develop human resource plans to increase productivity. Artificial intelligence with learning management systems and training modules can be used in the HR sector to provide employees with the right career path and develop their

abilities to help them excel in their staff work while increasing their ambition for higher levels of responsibility and promotions.

Today's employees are independent and active. Technology, including smartphones and self-service appliances, is the most effective way to communicate with them.

Many businesses use different forms of AI in their recruitment process, selection, and evaluation by implementing Chabot's or other electronic appliances. Recently, the regional company accurately sorted thousands of applicants and used a personalized tool to analyze the video created by the candidate himself, which is considered an amazing advance in technology.

An organization needs to use its resources to achieve the benefits of the AI capability framework, integrating a resource-based view with a knowledge-based view. It has been confirmed that between 2015 and 2020, there will be a 35% change in the human skills that are highly required in organizations to create value.

The experts also emphasize the importance of governments collaborating with various sectors and partners to improve human resource capability to bring about the radical transformation that artificial intelligence can bring to the nature of jobs and career specialization in the future. AI is launching a community and human dialogue on creating new career paths and quality options. Artificial intelligence can enhance productivity and cost-effectiveness and promote innovation, organizational culture, and entrepreneurship by integrating human capabilities with machine learning.

Challenges of AI in the HR sector

AI has had a significant impact on how employees work, particularly in Asia and Africa, where traditional low-skilled workers are being replaced by intelligent machines, threatening the growth and livelihoods of workers in these economies (BBC, 2019).

The organization needs to focus beyond the technical terms and put their efforts into non-technical development such as human skills and competencies, leadership, team coordination, organizational culture, innovation mindset, and governance strategy, and also focus on the benefits of AI-based employee integration strategies.

Artificial Intelligence in Business

AI is an activity that makes a machine intelligent, and intelligence is the quantity that enables an organization to perform appropriate functions with foreknowledge of its dynamic environment (Wang et al. [6]).

Artificial intelligence is a field devoted to making machines intelligent and Intelligence is the ability of an entity to function appropriately and with foresight in its environment in artificial intelligence (AI), computer science, and machine intelligence, as demonstrated by machines in contrast to the natural intelligence displayed by humans and other beings. Computer science defines artificial intelligence research as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Kaplan and Haenlein [7] defined AI as "a system's ability to correctly interpret external data, to learn from such data, and to apply what they've learned to achieve specific tasks and goals through flexible adaptation." Colloquially, the term "artificial intelligence" is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem-solving."

The research studies have discovered the benefits of using AI in the organization without sacrificing time, effort, or resources. (Soumyadeb Chowdhury et al., 2023)

The data is the most crucial element of artificial intelligence; the AI is trained by utilizing a large collection of data (Pumplun et al., 2019; Schmidt et al., 2020). The AI gains the ability to

make the decision that is made based on these large sets of data despite using detailed knowledge defined by experts (Pumplun et al., 2019; Schmidt et al.,2020). Therefore, the organization having AI has the most crucial element, i.e., data, for example, sensor data (Demlehnar&Launer, 2020), or has access to it (Mikalef& Gupta, 2021). There is a three-dimensional research model in AI that is based on Neo-Schumpeterian economics, and its forces are innovation, knowledge, and entrepreneurship. The first dimension deals with research and innovation; the second one deals with the global market and strategic objectives; and the last dimension examines how AI is shaping the business context. (Neha Soni et al., 2019)

In the present scenario, artificial intelligence can estimate human intelligence and perform different activities that require thinking and learning. These issues need to be addressed and settled with different methods. The robots, PCs, or other related technology that are designed for AI programming or projects provide basic reasoning capacity (Zhang et al. 2016).

Large companies, such as Google, Amazon, and Microsoft, have started to provide the framework for machine learning in the cloud (Borges et al., 2020), for example, Google cloud AI. These solutions give online access to the infrastructure in other organizations for adopting AI (Borges et al., 2020; Schmidt et al., 2020; Wang et al., 2019). Therefore, companies need to access a cloud-based solution or use the right computational hardware to provide access to AI on their own.

The current trend is that top management support is one of the most important determinants of AI adoption.(Alsheiabni et al., 2018; AlSheibani et al., 2020; Alsheibani et al., 2020; Demlehner&Laumer, 2020).

According to the report by Narrative Science, it was found that around 61% of businesses have adopted artificial intelligence to carry out their operations, which is higher than the 38% in 2016 (as cited in Royame, 2018). This shows that organizations have a positive attitude toward AI adoption for their business operations. Based on previous reports and articles, AI adoption has been implemented in different sectors like HR, IT, finance, and many more.

The adoption of artificial intelligence has changed the dynamics of the business world, according to Muhammad Zafeershahid (2019). The application of artificial intelligence helps improve the marketing field's performance and, thus, profitability and competitive advantage.

ARTIFICIAL INTELLIGENCE IN HUMAN RESOURCE MANAGEMENT

Recent research has demonstrated the positive impact of AI adoption in the field of human resources. (Jia, Guo, Li, and Chen), Garima, Vikram, and Vinay), George and Thomas), and Vivek and Yawalka) in their similar studies, the advantages of AI adoption are described in the dimension of HRM, which includes employee relation management, recruitment and selection, compensation management, training and development, performance management, and HR strategic planning. They further elaborated on the usefulness of AI adoption for its employees, HR professionals, and the organization as a whole.

CONCLUSION

Artificial intelligence is a type of machine learning that has had a significant impact on a variety of industries. Industries like retail, manufacturing, logistics, healthcare, transport, and so on. Many companies have adopted AI integration in the three basic fields of automation, data analytics, and natural language processing. These three fields of AI are streamlining operations and improving efficiency (Rebecca 2019).

The successful AI integration companies are ABB, Alphabet, Amazon, Microsoft, Google, Apple, etc.

The workplace may be transformed by AI-based solutions that bridge the talent and human resource gaps. Thus, we may draw the conclusion that artificial intelligence contributes to corporate economic growth by increasing productivity and reducing time and cost across a number of industries (human resources, finance, and marketing).

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TUMOR BIOLOGY AND ARTIFICIAL INTELLIGENCE: AN OVERVIEW

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ABSTRACT
Cancer or tumor globally affected and leading cause of death. Updated screening, diagnosis, along with management still is major concern to deal with in past decade. Artificial intelligence or machine learning said "A branch of computer science intended for assuming & automation, emerging like impactful resolving the healthcare system as well as facilitate error less services in medical system. AI significance in tumor biology, still beyond that, mediating or facilitate tumor research along with advancing clinical practice as well as precise learning related with molecular biology of tumor. In this review analysis the current scenario of Intelligence oncology, including fundamentals, applications, boundaries & future outlook .Artificial Intelligences is also consist for optimization of most cancer studies, development of scientific practice (e.g., Prediction of the affiliation of a couple of parameters and outcomes – analysis and response) and higher knowledge of tumor molecular biology. The modern nation of Artificial Intelligences in neurologist, such as fundamentals, modern programs, boundaries and destiny perspectives.

Keywords: Artificial Intelligences, Cancer, Data Integrations, Neurologist

INTRODUCTION
Cancer debts for considerable morbidity and mortality worldwide. An envisioned 19.three million new most cancersinstancescame about in 2020 [1], and this determine is anticipated to boom over the following few decades. Projections display that 30.2 million new most cancersinstancesmight berecognized in 2040 [1]. Despite extensiveenhancements in most cancersprognosis and control [2] which haveled toa discount of most cancers mortality over the past decades, a magnificent 10 million most cancers-associated deaths came about in 2020 [1]. It is vital to sell innovation in healthcare and particularly in most cancers care. Early prognosis of cancers staysa primeworldwidetask. Effective screening projects are constrainedthrough public buy-in, monetaryguide, etc. and do now no longercowl all at-danger populations [3]. However, increasing screening projects without evidence-primarily based totally indication can cause a considerablemonetary burden and waste treasuredsources in resource-restrictedfitnessstructures [4]. Although most cancers remedy alternatives have multiplied with inside the ultimate decades, simplest a subset of privledged sufferers advantage from novel most cancerspills and the cost-advantage ratio of modernremedies is suboptimal [4]. Thus, there sanpressing want to make most cancers remedy greater low-cost and customized. The improvement of latest anticancer remedies is a time and resource-in depth method. Even after a drug passes preclinical checking out and undergoes scientific trials, the achievement charge is low, and affected person enrollment will become challenging [5]. Despite those demanding situations, sixty four interventions targeted on most cancers diagnostic or remedyhave beenauthorised or had their warning signsmultipliedthroughthe United States FDA in 2020 [6]. The fast movingsurroundings of most cancersstudiesresults in a surplus of applicable literature posing a task to physicians looking toobserve the contemporarytips to their practice. Data captured from oncology vendors and healthcare structures are complicated and diverse. Doctors' typed or dictated notes, laboratory findings, histo-pathological and imaging records and affected person-generated fitnessrecords are examples of the unpredictability of the facts captured. Crude scientificrecords are of regularly of constrained relevance, accordinglyacquiringsignificantscientific insights and analytics is predicated on good enoughrecords extraction, processing, analysis, interpretation and integration. Acknowledging

that the potential of the human mind to method facts is constrained, there'sanpressing want for the implementation of opportunity techniques to method contemporary-day huge records (describes the huge quantity of records – each dependent and unstructured – that inundates a healthcare on a everyday basis). In addition to the expanded availability of records, the augmentation of garage and computing strength has boosted the improvement of records-processing strategies, which includessystemstudying (ML) and synthetic intelligence (AI), which can be turning into more and more vital gear to address complicated problems in most cancers care. A developing frame of research spotlight AI as an rising device to assist customize most cancers-care techniques through study into be had records. A current observe diagnosed ninety seven registered scientific trials for AI in most cancersprognosis, maximum of them began out after 2017 [7]. Artificial intelligence (AI) Artificial intelligence may bedefined as a department of laptop technological know-how handling the simulation of sensibleconduct in computer systems. It is predicated on computer systems following algorithms set upthroughpeople or discoveredthroughlaptoptechnique to guideselections or execute sure tasks [8]. Machine studying is a subfield of AI and represents the methodthrough which a laptop is capable ofenhance its personaloverall performancethroughconstantly incorporating newly-generated records into anpresent iterative model [9]. Deep studying (DL) is a subfield of ML in which mathematical algorithms are deployed the use of multi-layered computational gadgetsakin to human cognition. These consist of neural networks with exceptional architectures types (e.g., recurrent neural networks, convolutional neural community and long time brief memory). Artificial neural networks can also additionally have exceptionalstructure on how they observe mathematical guidelines to records and may bebeneficialto research unstructured records [10]. Unstructured records are a totally not unusual place form of scientific records used to file qualitative and subjective factsnormallyobtainedthruaffected person–company interactions or imaging acquisition. Applying AI to unstructured textual content records may be carried out through herbal language processing (NLP) strategies and recurrent neural networks are DL algorithms typicallybeneficial for this task. In contrast, convolutional neural networks are the maximum used and promising AI architectures with inside the exploration of imaging files.

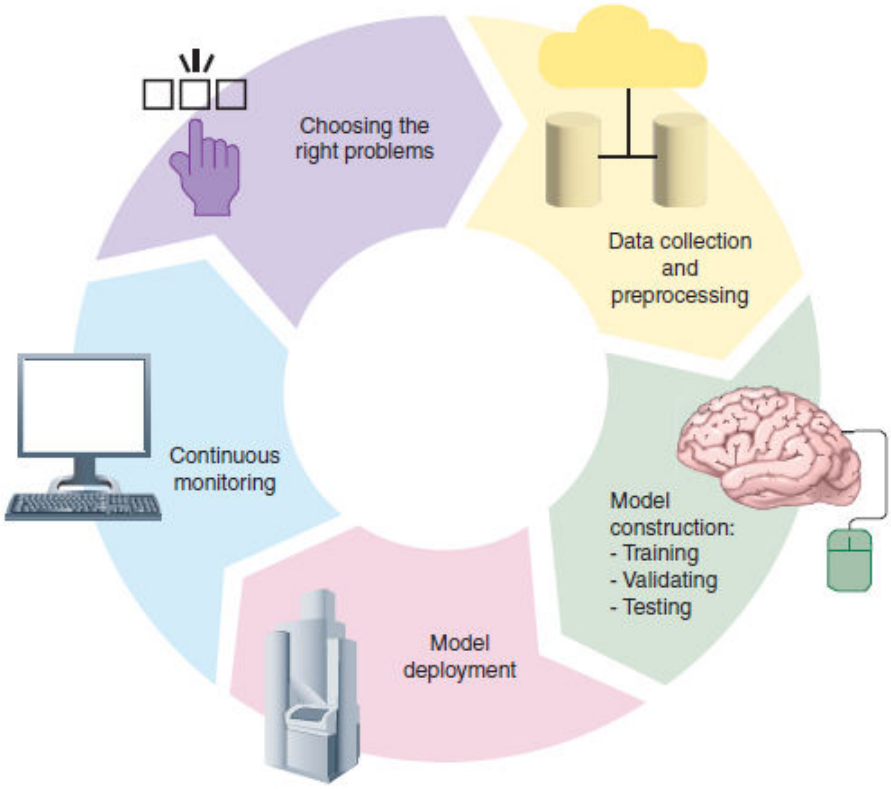

Figure: 1 Artificial intelligence fly wheel .graphic representation of the artificial Intelligence and data cycle for building effective and responsible machine learning models for healthcare.

Artificial intelligence for most cancersanalysis Cancer diagnoses also can be optimized the use of AI. AI-powered colonoscopy has proven to be a cost-powerful intervention via way of means ofefficaciouslyfiguring out benign polyps for this reason now no longer requiring resection [11]. This could now no longer handiest store healthcare assets however could additionally save you unfavourable occasions from a greater invasive remedy approach. Accurate analysis of cancerous and precancerous lesions can permit for minimization of overtreatment. On that note, AI algorithms assisting colposcopy pics assessment have proven excessive accuracy in predicting precancerous lesions in cervical most cancers screening [12]. AI-primarily based totally specific most cancers stratify cation at analysis can assist in minimizing invasive interventions and pointless surgical procedures [13]. Artificial intelligence for most cancersstudies Recent research have talked about that the blessings of AI in most cancers care crosspast optimization of modern-dayinstalledremedy strategies. AI is likewise relevant in preclinical settings along with fundamental translational studies and most cancers tablets improvement [14]. Artificial intelligence can assist combine and technique data from a couple of databases and allow drug repurposing [15]. AI identifies capacity new tablets inside a quick term at an low cost [16]. Drug checking out can simulate and are expecting the effectiveness of most cancers healing procedures main to higher effects in in-vivo experiments [17], which in flip could boost up scientific studies. Clinical trials also can come to be greater green with using AI. Study consequences may be expected the use of AI models [18] that could drastically decrease charges of drug improvement. AI has been used to become aware of sufferers for scientific trials [19] via way of means of incorporating inclusion and exclusion standards to look EHR(electronic health records) and become aware of eligible sufferers, therefore facilitating player accrual. These structures have provenexcessive accuracy even ashandiest requiring a 5th

of the time utilized byguidereview [20]. Previously posted statistics cautioned that a better charge of scientific trial enrollment now no longer handiest results in quicker advances in most cancers remedy however is likewise associated with higher most cancers populace survival consequences [21]. AI from lab to clinics: challenges & scopes Despite AI-primarily based totally algorithms having been carried outvia way of means of many groups for statisticsassessment, their translation into scientificexercisestaysaundertaking [22]. Barriers consist ofboundaries in statisticsseries and training, shortage of potentialscientific validation, problems in consumertraining and moral/regulatory suggestions [23, 24]. Challenges associated withstatisticsvariety accuracy to relevancy of the data assembled. Meaningful statisticswishes to be relevant, with excessivenice and technique able [25]. The first step for statisticsevaluation is the pre-processing of a described set(s) of statistics(s). This calls for normalization, noise filtering and characteristic choice while a couple of dataset is combined. Normalization turns into a critical step to take away bias while studying exceptional units of statistics which can be merged. The choice of described capabilities is an essential section within side the fulfillment of a classification, regression and sample popularity algorithm. Another foremost undertaking in precision oncology is to combine statistics generated from diverse forms of genomics and a couple of reassets of data to are expecting biomarkers or scientific consequences [25]. In addition, there may be a relative lack of know-how of the scientific network associated with AI and its techniques and programs. Education of all stakeholders along with sufferers, companies and commercial enterprise directors is important in order that advances may be translated right into a better nice care [26]. A seamless integration of any new device into scientific workflow is essential to its long-time periodfulfillment. Rigby et al. highlighted the moral undertaking with AI in healthcare. It is vital to deal with the moral problems associated with use of affected person statistics in unwarranted and unconsented situations even as respecting moral guidelines and suggestions designed to shield affected person protection and privacy [27]. Although AI may be hired to decrease charges within side the numerous situations provided on this review, large infrastructure investments are required to allow its utility. Data garage and compute energyaren'tfreed from cost, and human assets (along with data era and bioinformatics personnel) are crucial for the well timed and steady utility of those equipment [26]. Cloud offerings have become greater sizable and will probably lower the want for preliminary investments on single-groupexcessive-overall performance computing clusters and devoted professionals. Nonetheless, garagecharges and compute time nevertheless incur large expenses, and compensation for AI-primarily based totally scientific offerings will should be described. Quality manipulate approaches will want to be in region to make sure secure utility of era. It is important to factor out, however, that despite the fact that AI improvement and implementation charges might also additionally pose an undertaking, preliminary funding interprets into large technique enhancement at minimum extra destiny charges [27].

CONCLUSION

AI has already had a large effect in healthcare and could keep to revolutionizing medicine. The capacity is superb and has programs in most cancers studies, screening, analysis, remedy and monitoring. AI additionally has the capacity to lower healthcare charges and disparities. Several equipmenthad beenevolved harnessing the various set of scientificstatistics (along with free-text, laboratory and imaging effects, radiological pics and genomics statistics).With those dreams in mind, in addition studies is important to keep and make sure analytical and scientific validity and scientific utility.

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PHARMACEUTICAL APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS (ANNS)

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ABSTRACT
Artificial neural networks (ANNs), also known as "artificial neural nets" or "neural nets", are one of the most popular and promising areas of artificial intelligence research.Artificial Neural Networks (ANN) is used as powerful thinking tool in development of pharmaceutical formulation this can be used in diagnosis of disease, drug design, determination of physicochemical properties of a drug, drug testing, optimization, pharmacokinetics, in vitro and in vivo correlations, and also in drug interactions study. ANNs are artifificial intelligence systems mimicking the human brain is made of bunch of connected neurons.Thereare two main categories of AI developments. Thefirst includes methods and systems that simulatehuman experience and draw conclusions from a setof rules, such as expert systems. The second includes systems that model the way the brainworks, for example, artificial neural networks (ANNs).AI is also being used extensively in precision medicine to construct and optimize diagnosis routes and treatment techniques.This review focuses on the potential applications of ANN methodology in the pharmaceutical sciences in prediction, dosage form design,characterization and optimization of pharmaceutical formulation to provide a reference for the further interdisciplinary study of pharmaceutics and ANNs.

INTRODUCTION
ANN represents a promising modeling technique, especially for data sets having non-linear relationships which are frequently encountered in pharmaceutical processes[1 Mendy A sic2010].

The brain is an essential organ in the human body that can control the whole body. It can quickly analyze disordered and unclear information within a short time. It is interconnected with the number of cells, particularly neurons.Human brainfunctionality is the same as one mathematical model: Artificial Neural Networks (ANN) are the type of artificial intelligence system. ANN is the same as the structure of biological neural networks in the human brain. Like, Neurons in the brain are equivalent to a processing element (PE) or artificial node in ANN[2 Puri M 2015].In the recent decade, researchers have been using AI to drive the emergence of computational precision medicine[3 Azuaje F 2019].

AI allows the identification of complex biomarker signatures, i.e. diseasespecific altered networks of genes and proteins shared throughout tumour types and across multi-omics layers, which overcomes the outdated 'one gene, one medication, one illness' paradigm[3 Azuaje F 2019]. Nevertheless, AI is also being used extensively in precision medicine to construct and optimize diagnosis routes, treatment techniques, and prognoses.It is also being used to create biomarkers that may be used to stratify patients depending on their sickness risk, prognosis, and/or responsiveness to therapy[4 Saxena A 2021]. Additionally, AI facilitates the design, selection and repurposing of drugs interacting with targets. AI and machine learning (ML) improve medication design and development by understanding disease heterogeneity, discovering dysregulated molecular pathways and therapeutic targets, creating and optimizing drug candidates, and assessing clinical effectiveness in silico. By offering a previously

unrivalled degree of understanding of both patient specificities and medication candidate features[5 Moingeon P 2022]. Among the different networks in AI, ANN has a prime role in pharmaceutical drug development applications. ANN is made up of a bunch of interconnected nodes. All of these nodes are useful in communicating with one another. They are made up of numerous layers called multi-layer perception (MLP). Each layer in this system plays a distinct role in the data it receives. The first of these layers is an input layer, which gets the necessary data. The hidden layers (one or multiple) then collect data from the input layer, process it, and transfer it to the output layer. The hidden layers capture all the minute nuances as they progress deeper. Finally, the output layer produces a result that is straightforward to comprehend. Because it is carried out in parallel, this technique is known as parallel processing[2 Puri M 2015]. It is well-known fact that drug discovery and development is a multi-step and expensive process. Since begun of the 20th century, ANN has been used in the field of drug discovery and development effectively. Virtual screening (VS) or high-throughput screening (HTS), formulation development, design of chemical synthesis, docking, quantitative structure-activity relationship (QSAR)[6 Mandlik V 2016], quantitative structure-toxicity relationship (QSTR), pharmacokinetics, and pharmacodynamics, and others have been used with the help of ANN.They are an effective tool for learning, understanding, and extrapolating data for analysis and prediction.

Table 1: Role of ANN in Pharmaceutical Sciences

Area in pharmaceutical sciences	Applications of ANN
Drug discovery	◆ It has been used to assess ligand-receptor shape complementarity. ◆ Their purpose is to anticipate nonlinear correlations between physicochemical characteristics to predict a compound's biological activity. ◆ Used to estimate the binding energy of the final docked complex using match surface characteristics, speeding up the ligand screening process. ◆ They are used for docking data feature analysis. ◆ It is used to predict the ADMET properties, including biotoxicity.
Pharmaceutical formulation development	◆ They are used in the pre-formulation studies in formulation development. ◆ It is used to develop formulations containing multiple active ingredients as well as controlled-release formulations. ◆ The formulations' alternative to multiple regression analysis, includes liposomes, hydrogels, tablets, powders, pellets, gelispheres, transdermals, granules, and emulsions.
In vitro-in vivo relationship	◆ For example, in vitro qualities and in vivo patient features have been utilized to predict clinical outcomes. ◆ It is used to anticipate in vivo outcomes from in vitro research and to analyze various product formulations more

	efficiently.
Qualitative and quantitative drug analysis	◆ They are used for the identification, separation, quantification, and optimization of various analytical conditions.
PK/PD modelling	◆ Useful in PK/PD models with many layers (input, PK compartment, receptor, and pharmacological output). ◆ It is used to analyze analytical data, the process in vitro/in vivo correlations, and generalize the relationship of drug concentrations with discovered functional effects.
Drug-drug interactions	◆ Used to predict potential DDIs.

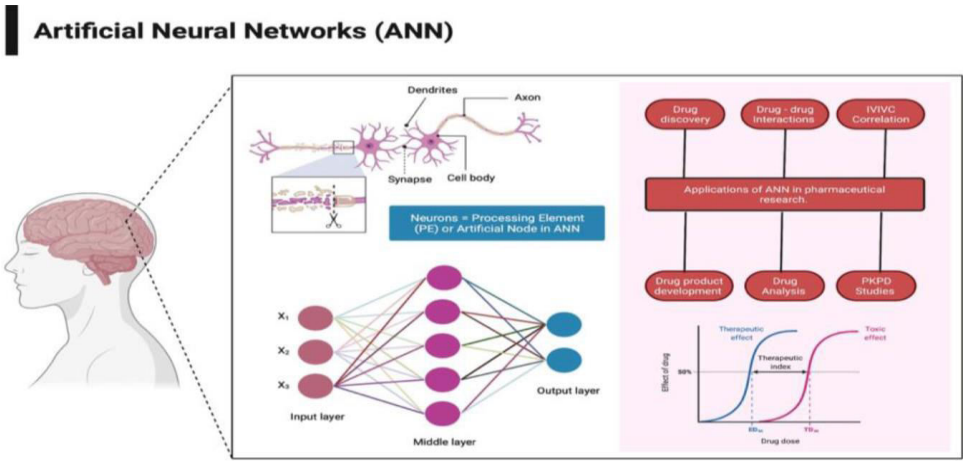
TYPES OF NEURAL NETWORKS

As biologically inspired computational model, ANN is capable of simulating neurological processing ability of the human brain. A single neuron consists of three major parts—dendrites (fine branched out threads) carrying signals into the cell, the cell body receiving and processing the information, and the axon (a single longer extension). The axon carries the signal away and relays it to the dendrites of the next neuron or receptor of a target cell. Similarly to the brain, ANN is composed of numerous processing units (PE), artificial neurons. The connections among all the units vary in strength, which is defined by coefficients or weights. The ANN mimics working of human brain and potentially fulfills the cherished dream of scientists to develop machines that can think like human beings.ANNs simulate learning and generalization behavior of the human brain through data modeling and pattern recognition for complex multidim- ensional problems. A significant difference between an ANN model and a statistical model is that the ANN can generalize the relationship between independent and dependent variables without a specific mathematical function[7 N. Minovski jan2013],[8 R. Bartzatt sep2012].

There are many types of neural networks with new ones being continually invented; however, all ANNs can be characterized by their transfer functions of their processing units (PE), the learning rules, and by the connections formulas. PE, building component of ANN, receives many signals as weighted process variables from the response of other units[9 J.S.Almeida feb2002]. The most commonly applied ANN layout is forward propagating network The ability of neural networks to classify information depends on hidden layers, which are fully connected by the synapses to the neighboring layers[10 S.Agatonovic-kustrin jun2000],[11 D.R.JL.McClelland 1998],[12 J.Bourquin May1997].

Models of Artifificial Neural Networks

Artifificial neural network models can be divided into many types according to the mutual combination relationship between neurons. Some of the well-known ANN models include: the multilayer perceptron (MLP); the radial basis function neural network (RBFNN); the convolutional neural network (CNN); the Kohonen network; and the recurrent neural network (RNN)[13 Ibric S. 2002],[14 Jelena Djuris 2013]. ANN models with distinct structures have been developed and applied to deal with various problems. On one hand, the MLP is the basis of ANN modeling and brings ANN universality. After understanding MLPs thoroughly, the whole framework of artifificial neural networks will be easily connected. On the other hand, most ANN models introduced to pharmaceutical science are static neural networks, especially MLPs and GRNNs (generalized regression neural networks, an improved kind of RBFNN). Hence, starting from the MLP, the components and elements of the MLP and GRNN models are introduced in detail.



Applications of ANNs in Pharmaceutical Science

Although it delivered excellent outputs, ANNs were not popular until the beginning of the 21st century among the pharmaceutical researchers. Reasons for this may include the unavailability of infrastructure, lack of the knowledge of algorithms and programming languages of ANNs, lack of confidence on the new system of process development, etc. However, from 2001 onward, different pharmaceutical researchers took interest in the field and developed different techniques and programs to cover different aspects of the pharmaceutical product and process development.

ANNs for Prediction of In Vitro Dissolution Profile

Dissolution testing allows one to examine the drug release behavior of pharmaceutical dosage forms in vitro to differentiate formulation types and perhaps give an estimate of dissolution behavior in vivo. Dissolution testing is routinely used in quality control studies such as batch-to-batch consistency, stability, and detection of manufacturing deviations

Goh et al. used the leave-one-out cross-validation approach. The dissolution profiles of all of the matrix ratios were used for training of the ANN, except a reference profile, to which the network-predicted profiles were compared. Performance of the network was assessed using the similarity factor, f2, the criterion for dissolution profile comparison recommended by the U.S. Food and Drug Administration (FDA). Study results indicated that the ANN was capable of predicting dissolution profiles that were similar to the reference profiles with an error of less than 8%. In addition, they also used the bootstrap method to estimate the confidence intervals of the f2 values. The results revealed the potential of a neural-network-based intelligent system in solving nonlinear time-series prediction problems in pharmaceutical product development.Goh and colleagues reported the use of an ANN for the prediction of in vitro dissolution profiles of matrix-controlled release of theophylline pellet preparation.

Leane et al. reported the use of ANN to predict the in vitro dissolution of sustained-release (SR) minitablets. They studied the relative importance of various factors, both formulation and process, governing the in vitro dissolution from enteric-coated SR minitablets with the help of ANNs. They used input feature selection (IFS) algorithms to estimate the relative importance of the various formulation and processing variables in determining the minitablet dissolution rate.

ANNs in the Modeling and Optimization of Pharmaceutical Formulations

ANNs in Prediction of the In Vitro Permeability of Drugs

In vitro permeability studies can assess the oral absorption potential and characteristics of drug candidates, especially for Biopharmaceutics Classification System Class III and Class IV drugs.

Typically, Caco-2 (human carcinoma of the colon) and/or MadineDarby canine kidney cells are grown as monolayers in Transwell plates and are used for these types of studies.

Paixao et al. predicted the in vitro permeability determined in Caco-2 cells by using ANNs. For the study, they collected the in vitro Log Papp values for 296 different drugs from published studies of drug absorption in Caco-2 cells.From the study, they concluded that the ANN model may be a valuable tool for prediction and simulation in the drug development process because it allows for the in silico estimation of the in vitro Caco-2 apparent permeability

ANNs in Minimization of the Capping Tendency by Tableting Process Optimization

Belic et al. described about the minimization of the capping tendency by tableting process optimization with the application of ANNs and fuzzy models.ANN and fuzzy models were used for modeling of the effect of the particle size and the tableting machine settings on the capping coefficient. The suitability of routinely measured quantities for prediction of the tablet quality was tested.ANN and fuzzy models were used for modeling of the effect of the particle size and the tableting machine settings on the capping coefficient. The suitability of routinely measured quantities for prediction of the tablet quality was tested. The results showed that model-based expert systems based on the contemporary routinely measured quantities can significantly improve the trial and error procedures;

ANNs in Optimizing Emulsion Formulation

Kumar et al.reported on the application of ANNs in optimizing the fatty alcohol concentration in the formulation of an o/w emulsion. The purpose of their study was to optimize the concentration of a fatty alcohol, in addition to an internal phase, for formulating a stable o/w emulsion by using ANNs.The ANN model's predictive results and the actual output values were compared. R2 values depicted the percentage of response variability for the model; the R2 value of 0.84 for the model suggested adequate modeling, which is supported by the correlation coefficient value.

ANNs in Determination of Factors Controlling the Particle Size of Nanoparticles

Asadi et al. prepared biodegradable nanoparticles of triblock poly (lactide)e poly (ethylene glycol)epoly (lactide) (PLAePEGePLA) copolymer and studied the factors controlling the particle size of the prepared nanoparticles using an ANN. The purpose of their study was to prepare nanoparticles made of triblock PLAePEGePLA with controlled size as the drug carrier. ANNs were used to identify factors that influence particle size.

The model was then used to survey the effects of processing factors including polymer concentration, amount of drug, solvent ratio, and mixing rate on particle size of polymeric nanoparticles. They observed that polymer concentration is the most affecting parameter on nanoparticle size distribution. Their salts demonstrate the potential of ANNs in modeling and identification of critical parameters effective on final particle size.

ANNs in Tablet Manufacturing

Tablets are the common dosage form available on the market because of their desirable advantages, which include the following: patient acceptability; noninvasive; portability.Aksu and colleaguesapplied ANNs in the manufacturing of tablets by a direct compression technique. From the study, they concluded that ANNs provide a huge time benefit; in addition, these programs are not used for the pharmaceutical industry as much as other industries. The objective of their study was to optimize ramipril tablet formulation and to create knowledge and design spaces, which were the new approach for the pharmaceutical product development with the aid of an ANN program and genetic programming. After the optimization, it was confirmed that the explored formulation was within the design space.

ANNs in Investigation of the Effects of Process Variables on Derived Properties of Spray-Dried Solid Dispersions

Patel et al. published their study report regarding the use of an ANN and polymer-based response surface model for investigation of the effects of process variables on the derived properties of spray-dried solid dispersions (SSDs). The objective of their study was to use different statistical tools to understand and optimize the spray-drying process to prepare solid dispersions. In the study, they investigated the relationship between input variables (inlet temperature, feed concentration, flow rate, solvent, and atomization parameters) and quality attributes (yield, outlet temperature, and mean particle size) of SSDs using a response surface model and ensemble ANN.

ANNs in the Validation of Pharmaceutical Processes

Behzadi et al.compared two types of ANNs used for validation of pharmaceutical processes. They used a multilayer perceptron (MLP) and a GRNN for the validation of a fluid-bed granulation process.s. They found that the two networks gave comparable results.They also found that the correlation coefficients between the experimentally determined and the calculated output values, the corresponding prediction accuracy for the different granule.properties, and the overall prediction accuracy using GRNN were better than using MLP. In conclusion, they said that the comparison of two different networks showed the higher capacity of the GRNN for validation of such granulation processes

Other Applications of Artifificial Neural Network

In addition to the applications mentioned above, ANNs can be used to determine drug concentration, predict transdermal permeability , determine the critical quality attributes that affect a certain formulation property , predict the intrinsic solubility of drugs , control the granulation process within a flfluidized bed , predict the stability of dosage forms , characterize physicochemical properties , control drug quality in ulticomponent formulation with overlapping spectra and predict complex colloidal delivery systems phase behavior so as to improve the effificiency of conducting various related processes

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APPLICATION OF NANO FORMULATION DIRECT NOSE TO BRAIN DRUG DELIVERY

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ABSTRACT
Drug administration through the nose to the brain is thought to be a practical way to get across the blood-brain barrier and deliver a variety of therapeutic medicines with limited cerebral bioavailability (BBB). The fundamental process for the transfer of drugs from the nose to the brain involves drug absorption from the olfactory area via nerve fibres and the vascular system. In addition to overcoming biological barriers (BBB, first-pass metabolism, and intestinal degradation), drug-loaded nanocarriers designed for nose to brain delivery also have many benefits, including higher patient compliance (compared to injection), rapid drug absorption, and enhanced bioavailability (especially for lipophilic drugs). This paper highlights developments in drug-loaded nanocarriers for effective nose-to-brain drug delivery, including nanoemulsions, microemulsions, lipid nanoparticles, transfersomes, liposomes, and polymeric micelles etc., It also discusses various ways to get around the mucociliary clearance, lower brain-blood ratio, and the cap on the amount of drug that can be incorporated, which are the most frequent drawbacks. Important issues related to the toxicity of nose-to-brain medication delivery devices are also covered.

Keywords: Nanostructure lipid carrier, Blood brain barrier, Nanoparticles, Nanoemulsion, Liposomes.

INTRODUCTION
Numerous routes, including the systemic, olfactory, and trigeminal nerve pathways, have been proposed as potential routes for Nose-to-Brain medication administration. The medicine is delivered into the systemic circulation via the systemic pathway, which involves direct absorption from the highly vascular nasal epithelial cells and lymphatic system. Drugs with low molecular weight that are easily absorbed into the bloodstream and may then pass across the blood-brain barrier (BBB) to reach the site of action are most often transmitted in this way (1,2). For the delivery of drugs that are specifically intended for the brain, olfactory (nerve & epithelia) and trigeminal nerve pathways are important because they allow for quick beginning of action, less systemic exposure, and circumvention of the BBB (3). The internalisation of medicines into olfactory neurons and their intracellular axonal transport along the neurons into the olfactory bulb, from where they are further disseminated to other areas of the brain, are accomplished via pinocytosis and endocytosis (4,5). In addition, the nose's anatomy and physiology complicate the nose-to-brain barrier. P-glycoprotein efflux pumps, which limit drug exposure in the CNS by expelling them back into the nasal cavity, are located in the olfactory epithelium and endothelial cells that surround the olfactory bulb (6). Additionally, the volume of medication that may be delivered intranasally (25–200 L) is extremely constrained, which restricts the dosage and concentration of medication that can be delivered to the brain. Large dosages of drugs with higher concentrations may have an adverse effect on absorption because of local side effects, which in certain situations may harm the nasal mucosa. In addition, mechanisms such mucociliary clearance, enzymatic degradation, and a brief drug retention period restrict drug administration with IN delivery methods (7,8). To overcome these challenges, some researchers have focused only on developing an advanced drug delivery mechanism. Treatment for a variety of CNS illnesses and disorders can be beneficial after overcoming the challenging difficulties.

There is currently potential for selective and targeted brain delivery due to developments in nanotechnological formulations for medication delivery to the brain (9). The administration of powerful and tailored medications to the CNS by-passing the primary physiological barriers—the blood-brain barrier (BBB) and the blood-cerebrospinal fluid barrier (BCFB)—through intranasal drug delivery has attracted increasing attention (10,11). An ideal absorption surface for medications and highest access to the CNS are ensured by the greater vascularization of the nasal mucosa, the leaky epithelial nasal tissue, and direct drug access via the trigeminal and olfactory pathway of the nasal cavity (12,13). Additionally, it can have a number of advantages over oral or intravenous administration, including non-invasiveness, self-administration, a quicker onset time, a higher cerebral bioavailability due to the avoidance of first-pass liver metabolism, and bypassing the BBB and BCFB, which may potentially increase drug availability to the central nervous system (CNS) (14,15). Lipid nanoparticulate systems (solid lipid nanoparticles (SLN)/nanostructured lipid carriers (NLC)), liposomes, nano emulsions, micro emulsions, polymeric micelles, dendrimers, transfersomes, etc., are just a few of the numerous nanocarriers loaded with drugs that have been successfully tested for better CNS delivery (14,16). In order to achieve better targeting and less systemic adverse effects, the nanocarrier formulations are thought to be a potential strategy since they shield medications from chemical and/or metabolic degradation, enhance their solubility, or permit transport over biological barrier membranes (17).

INTRANASAL ROUTE FOR BRAIN DRUG DELIVERY

For a drug to act centrally when delivered via the intranasal route must traverse effectively and rapidly across the nasal mucosa and from a kinetic point of view the nose is a complex organ with drug deposition, clearance and absorption occurring concurrently (18). Hence, to understand the mechanisms and pathways of drug transport to the brain following intranasal administration, an understanding of the anatomy and physiology of nasal cavity is crucial.

MECHANISMS OF NASAL DRUG ABSORPTION

Several mechanisms have been proposed to demonstrate the transnasal absorption of drugs into the brain (19, 20). However, the paracellular and the transcellular mechanisms are considered predominantly. The paracellular/extracellular mechanism is a passive and slow aqueous route of transport through the intercellular tight junctions or the open clefts of the epithelial cells of the nasal mucosa (21,22). In nose to brain transport of drug the paracellular mechanism involves two extracellular routes, first across the olfactory neurons and the second across the trigeminal nerve. After reaching the olfactory bulb or the trigeminal region the therapeutics may enter other brain regions by simple diffusion, facilitated by an arterial pulsation driven perivascular pump. Paracellular mechanism demonstrates an inverse log-log correlation between intranasal absorption and the molecular weight of polar compounds. Poor bioavailability has been observed for drugs having molecular weight greater than 1000 Daltons irrespective of their lipophilicity. Agents like chitosan have also been tried to manipulate the tight junctions between the nasal epithelial cells to facilitate transnasal drug absorption (23).

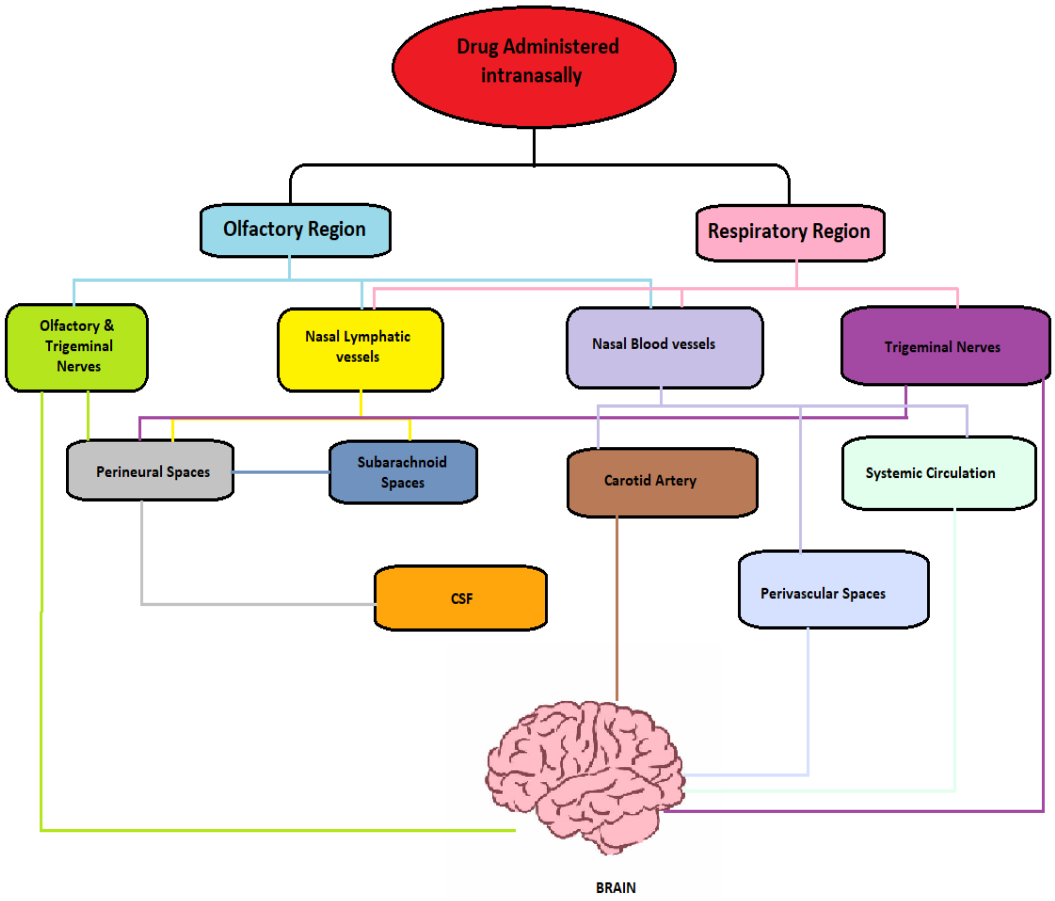

Fig-1- Nasal Product for Brain Drug Delivery on Market and under Development.

The second transcellular/intracellular mechanism entails transport through a lipoidal route by either receptor mediated endocytosis or passive diffusion or fluid phase endocytosis (24,25). This mechanism accounts for the transnasal absorption of both small and large lipophilic molecules. Hence, transcellular drug uptake is mainly a function of the lipophilic nature of the drug compound with highly lipophilic drugs being expected to have rapid/complete transnasal uptake. However, the transcellular mechanism is a slow process taking hours for nasally administered drugs to reach the olfactory bulb via the intercellular axonal transport by processes like endocytosis within the olfactory neurons (26-29).

NEURAL PATHWAYS

The neural connections which the olfactory and the trigeminal nerves provide between the nasal mucosa and the brain offer a unique pathway for the nose to brain delivery of therapeutics (30). This neural pathway may involve either an intraneuronal/transcellular or extraneuronal/paracellular route or both for drug delivery to the brain. The intraneuronal pathway is slow and involves axonal transport of drugs to the different brain regions. While the extraneuronal pathway delivers drugs directly to the brain within minutes (31-33).

Olfactory neural pathways originate in the olfactory region at the roof of nasal cavity, with the olfactory neurons being scattered among the supporting cells (sustentacular cells), the microvillar cells, and the basal cells. Olfactory nerve pathways have been demonstrated by several researchers evidenced by a high concentration of fluorescent tracers in the olfactory bulbs following nasal administrations (34-37). The dendrites of olfactory neurons extend into

the mucous layer of the olfactory epithelium, while axons of these bipolar neurons extend centrally through the lamina propria and through perforations in the cribriform plate of the ethmoid bone. The axons of olfactory neurons pass through the subarachnoid space containing CSF and terminate on mitral cells in the olfactory bulbs. From the olfactory bulb, neural projections extend to multiple brain regions including the olfactory tract, anterior olfactory nucleus, piriform cortex, amygdala, and hypothalamus. While, the trigeminal nerve innervates the respiratory and olfactory epithelium of the nasal passages and enters the brain in the pons. A segment of trigeminal nerve also terminates in the olfactory bulbs (38). It conveys sensory information from the nasal cavity, the oral cavity, the eyelids, and the cornea, to the CNS via the ophthalmic, the maxillary, or the mandibular division of the trigeminal nerve. Branches from the ophthalmic division of the trigeminal nerve provide innervation to the dorsal nasal mucosa and the anterior nose, while branches of the maxillary division provide innervations to the lateral walls (the turbinates) of the nasal mucosa. Nose to brain drug delivery along the trigeminal pathways was first clearly demonstrated for 125I-IGF-I, where high levels of radioactivity were observed in the trigeminal nerve branches, trigeminal ganglion, pons, and olfactory bulb (39). Since, one portion of the trigeminal neural pathway enters the brain through the cribriform plate alongside the olfactory pathway, it is difficult to distinguish whether an intranasally administered drug reaches the olfactory bulb and other brain areas via the olfactory or the trigeminal pathway or both.

VASCULAR PATHWAYS

The therapeutics can also be transported transnasally to the brain through the blood vessels supplying the nasal cavity, and from systemic circulation following nasal administration. Initially, the intranasal route was utilized to deliver drugs to the systemic circulation through absorption into the capillary blood vessels underlying the nasal mucosa. The nasal mucosa is highly vascularised receiving blood supply from branches of both the internal and external carotid artery, including branches of the facial artery and maxillary artery. The olfactory mucosa receives blood from the anterior and posterior ethmoidal artery (small branches of the ophthalmic artery), whereas the respiratory mucosa receives blood from the sphenopalatine artery (a branch of the maxillary artery) (40). The relative density of blood vessels is greater in the respiratory mucosa than the olfactory mucosa, making the former an ideal region for absorption of drugs into the systemic circulation. The respiratory region is a combination of continuous and fenestrated endothelium allowing the egress of both small and large molecules into the blood and subsequent transport across the BBB to the brain. This is especially true for small lipophilic drugs which more easily enter the blood stream and cross the BBB compared to large hydrophilic therapeutics such as peptides and proteins. It is also possible that the therapeutics rather than being distributed throughout the systemic circulation, enter the venous blood supply in the nasal passages to be rapidly transferred to the carotid arterial blood supplying the brain and spinal cord, a process known as counter-current transfer (41-43).

The drugs can also enter the brain by bulk flow through the perivascular spaces in the nasal passages or after reaching the brain parenchyma, to be distributed throughout the brain. Perivascular spaces act as a lymphatic system for the brain, where neuron derived substances are cleared from brain interstitial fluid by entering perivascular channels associated with cerebral blood vessels (44). Increasing number of evidences suggest this pathway involving perivascular channels associated with blood vessels, as a potential nose to brain drug transport mechanism (45-47). Perivascular transport is a bulk flow mechanism rather than diffusion alone (48,49) and the arterial pulsations are also a driving force for the perivascular transport (49, 50). Several intranasal studies demonstrate high levels of therapeutics in the walls of cerebral blood vessels and carotid arteries, even after removal of blood by saline perfusion, suggesting that intranasally delivered drugs gain access to the perivascular spaces (51-53).

CSF PATHWAYS

Pathways that connect the subarachnoid space containing CSF, perineural spaces encompassing olfactory nerves, and the nasal lymphatics, important for CSF circulation and drainage, provide access for intranasally administered therapeutics to the CSF and other areas of the brain. The CSF is produced by secretion at the four choroid plexi, especially at the fourth and lateral ventricles. CSF is a secretory fluid produced by the choroid plexi to cushion the brain (54). Numerous studies report that tracers injected into the CSF in the cerebral ventricles or subarachnoid space drain to the underside of the olfactory bulbs into channels associated with olfactory nerves traversing the cribriform plate, and reach the nasal lymphatic system and cervical lymph nodes (55, 59). Thus, CSF flows along the olfactory axon bundles between the cribriform plate of the skull and the olfactory submucosa in the roof of the nasal cavity. Intranasally administered drugs can take these same pathways moving from the nasal passages to the CSF into the brain interstitial spaces and perivascular spaces for distribution throughout the brain. Several intranasal studies demonstrate that drugs gain direct access to the CSF from the nasal cavity, followed by subsequent distribution to the brain and spinal cord, with the transport being dependent on the lipophilicity, molecular weight, and degree of ionization of drug molecules (60-62).

LYMPHATIC PATHWAYS

For several years the principle of CSF production via the choroid plexus and its absorption via the arachnoid villi to the cerebral venous sinuses had remained widely accepted. However, in the last two decades, there have been few reports describing the presence of a functional and anatomical connection between the extracranial lymphatics (nasal submucosal and cervical lymphatics) and the subarachnoid space via the perineural spaces and the cribriform plate (63). The nasal submucosal layer consists of a dense vascular network that leads to systemic circulation, and a dense network of lymphatics, that communicates directly with the subarachnoid space. The nasal submucosal lymphatics lead directly to the subarachnoid space via a perineural route to the cribriform plate. Nasal lymphatics offer a direct shortcut to the subarachnoid space and have been proposed as a potential pathway for the invasion of several pathogens such as S. pneumoniae, N. meningitis or H. influenzae responsible for bacterial meningitis (64).

Basic Formulation Consideration in Nose to Brain Drug Delivery System

Recent developments in nanotechnology have opened up promising possibilities for the treatment of brain disorders. A drug that is currently known to have poor brain absorption might be put into a nanocarrier system, which could interact favorably with nasal mucosa to extend the residence duration or with endothelial micro vessel cells at the BBB to increase drug concentrations in brain parenchyma. Additionally, for improved brain selectivity and permeability, such a nanocarrier can be altered with targeting ligands to selectively bind to receptors or transporters expressed at the BBB. Moreover, by using cell transcytosis procedures, this system may be further utilized for effective drug trafficking across the barrier.

Drug absorption via the nasal route is significantly influenced by the drug's residence duration in contact with the mucosal membrane. As was previously noted, mucociliary clearance allows drugs to be removed from the nasal mucosa and reduces the amount of nasal absorption. Mucoadhesive polymers can be utilised as gelling or viscosity building agents to get around this restriction. To lengthen residence duration, substances including gelatin, alginate, chitosan, and cellulose have already been developed.

The important aspect of nose-to-brain transport that must be taken into account is the size of the nanocarrier. The drug is better absorbed into the brain through the nose when it is included in particles between 5 -10 μm in size, either because of a longer nasal residence period or to prevent deposition in the upper respiratory tract (65,66). However, there is also proof that using

nanoparticles, especially those smaller than 100 nm, results in effective direct nose-to-brain transport (67). Larger particles may have a longer nasal residency period, whereas smaller particles are thought to enter the brain by transcellular or paracellular pathways, followed by axonal or peri-axonal transport. In addition to size, the nanocarrier's possible toxicity is a concern that needs to be handled carefully. For instance, excipients and absorption enhancers used topically may irritate the nasal mucosa (68).

Nano-Carrier Based Approaches

There are new possibilities for the treatment of brain illnesses as a result of nanocarrier-based delivery methods (69–76). Currently, a drug that is poorly absorbed by the nasal mucosa can be loaded into a nanocarrier-based system that interacts well with the olfactory nerve fibres to promote direct nose-to-brain delivery, the endothelial microvessel cells at the BBB, or the nasal mucosa to increase drug absorption time. This results in higher drug concentrations in the brain parenchyma through the indirect nose-to-blood-to-brain pathway

For improved brain selectivity and affinity, targeting moieties might be added to nanocarriers to make them more likely to bind to certain transporter receptors found on respiratory epithelial cells, neurons, and the BBB. In order to effectively transport drugs over the barrier structure, they can be used in membrane transcytosis operations.

1. liposomes

Liposomes are lipid-based nanosized vesicles with an aqueous core surrounded by unilamellar or multilamellar phospholipid bilayers (77). The first in vivo investigations using liposomes for medication transport from the nose to the brain were published in 2007 (78). Since then, a number of pre-clinical investigations have demonstrated that drug-loaded liposomal formulations delivered orally improve the therapeutic effectiveness of the treatment in vivo, boost drug transport into the brain, and decrease drug-related systemic adverse effects. According to published reports, studies on liposomal diameters for nose-to-brain medication transport ranged from 40 nm to 10,000 nm, however a sizable fraction were limited to sizes between 100 and 200 nm. Uncharged phosphatidylcholine, frequently in conjunction with the stabilising ingredient, cholesterol, proved to be the most prevalent lipid employed in the formulations of the mentioned liposomes. Nearly half of the experiments were of more "advanced" liposomes, where the nanocarriers' surfaces had been altered (79). However, compared to the traditional liposomes or drug solution, these complex liposomes did not necessarily exhibit exceptional improvement in brain transport, side effect profiles, or neurological functioning (80). One explanation might be the delayed drug release kinetics for both hydrophilic and lipophilic molecules from these liposomal carriers (81-84). The physiological characteristics of utilising the nose as the administration location may be another significant element.

4. Lipid Particles

Drug carriers with lipid particulates have recently been found to have a high potential for drug delivery, particularly nanometer-ranged colloidal carriers like SLNs and NLCs (85), that have drawn a lot of attention in recent years due to their distinct properties and behaviours brought on by their small size. They are a viable option for use as targeted carriers for the treatment of a variety of illnesses because of their advantages in regulating drug release, increased stability, high loading, and low toxicity (86,87). They are a good option for drug administration to the brain because of their lipophilic nature's ability to pass the blood-brain barrier (BBB) through an endocytotic route without surface functionalization (88). Both lipophilic and hydrophilic bioactive compounds can be included into SLNs and NLCs since they are constructed of biocompatible and biodegradable materials. They are composed of triglycerides of physiological lipids, including cholesterol, cholesterol butyrate, cetyl palmitate, and stearic acid, which are distributed in a surfactant solution and include tristearin, compritol 888 ATO, and dynasan112.

A higher drug encapsulation capacity and greater stability during storage are ensured by the use of liquid lipids in combination with solid lipids, including cetiol, almond oil, peanut oil, corn oil, soybean oil, olive oil, oleic acid, sesame oil, L-phosphatidyl choline, soy lecithin, mygliol® 812 N, suppocire® NC, tegosoft® M, and capmul® MCM C The intranasal route is the aim of several drugs for the brain that are encapsulated in either SLNs or NLCs (89).

5. Transfersomes:

Transfersomes are supposed to be the second generation of vesicular systems, and they include phospholipids as well as an edge activator (a single chain surfactant), that gives these vesicles their flexible and elastic properties. Transfersomes may bend and flex to fit into the nasal passage and transport proteins, vaccines, and other substances more successfully because of their elasticity and deformability (90,91). The most widely utilised soy phospholipids are soy phosphatidylcholine and hydrogenated soy phosphatidylcholine, that have been combined with edge activators such Span 80, Span 20, Tween 80, sodium oleate, sodium cholate, sodium deoxycholate, etc. The kind and proportion of the various edge activators have an impact on the size, entrapment effectiveness, and zeta potential. Upon storage, it has been noted that transfersomes aggregate and grow in size (92).

6. Nanoemulsion:

Oil-in-water (O/W) and water-in-oil (W/O) nanoemulsions (NEs) are two types of NEs, where two immiscible liquids are dispersed and stabilised by adding the necessary surfactants as well as co-surfactants, with a suitable particle size that may be as small as 100 nm (93). The most popular formulation for delivering drugs from the nose to the brain is the O/W nanoemulsion (94). NEs frequently assist in determining the cause of issues that arise during the drug preformulation study, such as the drug's solubility or stability, or additional issues that can be categorised as formulation challenges, such as oxidation, enzymatic action, hydrolysis of the drug formulation, or physiological effects (95, 96). The right amount of oil (Campul MCM) and the surfactant tween 80 were combined to create the risperidone nanoemulsion. Chitosan (0.50%, w/w) was added to the risperidone nanoemulsion to develop the mucoadhesive formulation, which was then mixed for one hour. Two formulations of the medication risperidone were delivered in and IV through the administration of NEs and solutions of risperidone, and technetium (99mTc) labelling was used to monitor drug distribution in both the brain and blood during in vivo investigations on an animal such as albino rats.

The study's conclusion section demonstrated that intranasal administration of the mucoadhesive chitosan-NE caused the medication to enter the CNS area more quickly than previous risperidone NE and solution formulations (97).

7. Microemulsion:

Thermodynamically stable isotropic mixes of oils, surfactants, and/or co-surfactants are known as microemulsions (ME). In microemulsions, the dispersed phase globule size ranges from 50 to 250 nm (98,99). The ME liquid combinations reduce dosage variance and may be created as a spray formulation as well (100). The IN MEs is considered to be an effective route of administration since they enable direct delivery of the specific dissolved medication to the CNS. The O/W microemulsions formulation was successfully employed to increase the solubility of intranasal medications that were weakly water-soluble. Inhibiting P-glycoprotein (P-gp) efflux transporters may also enhance the delivery of medications from the nose to the brain (101). Drugs and chemicals are transported through the BBB by ME components such long-chain triglycerides and polyunsaturated fatty acids (PUFA) (102).

Docosahexaenoic acid, a PUFA, was observed to improve the transport of curcumin from the nose to the brain with a continuous release for up to one day (42). The diffusion of medicines over the nasal olfactory membrane to the brain was reported to be improved by adding butter oil

and fish oil as a penetration enhancer for IN ME administration of donepezil (50) and rivastigmine (103). Buspirone hydrochloride (104), carbamazepine (105), and zotepine (106) are just a few examples of drugs delivered as mucoadhesive ME by IN route that demonstrated good bioavailability and improved cerebral targeting efficiency, indicating the incorporation of mucoadhesive polymers like chitosan in ME components extend the contact time between nasal mucosa and ME, thereby improving drug absorption and bioavailability.

Histopathological analysis of nasal epithelial tissue had been used to study at the safety profile of the MEs during IN drug delivery. According to the studies, the majority of these MEs were harmless and non-toxic. One of the most frequent adverse effects of IN ME is nasal discomfort. It might be diminished by raising the water content in ME formulations to at least 50%, lowering the surfactant concentration, and excluding alcohol from the formulaion (45,107).

8. Polymeric Micelles:

These are colloidal nanostructures with amphiphilic copolymers. They feature a hydrophobic core that incorporates drugs that are not soluble in water and a hydrophilic shell that gives the pharmaceuticals high stability in the physiological condition (108). The polymeric micelles have a diameter of less than 100 nm (109). In vivo and in vitro research have shown that compounds can be solubilized and transported across the BBB in the right concentrations because to their nanometer size range. Polymeric micelles have a higher level of stability and a longer-lasting drug release than surfactant-based micelles (110). When compared to IV drug delivery, the bioavailability of efavirenz, an anti-HIV medication, was shown to be 4-fold higher in polymeric micelles comprising copolymers such poly (ethylene oxide) and poly (propylene oxide) (111). In order to overcome nasal mucocillicary clearance, lurasidone was successfully loaded into a mixture of pluronic F127 (PF127) and gelucire 44/14 (GL44) as micelle-forming agents. The resulting nanosized mixed lurasidone micelles allowed the drug to reach brain tissue via the olfactory and trigeminal systems by passing the BBB (112).

9. Nanosuspensions:

These are liquid-based colloidal dispersions of very small medication particles. This sub-micron sized dispersed particles might be stabilized by adding surfactants or polymers (113). Hydrophobic compounds have been administered using nanosuspensions to enhance drug delivery (114). The increased surface area of the small particles may help improve the medications' bioavailability in the brain and throughout the body. Loratadine and zotepine were created to be delivered intravenously (IN) via mucoadhesive nanosuspension (115, 116). According to research, the stability of nanosuspension is largely dependent on the technique of synthesis and quantity of mucoadhesive agents utilised, in addition to the increased bioavailability of these hydrophobic medicines.

10. Dendrimers:

They are smaller than 10 nm in size and are branching macromolecules. Small and uniform particle size, a high level of water solubility, excellent encapsulation effectiveness, and a clearly defined homogenous structure are the distinguishing features of dendrimers. One of the earliest introduced dendrimers for drug administration was polyamidoamine (PAMAM) (117). High medication solubilizing effect and excellent tissue targeting may be their defining traits. It was found that PAMAM dendrimer may successfully transport haloperidol to the brain during IN injection without causing systemic absorption (118).

Outline of in-vitro BBB model

A therapeutically effective brain medication delivery system must go through several stages of research and testing. A novel brain medication delivery system must be tested for a number of crucial delivery characteristics. As previously discussed, nose-to-brain nanocarriers may be able to carry drugs directly to the brain. The BBB acts as a significant barrier to brain delivery when

it comes to an indirect pathway, hence it is important to examine the effectiveness of macromolecular systems crossing the BBB in vitro at an early stage. In fact, a suitable in vitro BBB model is essential since the BBB is increasingly being used as a therapeutic target in various brain illnesses.

The most popular in vitro model platform is made with Transwells and polycarbonate or polystyrene membranes (119). One, two, or more cell types can be used to create the models. Basically, the Transwell's top (luminal) compartment is where endothelial cells are often cultivated. A few extra cells, such as astrocytes or pericytes, are often cultivated in the bottom compartment of Transwells or on the lower (abluminal) side of the membrane. However, also because transport activities in cultured cell cultures have been severely downregulated, they might not be the best models for studying BBB permeability (120). For instance, compared to levels found in vivo, the expression of glucose transporter 1 is 150 times more reduced in bovine primary cultured brain capillary endothelial cells (121). Researchers exhibited conditionally immortalised cell lines produced from transgenic mice in a practical in vitro BBB model in order to prevent the function variations of primary cultured endothelial cells and increase the transport characteristics (122). The use of human cells is preferable in order to reduce species-specific reactions. Different kinds of stem cells have been employed as an alternate source for BBB remodelling due to the challenges of sources. In particular, circulating endothelial progenitor cells mobilised from bone marrow, human induced pluripotent stem cells, hematopoietic stem cells from human umbilical cord blood, and human induced pluripotent stem cells have been used for BBB modelling with promising in vivo-like properties.

There have been several attempts to model the human BBB and put all the relevant parts together in an organic system to mimic the mechanisms controlling drug-to-BBB penetration under normal or pathological circumstances. The primary components of the in vivo BBB were imitated using a flow-based dynamic in vitro BBB (DIV-BBB) system (123). The development of cell-to-cell tightness, matching of luminal to aluminal volume displayed in vivo, and functional transport and metabolic mechanisms governing drug blood-to-brain transit are among these critical characteristics. T-cell differentiation, the creation of tight junctions, and the control of the cell cycle, which results in mitotic arrest, have all been demonstrated to be impacted by brain endothelial cells being exposed to laminar flow (124,125). Especially, in vivo cerebral blood flow controls vessel size and cell adherence to the vascular BBB wall and is correlated with levels of energy substrates. In the DIV-BBB system as well as in Transwells, brain endothelial cells may be co-cultured with other brain-derived cells such astrocytes, neurons, and smooth muscle. Since the BBB sits at the point where the peripheral circulation system and the brain meet, it is crucial that those co-cultured cells can be exposed intraluminally to serum components, white blood cells, and even platelets. It is crucial to expose BBB cells to these cells because they probably play crucial roles in the pathophysiological alterations influencing BBB status under disease conditions (126). The DIV-BBB model makes it possible to identify the specific factors that affect BBB function, such as the impact of reduced or absent luminal flow, oxygen, or glucose. The DIV-comprehensive BBB's setup has facilitated pharmacological investigations such as those examining drug-induced brain permeability and sped up research into the processes behind BBB alteration in diseased situations (127,128).

Although a dynamic BBB model on a three-dimensional tube construction offers constant flow of culture media, the hollow fiber approach does not allow for real-time cell imaging. A lab-on-a-chip microdevice that allows for the co-culture of two or three cell types, the flow of the culture media, the viewing of the cells by microscopy, and the monitoring of the permeability was devised and produced by Walter et al. in (129)

Toxicity issue related to nano carriers via nasal administration

Deeper investigation into the biological importance of nanocarriers has raised significant concerns regarding potential toxicological problems. In contrast to polymeric solutions, nanoparticles increased local inflammation in the nasal mucosal membrane without manifesting a systemic inflammatory response (130). Nanoparticles go from the olfactory epithelium to various parts of the brain. Md et al. gave mice NPs and checked the mice's brains for toxicity. The treated brain and the untreated brain were identical. Lesions in mice treated with this medication were smaller and had less eosinophilia. Lectins are thought to be poisonous to mammalian cells and to cause oxidative stress and nasal toxicity. WGA attached PEG-PLA nanoparticles showed no toxicity when used to deliver coumarin intravenously. Cargo-dependent cytotoxicity may result via Tat-mediated nose-to-brain transport. Even though LMWP is said to be noncytotoxic, its lack of cell type selectivity means that it could still injure healthy tissue. A total of PEG micelles containing zolmitriptan were created. Micelles were delivered intranasally for 28 days during toxicological testing, and no harm was discovered (131). Micelles of olanzapine-loaded pluronic-based block copolymer were developed and examined for toxicological research. Small histological alterations were seen in sheep nasal mucosa after ex vivo toxicological screening (132). Naturally occurring lipids that are regarded to be harmless make up liposomes. Toxicological testing on liposomes for intranasal brain administration was done. Thin-film hydration was used to create liposomes that contained quetiapine, and diffusion through sheep nasal mucosa was seen. Liposomal administration to nasal mucosa did not result in any histological alterations, according to toxicology tests (133).

Advances in Nasal Drug Delivery

It is necessary for formulation to be deposited on the olfactory epithelium for nose-to-brain medication delivery to be successful. The first nasal administration methods likely include drops and mist. Nasal drops have a high level of deposition in the olfactory region and can prolong retention duration there when combined with mucoadhesive agents. However, patients who administer the nasal drops incorrectly may restrict their effectiveness (134). Currently, meter-dosed pump sprays are used to administer a lot of nasal medicines on the market. Patients may use the pump sprays easily, and they consistently give accurate dosages. However, deposition from sprays is often restricted to the vestibule and nasal vale areas in the anterior nasal cavity.

To get around the challenges of targeting the olfactory area, new delivery methods have been devised. The Vianase electronic atomizer consists of a vortex chamber coupled to a nebulizer. The vortex-like motion of the nebulized drug particles in the vortex chamber and their continued display of this flow after exiting the device encourages deposition to the olfactory area to optimise delivery to the brain (135). The bidirectional delivery system Optinose emits the dosage using the patient's own exhale force. Soft palate closure prevents any of the flowing powder from being deposited in the lungs. Small particle aerosols may be delivered using SipNose's drinking-actuated nasal device without depositing in the lower airways (136). Impel Similar to Optinose, Neuropharma has created a POP device to administer powder or liquids by insufflation; however, the device emits the dosage using pressured gas rather than the patient's own exhalation force. Hoekman et al. used this device and discovered that there was substantially less deposition in the front portion of the nasal tract and significantly more deposition in the upper regions (137).

Future Perspectives

If medications with low BBB permeability can be synthesised with suitable mucoadhesives and targeted ligands on the carrier surfaces, the direct nose-to-brain route may be particularly appealing for brain administration Drug absorption into the brain appears to be significantly impacted by nanocarriers. Future study in formulation design and preparation is needed, nevertheless, as not all nanocarriers have been demonstrated to result in appreciable

improvements in brain delivery. Future research should also take into consideration any possible toxicity problems caused by nanocarriers. Standardization of in vitro and in vivo experimental settings merits additional focus because it is challenging to compare pertinent data provided by various authors.

Formulation techniques by themselves are insufficient to utilise this route for the delivery of human drugs. Novel technologies are being created in an effort to get over the limitations of the architecture of the nasal cavity and target formulation deposition in the olfactory area. Therefore, intranasal therapeutic drug administration will need increasingly sophisticated and automated delivery systems in the years to come to assure precise and repeatable dosage.

It has been difficult to create effective treatments for brain disorders including Alzheimer's, Parkinson's, and stroke. This may be because we lack knowledge of the brain processes and pathology underlying these disorders. Increasing our knowledge of these disorders will aid in the creation of fresh prospective treatment approaches. The effective translation of nanocarrier-based drug delivery for the treatment of brain illnesses from laboratory to clinical application may be facilitated by closer cooperation and cross-talk among medicine, pharmaceutics, pharmacology, and engineering.

CONCLUSION

Neurological illnesses are currently difficult to treat because medications must get across the BBB to the CNS. Many solutions have been put out to get around this issue. Among them, the use of nanocarrier delivery systems via the intranasal route has been demonstrating promising results, since it eliminates the need to cross the BBB, permitting quick access to the brain and removing the restrictions connected with intravenous and oral routes. Additionally, it appears favourable to include medications into nanocarrier systems as liposomes, SLNs, nanoemulsions, microemulsions, nanosuspensions, polymeric nanoparticles, and dendrimers since they considerably lessen the risk of medication degradation and enhance brain targeting. Thus, the utilisation of drug-loaded nanocarriers for intranasal delivery to the brain for the treatment of many CNS illnesses has shown great potential.

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ARTIFICIAL INTELLIGENCE IN DIGITAL MARKETING

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ABSTRACT

Artificial intelligence (AI) is intelligence — perceiving, synthesizing, and inferring information — demonstrated by machines, as opposed to intelligence displayed by non-human creatures and humans.

Traditional marketing is any form of marketing that uses offline media to reach an followership. Basic exemplifications of traditional marketing include effects like review advertisements and other print advertisements, but there are also billboards, correspondence announcements, and television and radio announcements.

Digital marketing is the element of marketing that uses the Internet and online predicated digital technologies analogous as desktop computers, mobile phones and other digital media and platforms to promote products and services. And people have been trying to interpret so numerous new ideas and invention using AI powered digital marketing services to boost their stats of business.

Keywords: Perceiving, synthesizing, inferring,analogous, AI, Traditional Marketing, Digital Marketing

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Artificial intelligence is a computer science method for teaching computers to analyse and emulate human communication and behaviour. In its most basic form, AI is the technology or system that accomplishes task by mimicking human intellectual ability and may continually refine itself based on the data they gather.

Artificial intelligence is a broad field of computer science concerned with creating intelligent machines capable of doing activities that generally require human intelligence. The phrase is usually referred to the goal of producing systems with human like thinking skills, such as the ability to reason, discover meaning, generalize or learn from experience.

What Is Digital Marketing?

Digital marketing is the component of marketing that uses the internet and mobile based digital technologies such as desktop computers, mobile phones and other digital media and platforms to promote product and services. It is the promotion of brands to connect with potential customers using other forms of digital communication. This includes not only email, social

media and web-based advertising, but also text and multimedia messages as a marketing channel.

Digital marketing can be broadly broken into 8 main categories including:

1 Search engine optimization

2 Pay- per- click

3 Social media marketing

4 Content marketing

5 Email marketing

6 Mobile marketing

7 Marketing analytics

8 Affiliate marketing

How is AI transforming the future of Digital marketing?

Once marketing was not client- centric like television advertisements, billboard advertisements or man-to-man marketing, but after introducing digital marketing, it's now more focused on implicit guest. People regularly interact on social media, which could precisely prognosticate(predict) their requirements. And then, AI may play a significant part.

Artificial Intelligence has formerly changed the way brands communicate with guests and how marketing juggernauts are managed. Since the rise of AI, the geography of Digital marketing has drastically reshaped.

It assists business in developing effective digital strategies, optimizing juggernauts and adding return on investment. AI influences numerous angles of life through smart bias chatboards and tone driving motorcars. These are intended to identify client interests and preferences to give a substantiated client experience. As technology changes too presto, its tough to predict the future. Still, in this composition, we will try to give some egregious effects which will change the future of digital marketing.

How AI is transforming digital marketing scenarios?

Hundreds of sectors are being converted by AI. Artificial intelligence is constantly evolving, brands do business in diligence ranging from finance to technology and retail. Brands have begun to use AI to communicate with their guests. Itsan trial to include conversational marketing into their diurnal lives. AI is unleashing the possibility of hyperactive personalization through personalized products recommendations and client backing suggestions as machine literacy develops. (https://ied.eu/blog/how-ai-transforming-the-future-of-digital-marketing/)

LITERATURE REVIEW

Abadir, A.P., Ali, M.F., Karnes, W., &Samarasena, J.B. (2020) found that AI is a fairly new technology in digital marketing with the eventuality to ameliorate(improve) the impact on consumer gesture. AI marketing is a new marketing playbook that allows companies to move from marketing robotization to marketing personalization more effectively. The Impact of AI on digital marketing has accelerated in recent times allowing marketers to personalize deals and digital marketing sweats beyond prospects. Because of the vast quantum of data available, marketers have personalized their deals and marketing sweats and exceeded their guests' prospects beyond what they imagine. AI engineering has the implicit to change the way services and products are delivered to guests. Eventually, we can say that digital marketing robotization is more dynamic than ever ahead, and information for analysing buyer gesturesbrings largely prophetic results. AI's involvement helps business identify their target guests in digital marketingplatforms, understand their guest's needs and preferences and adding translucency. AI tools in digital marketing platforms are integrated into live converse via chatbots that engage consumer's by instantly responding to inquiries in an easy to use interface. Using artificial digital marketing intelligence technologies together with mortal produce data, companies can make trust in digital platforms and increase positive, personalized customer gestures through a deep dive.

Technological advancements have always helped businesses by creating new openings for reaching guests. One of the topmost technologies of our time is artificial intelligence which is creating quite the buzz in the digital space. Given its eventuality for liar and marketing, artificial intelligence in B2B deals and marketing is then to transfigure the way people interact with brands, information and services. The world of B2B marketing and its future is poised to be touched by AI. A good sprinkle of enterprise titans dread the idea of full robotization of

marketing movements through smart artificial intelligence technology, still, measuring the effect of AI- powered robots in numerous client service diligence, one can affirm that understanding client nuance want be entirely homemade or managed by mortal power alone. Artificial intelligence made its presence felt this time through its supplementary processes similar as big data, internet of effects and machine literacy. But these are only factors that will ultimately contribute towards unleashing the full eventuality of AI. The coming times, specially 2018 would see visible changes and impact due to the operation of AI. Artificial intelligence is continually getting an empowering tool for digital marketers and workshop on the tricks to get the information from an individual or the group of people to and make any brand a huge bone. Its safe to say that artificial intelligence is a secured investment which is sure to get returns.

De Ruyter, K., Keeling, D. I., & Ngo, L. V. (2018) studiedArtificial intelligence isa digital revolutionary tool that helps produce this arising digital request which has been proven with a variety of inventions similar as the creation of that content AI becomes precious and can be used for developing algorithms to be more innovative in creating content that's further intriguing. Due to the nonstop advancement of AI technology, marketers have the occasion to understand and make connections with their own guests at a advanced position which will help them ameliorate access to particular information until getting more professed in developing the shopping experience according to the requirements of guests. The information entered from AI should be used in the correct wat, easily relating and knowing what kind of content that guests in digital marketing want to admit from the brand which will be positive impact to make life better.

Turing, A. (2004) discussedthe marketing sector has been set up to be one of the sectors of the frugality with the loftiest implicit to ameliorate. It's feasible space for development especially through technology(fragella). Marketing ways have grown and evolved overtime, including ultramodern technology to enhance effectiveness. Digital marketing has the implicit to have profound impact on individualities, thanks to technological advancements that enable businesses to produce large amounts of goods and use digital marketing to expand diligence openings to announce and vend products to guests(Ali and Manisha 2020). Likewise, digital marketing developments are the consequences of combining big data and scientific exploration on smart apps. Thus, data on each existent, and their preferences is recorded for easy use during marketing procedures. This study aimed to determine the benefits of digital marketing, particularly, use of AI and request robotization to ameliorate request issues. Also, the effect of digital marketing on company performance was considered.

The study set up that a positive impact of Artificial technology, request robotization on digital marketing exists. Like any form of technology, significant enhancement was observed in the marketing companies under study and findings aligned to once literature (Rust, 2020; Mari, 2019. Huang and Rust,2021). Marketers have high norms that AI will continue to develop robotization parameters and that robotization will gradationally take over the maturity of marketing procedures. Marketers moment are willing to learn how to ameliorate digital marketing to touch on every client and easily express their solicitations.

Virginia Braun & Victoria Clarke (2006) mentionednonetheless, marketers also expressed concern and, in some cases, an incapability to comprehend the form of control the association keeps over its swats when AI robotization is stationed to its fullest extent. marketing directors who have not yet grasped the conception of AI technology may find it expensive and gratitude to include this technology into their marketing systems. Likewise, some marketers are also induced that AI can not comprehend that AI experts also agree upon. While they appear to feel that robotization is making their work and lives easier and will continue to break problems, they are concerned about losing control over their juggernauts. The suppositions that AI moxie may significantly impact the performance of marketers is not satisfied. The essential AI moxie for

robotization is viewed as knowing how well the systems behaves by grasping the tool's capabilities. For case, knowing how to remain objective as well as how to use AI tools, as opposed to comprehending their introductory structure. Thus, caution is recommended when applying digital marketing styles, not to surrender full autonomy or control of the marketing structure to technology.

(Virginia Braun & Victoria Clarke (2006) Using thematic analysis in psychology, Qualitative

Research in Psychology.

Vollero A, Palazzo M. Conceptualizing content marketing: a delphi approach. Mercati&

Competitività 2015; 1: 25–44; http://dx.doi.org/10.3280/MC2015-001003.

Wall A, Spinuzzi C. The art of selling-without-selling: Understanding the genre ecologies of

content marketing. Technical Communication Quarterly 2018; 27(2): 137–160).

Probing how AI is employed in digital marketing and its goods can offer light on this technology and its current operations. The results of this study will give further sapience on the benefits of AI technology and request robotization in the marketing field. With the rise of internet businesses around the world and enterprise promoting their products and services digitally, its critical to explain how artificial intelligence is being used to vend to guest and achieve marketing pretensions. The results show that AI is the ultramodern way of marketing, making the process of digital marketing effective. Marketers who use AI in digital marketing have reported great advancements in their marketing strategies. Thus, it has come critical that marketing directors learn the chops of artificial intelligence to remain competitive and grease positive issues in their businesses.

(Wang, Chen, &Xie, J. (2011). Online social interactions: A natural experiment on word of mouth

versus observational learning. Journal of Marketing Research, 48(2), 238–254.

Ward, D. 2019. 5 Trends in B2B Email Marketing. URL:

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email_marketing/125792. Accessed: 08 April 20220).

Wedel, M. & Kannan, P. K. (2016). The future of marketing relies on the enhancement of technology in marketing systems and structures. It's anticipated that AI technology will fully take over the marketing sector to produce client acclimatized gests and launch marketing to obscenely high situations. Thus, it should be the desire of every marketing director to incorporate artificial intelligence and request robotization into their systems because the technology is being accepted encyclopedically. The AI technology is anticipated to be an profitable boost by adding GDP through investment returns. The technology is sluggishly replacing mortal functions of marketing similar as communication, making it easier to perform and ameliorate on other tasks. The mode of virtual adjunct ensures that every client relates to the AI in the most mortal way possible. While this progress should be covered nearly, its clear that digital marketing is gradationally advancing for the better.

(Wichert, A. (2020). This study has linked which capabilities will come decreasingly pivotal for marketing professionals to acquire in the future in order for them to be more set. To gasp how to take advantage of AI's capabilities, analogous as new confines and prospects for assaying vast volumes of data, marketing professionals must have specialized chops in order to comprehend and estimate this data. Likewise, the expression of value propositions was discovered to be one of the most important results about the mileage of the marketing managerial position. Because

the customer experience has always had a technical element, as one party directed out, the capability to meliorate the customer experience using technological results is fairly precious. Marketing professionals will have to grasp how intelligent machines operate and how to use the results, thus they will need technical moxie. Likewise, softer rates associated with emotional intelligence, analogous as social awareness and empathy, tend to be essential for marketing professionals. These chops are essential for a variety of reasons, including carrying precious customer feedback for product development and invention, which requires informed concurrence of what guests are looking for and also knowing what tone to use when communicating with guests and mates. Also, cleverness appears to be a vital element of marketing professionals' places, since it's critical for rational decision timber, as well as the company's invention process and determining product attributes. The innovative dimension of the marketing specialist's position will remain a vital element of the position as the significance of companies seems to expand due to the entry of AI in marketing. Likewise, marketing professionals should avoid placing too important reliance in data, as this can kill originality and may lead to trouble aversion. As a result, marketing professionals will have to strike a balance between data and creativity. Nonetheless, because AI is anticipated to grasp aspects to the creativity process, it may be less vital for the invention of new products.

LIMITATIONS OF THE STUDY

During the exploration, a multitudinous lapses were endured. Originally, the study is concentrated on six responders who may have handed a small perspective of the factual situation. Thus, results from this study may be applicable in this situation only. To have a generalized view, one might need to cover a wider compass of data collection and use quantitative exploration design. Although the situation in other associations may be analogous, there are a multitudinous areas where there's a difference that may disallow the connection of results from this study. Secondly, the time limit was another limitation in the study. Although the attesters were canvassed on time, it's delicate to tell if the responses would have been different or more accurate under different circumstances. Thirdly, considering the authors' sweats to reach as multitudinous people in AI technology and digital marketing as possible, it was hard to find professionals who felt comfortable agitation AI and digital marketing and sharing their perspectives on the motifs. Indeed though the authors had several good leads, possible actors were not motivated in participating in this study due to their busy schedule or other constraints. Still, in order to meet their particular ideal of finishing ahead of time, the authors had to work under severe pressure. In addition, the authors agreed to attend sedulity events that could have produced more leads for pollers. But, due to the time constraint, the authors were only suitable to attend one analogous event and had to calculate on digital styles and channels on digital styles and channels to gather interviews. Nonetheless, working on and producing this study equipped the authors with excellent time operation exploits. This thesis could not be done in such a short period of time if time operation was not used.

(Zubcsek, P. P.,Katona, Z., &Sarvary, M. (2011). Network effects and personal influences: The diffusion of an online social network. Journal of Marketing Research, 48(3), 425– 443).

CONCLUSION

This study has anatomized the significance of AI in digital marketing for companies moment, looking at primary and secondary data to develop a clear analysis of the state of marketing moment. Still, the study on AI can not be completely exhausted in this single paper. This exploration paves way for further study. Farther studies can be done using different data sets from different regions, countries or different situations of companies and businesses. Findings from other repliers can be used to add to the compass of this study. Also, client perspective of the AI and robotization marketing technologies can be assessed by conducting a check on

different guests about their experience with digital marketing. This will give an in-depth view of how technology is affecting the marketing sector in the ultramodern frugality.

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RESEARCH PAPER ON AI IN FINANCE

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ABSTRACT
Artificial intelligence involves two basic ideas. First, it involves studying the thought processes of human beings. Second, it deals with representing those processes via machines (like computers, robots, etc.). AI has now taken over many sectors including financial sector.

This study aims at exploring the role of financial management and how it promotes sustainable business practices and development while specifically focusing on Artificial Intelligence (AI) and its affiliation to finance. With the help of thematic analysis and scholarly resources, it is evident that placed financial management models are important to improve productivity while reviewing issues of financial risks. Software tools like AI are meant to solve various financial risks that can be brought by human error. The findings also showed that using AI to handle various areas of finance like; automation, credit decisions, trading, sentiment and news analysis, risk management, fraud prevention, and personalized banking have helped improve competitive advantages in businesses. The study concludes that the roles played by financial management are very important and also help promote sustainablebusiness practices and development.

Keywords

1. ***Artificial Intelligence:*** *The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.*
2. ***Finance:****Finance is a term for matters regarding the management, creation, and study of money and investments.*
3. ***Fintech:*** *Fintech is the term that describes the group of new financial technologies designed to enhance and automate the use and delivery of financial services*
4. ***Cross Cultural Effect:****Cross culture is a concept that recognizesthe differences among business people of different nations, backgrounds. and ethnicities, and the importance of bridging them.*

INTRODUCTION
Artificial intelligence (AI) is the ability of machines to replicate or enhance human intellect, such as reasoning and learning from experience. Artificial intelligence has been used in computer programs for years, but it is now applied to many other products and services.

Artificial Intelligence is now become apparent trend in the current market. It is now being applied in various sectors. Financial institutes apply artificial intelligence in various innovative ways.The main advantage of AI is to work efficiently with big amounts of data.

Finance can greatly benefit from using AI in different areas like banking insurance, asset management among others. Financial management with the application of AI can ensure financial stability and the entire development of the business while getting benefits. AI is lending the financial services industry by super storm. Mostly now a day's every financial sector is using AI to avail the benefits like saving time, reducing cost & adding values.

Role of Artificial Intelligence in Different Financial Sector

Artificial Intelligence in Personal Finance

Consumers crave financial freedom, and the capacity to control one's financial health is pushing the use of AI in personal finance. Whether it's providing 24/7 financial advice through chatbots driven by linguistics or customizing insights for wealth management products, AI is a must-have for every financial institution wanting to be a market leader.

Artificial Intelligence in Consumer Finance

Among the most important business cases for artificial intelligence in banking is its capacity to identify and prevent frauds and breaches.

Consumers seek out banks and insurance companies that offer safe accounts, especially with digital payment fraud losses anticipated to reach $48 billion per year by 2023, according to Insider Intelligence. AI has the capacity to examine and identify abnormalities in trends that humans might otherwise miss.

Artificial Intelligence in Corporate Finance

AI is very useful in corporate finance since it can forecast and analyze loan risks more accurately. AI technology such as machine learning can enhance loan screening and minimize financial risk for businesses trying to raise their valuation.

AI can help reduce financial crime by detecting sophisticated fraud and detecting aberrant behavior as corporate accountants, researchers, treasurers, and financiers strive for long-term success.

AI is being used by US Bank both in its middle- and back-office operations. To assist in identifying bad actors, U.S. Bank accesses and analyses all relevant data on clients using deep learning. It has been deploying this technology for anti-money laundering and, per an Insider Intelligence assessment, has quadrupled the output compared to the usual capabilities of the earlier systems.

Advantages and Disadvantages of Artificial Intelligence

Advantages of Artificial Intelligence

1) Reduction in Human Error:

The phrase "**human error**" was born because humans make mistakes from time to time. Computers, however, do not make these mistakes if they are programmed properly. With Artificial intelligence, the decisions are taken from the previously gathered information applying a certain set of algorithms. So errors are reduced and the chance of reaching accuracy with a greater degree of precision is a possibility.

2) Takes risks instead of Humans:

This is one of the biggest advantages of Artificial intelligence. We can overcome many risky limitations of humans by developing an AI Robot which in turn can do the risky things for us.

Let it be going to mars, defuse a bomb, explore the deepest parts of oceans, mining for coal and oil, it can be used effectively in any kind of natural or man-made disasters.

3) Available 24x7:
An Average human will work for 4–6 hours a day excluding the breaks. Humans are built in such a way to get some time out for refreshing themselves and get ready for a new day of work and they even have weekly offed to stay intact with their work-life and personal life. But using AI we can make machines work 24x7 without any breaks and they don't even get bored, unlike humans.

4) Faster Decisions:
Using AI alongside other technologies we can make machines take decisions faster than a human and carry out actions quicker. While taking a decision human will analyze many factors both emotionally and practically but AI-powered machine works on what it is programmed and delivers the results in a faster way.

5) New Inventions:
AI is powering many inventions in almost every domain which will help humans solve the majority of complex problems.

Disadvantages of Artificial Intelligence

1) High Costs of Creation:
As AI is updating every day the hardware and software need to get updated with time to meet the latest requirements. Machines need repairing and maintenance which need plenty of costs. It' s creation requires huge costs as they are very complex machines.

2) Making Humans Lazy:
AI is making humans lazy with its applications automating the majority of the work. Humans tend to get **addicted** to these inventions which can cause a problem to future generations.

3) Unemployment:
As AI is replacing the majority of the repetitive tasks and other works with robots,human interference is becoming less which will cause a major problem in the employment standards. Every organization is looking to replace the minimum qualified individuals with AI robots which can do similar work with more efficiency.

4) No Emotions:
There is no doubt that machines are much better when it comes to working efficiently but they cannot replace the human connection that makes the team. Machines cannot develop a bond with humans which is an essential attribute when comes to Team Management.

5) Lacking Out of Box Thinking:
Machines can perform only those tasks which they are designed or programmed to do, anything out of that they tend to crash or give irrelevant outputs which could be a major backdrop.

DATA AND METHODOLOGIES:
The data gathered is Secondary data, which is qualitative data, which was further analyzed in order to draw conclusions and suggestions. A questionnaire was drafted for the survey and random sampling was done. The secondary data collection was done through internet which includes web, emagazines, research papers, e-books, newspapers etc.

LITERATURE REVIEW
Herbert David et all explain financial research is a tool which build genuine understanding for economy. Fundamental AI Research involves these aspects of economic & financial research (Reiter Stanley, Hurwicz Leonid 2017).

Artificial financial markets are always used in software enable computer system which actually helps in understanding real life market problem. (Blake Lebaron 2002).

AI in finance also enables online banking very easily which helps in online banking & finance transactions. (Louis Casino Arino et all, Chingoka (2016) et all, Vasant Dhar et all 2017).

CONCLUSION

Artificial Intelligence has numerous advantages to offer for the financial segment. Based on the findings, it can be concluded that Artificial Intelligence in Banking and Financial Services satisfying their clients or consumer's needs. Banking and Financial Services consumers have good awareness about Artificial Intelligence applications. Adoption of Banking and Financial Services AI in applications was highest followed by KYC/AML, Chatbots and Security Compliance and also helping to fulfil the customer demand faster and easier. The consumers more commitment from representatives to the banking and financial services by giving development innovative preparing to improve the AI procedures in the workplace. It is also being used to meet regulatory compliance, detect fraud, and assess individual creditworthiness.

AI will become more ubiquitous in finance, and with that comes more challenges including legal, ethical, economic and social hurdles. AI will also continue to bring new complexities to the global financial ecosystem. As more and more data become available and computing power increases, AI programs will become more complex.

In the present stage of AI, we can however safely contend that we have found productive uses of AI that affect the everyday life of the average consumer with face and voice recognition systems, interacting machines with human voices, data collection, and organization of market information, natural language processing, financial advisory, fraud and risk assessment, credit management, price setting, applications leading tofintech, and integration with other emerging technologies including cryptocurrencies and blockchain.

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THE ROLE OF AI IN DRUG DISCOVERY AND DEVELOPMENT

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ABSTRACT
The use of synthetic Genius (AI) has been developing in higher than a few sectors of society, normally the pharmaceutical industry. In this review, we spotlight the use of AI in superbly a extent sectors of the pharmaceutical industry, which consist of drug discovery and development, drug repurposing, bettering pharmaceutical productivity, and clinical trials, amongst others; such use reduces the human workload as applicable as enticing in pastimes in a unexpectedly dimension of time. We in addition talk about crosstalk between the tools and techniques utilized in AI, ongoing challenges, and techniques to overcome them, alongside with the future of AI in the pharmaceutical industry. Artificial Genius (AI) makes use of personified maintain shut and learns from the preferences it produces to tackle now no longer in reality one of a variety then as unexpectedly as elevated in addition difficult problems. At present, the pharmaceutical business enterprise is dealing with challenges in sustaining their drug enhancement programmes due to the truth of accelerated R&D prices and diminished efficiency. In this review, we talk about the important explanations of attrition costs in new drug approvals, the doable strategies that AI can beautify the effectivity of the drug enchantment strategy and collaboration of pharmaceutical enterprise agency giants with AI-powered drug discovery firms. The cautious design, implementation, and big difference of these AI enabled constructions will be essential in the effort to apprehend how AI can beautify healthcare.

Keywords: AI, drug discovery, digital health, machine learning, healthcare.

INTRODUCTION
Artificial intelligence has inspired computer-aided drug discovery and play a basic role in drug discovery and development (Luna & Jose., 2021). AI is a type of technologies that enable computer to perform a variety of advanced function including the ability to see, understand and translate, spoken and written analyze data make recommendations and also try to make mimic human intelligence (Yang

& Siau., 2018). The father of AI is john McCarthy which focus on main motive of AI development is to solve difficult problems easily and readily (Andresen et al., 2002).AI is like the brain of robot that enhance their working efficacy and made them human like intelligent as cognitive (Chen, Engkvist, Wang, Olivecrona & Blaschke., 2018). There are some major types of AI such as decision making, narrow artificial intelligence, reactive machines, limited memory,theory of mind and self-awareness. It specializes in presently varied methodology like algorithms for structure-based drug design along with virtual screening and de novo drug designing (Cavasotto, Aucar, Adler & Quantum., 2019). AI and machine learning works together for perform difficult tasks with the machine having intelligence like human. By the help of AI which might expected to form new drug faster, cheaper and more effective (Fleming et al., 2018). Since 1960, AI has applied in healthful chemistry with multiple degrees of success to design compound (Sellwood & Matthew., 2018). AI used the crosstalk between the tools and techniques. There are three studies genomic, proteomic and structural which give opportunities for future drug discovery and also impact hundreds of latest targets for future drug discovery and development (Batool, Maria, Ahmad & Choi., 2019). This study motivates the use of AI, as a result of it will collect sizable amount of information to perform impactful use of AI in numerous areas of pharmaceutical sectors like drug discovery and development, drug repurposing and improving clinical trials (Paul, Sanap,

Shenoy, Kalia, kalyane & Tekade., 2021). To finding a new drug is so difficult as a result of large number of chemical spaces that estimate to be drug like molecules. Artificial intelligence work in drug discovery techniques like HTS (high throughput screening), 3D (three dimensional), PL (protein ligand), SBVS (structure based virtual screening) and LBVS (ligand based virtual screening) (Spvrakis, Cavasotto & Arch., 2015; Heikamt & Bajorath., 2013). After perform those techniques, there are four major steps that accustomed identification of latest drug they are with successfully launched within the medical fields with a protracted and expensive method contains a series of complicated procedures, (i) Early stage: target identification and validation, hit discovery and lead optimization; (ii) preclinical studies; (iii) clinical trials: phases I, II and III; (iv) FDA review, and post-approval analysis and observation (Reymond, Ruddigkeit, Blum, Deursen & Wiley., 2012).

AI TOOLS AND NETWORK

Artificial intelligence includes in various method such as reasoning, knowledge representation, solution, search and fundamental paradigm of machine learning. ML uses algorithms that can declare

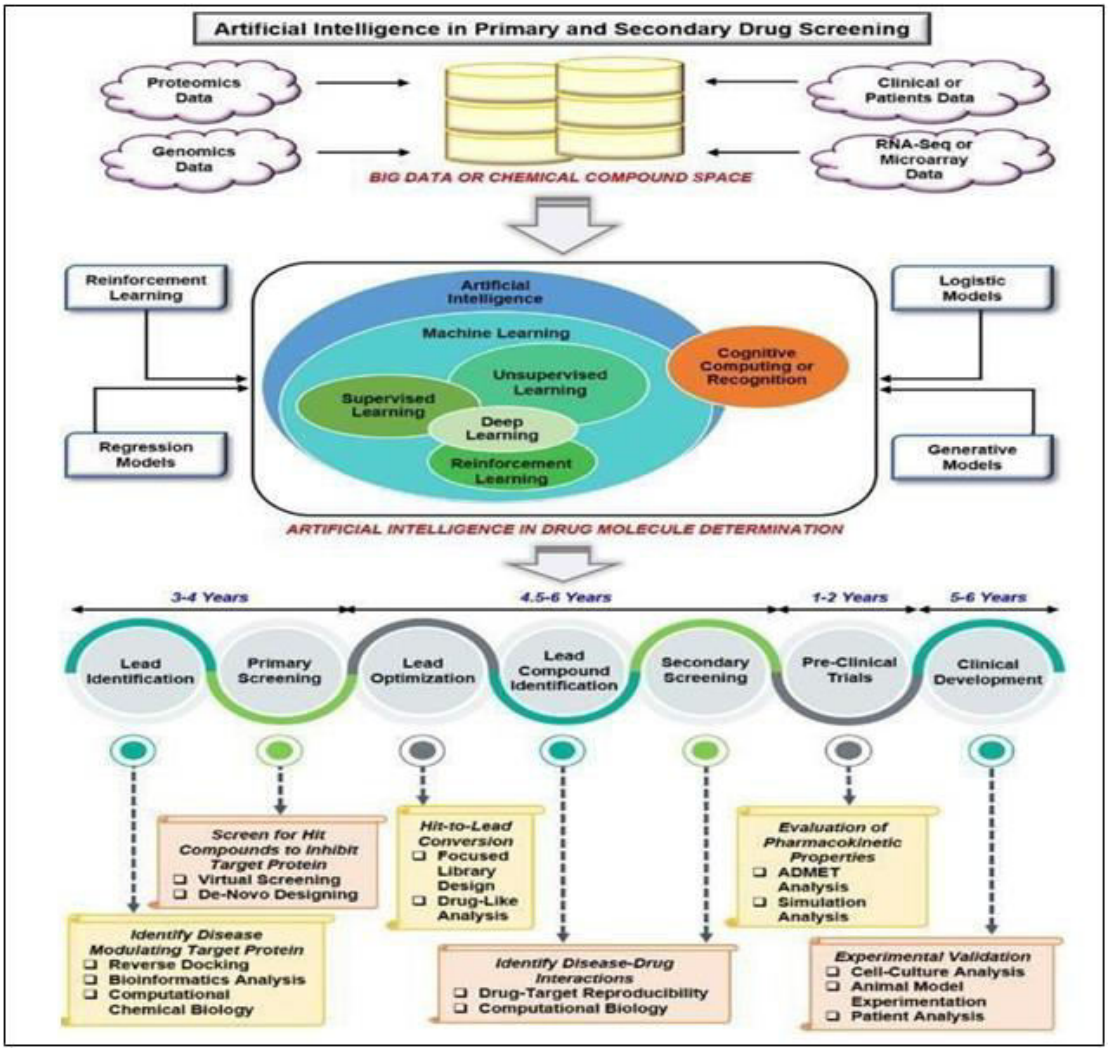
pattern within a set of data that has been classified. The field of machine learning is based on the deep learning which engages artificial neutral network (ANNs). The biological neurons and mimicking the transmission of electrical impulses which inter-connected with human brain and regulate by the ANNs (Beneke, F & Mackenrodt., 2019). ANNs consists group of nodes each received a separate input and converting them to output it is help to solve single or multi-linked using algorithms (Paul, Sanap, Shenoy, Kalyane, Kalia & Tekade., 2021). ANNs including in multilayer perceptron (MLP) network**,** recurrent neural network (RNNs) and convolutional neural networks (CNNs), which utilize training procedures. The MLP network has operating including pattern recognition, optimization aids, process identification, and controls and it can be used as universal pattern classifiers (Tekade et al., 2020; Silva, Spatti, Flauzino & Alves., 2017). RNNs is used to store data or information and it has ability to memorize such as Boltzmann constant and Hopfield networks. Boltzmann is a type of machine in which nodes makes binary decision. Boltzmann machine is known as stochastic Hop-field network. It is a special type of recurrent artificial neural network. Hopfield network impact with the human memory through pattern recognition and storage (Medsker & Jain., 1999). CNNs is a type of network which related to the series of dynamic system with local connection and have use in image and video processing, biological system modeling, brain function and sophisticated signal processing (Hanggi & Moschytz., 2000). Various tools have been developed the role of network and it isused in AItechnology of international business machine (IBM). AI tools and network is also used for diseases detection, breast cancer and analysis of patient's medical information (Rouse et al., 2017).

AI IN DRUG SCREENING

Today Artificial intelligence has a very successful and demanding technology in drug screening because it saves time, it's cheaper and quicker. The process of discovering and developing a drug can take overtime and cost US$2.8billion on average. Even then, nine out of ten therapeutic molecules fail phase II clinical trials and approval regulatory (Alvarez & Martinez., 2019). Algorithms, such as nearest- neighbor classifiers, RF, extreme learning machines, SVMs, and deep neural network (DNNs), areused for based on synthesis and it can also foretell in bio-activity and toxicity (Dana, Gadhiya, S.V Surin, Naaz, Ali & Narayan., 2018). Most pharmaceutical companies, such as Bayer, Roche, and Pfizer have teamed up with IT companies to develop for the discovery of therapy such as immuno-oncology and cardiovascular diseases (Mak & Pichika., 2019). AI used to cell classification, cell distribution and calculation properties of small molecules. It is used for synthesis organic

compound with help of computer program; design new compounds and developing molecules it can faster the process of drug discovery.

Artificial intelligence in drug screening are classified as- primary drug screening and Secondary drug screening (Watson, Cortes, Taylor & Watson., 2018).



AI TOOLS AND NETWORK

Artificial intelligence includes in various method such as reasoning, knowledge representation, solution, search and fundamental paradigm of machine learning. ML uses algorithms that can declare pattern within a set of data that has been classified. The field of machine learning is based on the deep learning which engages artificial neutral network (ANNs). The biological neurons and mimicking the transmission of electrical impulses which inter-connected with human brain and regulate by the ANNs (Beneke, F & Mackenrodt., 2019). ANNs consists group of nodes each received a separate input and converting them to output it is help to solve single or multi-linked using algorithms (Paul, Sanap, Shenoy, Kalyane, Kalia & Tekade., 2021). ANNs including in multilayer perceptron (MLP) network**,** recurrent neural network (RNNs) and convolutional neural networks (CNNs), which utilize training procedures. The MLP network has operating including pattern recognition, optimization aids, process identification, and controls and it can be used as universal pattern classifiers (Tekade et al., 2020; Silva, Spatti, Flauzino & Alves., 2017). RNNs is used to store data or information

and it has ability to memorize such as Boltzmann constant and Hopfield networks. Boltzmann is a type of machine in which nodes makes binary decision. Boltzmann machine is known as stochastic Hop-field network. It is a special type of recurrent artificial neural network. Hopfield network impact with the human memory through pattern recognition and storage (Medsker & Jain., 1999). CNNs is a type of network which related to the series of dynamic system with local connection and have use in image and video processing, biological system modeling, brain function and sophisticated signal processing (Hanggi & Moschytz., 2000). Various tools have been developed the role of network and it isused in AItechnology of international business machine (IBM). AI tools and network is also used for diseases detection, breast cancer and analysis of patient's medical information (Rouse et al., 2017).

AI IN DRUG SCREENING

Today Artificial intelligence has a very successful and demanding technology in drug screening because it saves time, it's cheaper and quicker. The process of discovering and developing a drug can take overtime and cost US$2.8billion on average. Even then, nine out of ten therapeutic molecules fail phase II clinical trials and approval regulatory (Alvarez & Martinez., 2019). Algorithms, such as nearest- neighbor classifiers, RF, extreme learning machines, SVMs, and deep neural network (DNNs), areused for based on synthesis and it can also foretell in bio-activity and toxicity (Dana, Gadhiya, S.V Surin, Naaz, Ali & Narayan., 2018). Most pharmaceutical companies, such as Bayer, Roche, and Pfizer have teamed up with IT companies to develop for the discovery of therapy such as immuno-oncology and cardiovascular diseases (Mak & Pichika., 2019). AI used to cell classification, cell distribution and calculation properties of small molecules.

PRIMARY DRUG SCREENING

The primary drug screenings include the classification and distribution of cells by the help AI technology. Some machine learning models using different algorithms recognize image with analyze big data. To classification the select cell and so, it can be identifying the cell and its features (Tripathy, Mahanta & Paul., 2014).

SECONDARY DRUG SCREENING

The secondary drug screening is used to analyzing the toxicity, bio-activity, and physical properties of the various compounds. Different methods like finger-printing, simplified molecular-input line- entry system and coulomb matrices is to essential new drug design. This information used in DNN, which classified into two different stages, generative and predictive stages (Andrysek et al., 2003).

AI IN DRUG DESIGN MOLECULES

Artificial intelligence can assist in structure based new drug design by predicting the 3d protein structure. Before the drug synthesis or the basis of environment of protein site andit help to predict the efficacy of compound along with safety consideration. Drug design molecules are two methods: Prediction of the target protein structure and predicting drug protein interaction (Wan, F & Zeng., 2016).

PREDICTION OF THE TARGET PROTEIN STRUCTURE: While developed a new drug molecule, itis essential to assign the correct target for successful treatment. Development of diseases are involved numerous proteins and some cases, they are unaffected. Because, for selective focus of disease, the drug design molecules are predicting of protein. AI can assist in structure by the help of drug discovery by predicting the 3D protein structure. Hence, the design is the chemical environment of the target protein site, thus helping to predict the effect of a compound on the target along with safety consideration before their synthesis or production. The AI tools and networks, Alpha Fold, it is based on DNNs, By the used to analyze the distance between the amino acids

and corresponding angles of peptide bonds to the foretell. The 3D focus protein structure and excellent results by correct predict 25 to 43 structures. In the study of

Alqurashi, RNN is mainly used to predict the protein structure. The author explains three stages- computation, Geometry and Assessment. It's termed the recurrent geometric network (RGN) and the primary protein sequence was encoded. A study was conducted the 2D structure of protein using by a nonlinear three layered NN toolbox based on the feedback learning and error of back propagation algorithm. The study was predicted that his AI method would be quicker, cheaper and more effective than alpha fold to predict the protein structure with sequences similar to the references structure (AlQuaraishi et al., 2019). It was used to train input and output data sets, and the NNs were learning algorithms and evaluators. The accuracy in foretell the 2D structure of protein was 62.72% (Avdagic, Purisevic, E, Omanovic & Coralic., 2009).

PREDICTING DRUG-PROTIEN INTERACTION

Drug protein interactions have a pivot role in the target of a therapy. The prediction of the interaction of a drug with the help of a receptor or protein is the essential role to allow the repurposing of drugs, efficacy and effectiveness and prevents poly pharmacology (Avdagic, Purisevic, Omanovic, S & Coralic., 2009). Some AI methods have been successful in the accurate prediction's ligand ensuring better therapeutic efficacy, protein interactions (Tian, Shao, wang, Guan & Zhou., 2016). Which were developed used in structural characteristics and primary protein sequences of small drug molecules to discover nine new drug compounds and there for their four targets of crucial (Wang, F., Liu, Wang, Luo, Zheng & Jiang., 2011). The protein interaction by the pharmacology and chemical data. Such as high sensitivity and specificity therefore, the speeding up the new drug discovery process. The drug, nuclear receptors (NR), ion channels enzyme, G-protein coupled receptors (GPCRs) arethe combination of sub-predicators. These predicators were compared with the drug between Jack knife tests. So, the both prediction accuracy and consistency (Xiao, Min, J.L, Liu, Cheng, X & Chou., 2015). The ability of AI to predict drug focused interaction was also used to repurposing of existing drugs and avoiding poly- pharmacology. Repurposing of a certain drug Directly for clinical trials (Mak, K.K., & Pichika., 2019). This also less expenditure because the relaunching the drug costs US$8.4 million compared withthe launching new drug costs US$41.3 million (Persidis et al., 2011). The 'Guilt by association' is used to treatment and improving a disease. Machine learning is used to widely area Such as NN, SVM, logistic regression and other ML approaches considered a drug-to-drug disease to disease similarity, the similar between the chemical structure, compound, gene and molecules (Park & K.,2019). The drug-protein is used to predict the chance of poly pharmacology. Which is used to increases the tendency of a drug molecules and it is not producing adverse effect (Li, Xu, Y., Cui. H., Huang., T., Wang, D., Lian & Xie., 2017).

DRUG REPURPOSING

Drug repurposing play a pivot role in drug discovery is to find a new use for an old drug, which help to reduce time and costs (Cavasotto & Filippo et al., 2020). In fact, when no treatments are available, these strategy promises to drug candidate that have passed the clinical phase I. This strategy is most impactful and useful to make new purpose for an old drug. There are various examples of ML application which linked in the field of repurposing practice Aliper et al (Aliper, Plis, Artemov, Ulloa, Mamoshona & Mol., 2016). That have performed a work in which a set of drugs were classified into several therapeutic categories. The dataset that has used to consisted of perturbation samples of 678 drugs across A549, MCF-7 and PC-3 cell lines, extracted from the LINCS Project (NIH et al., 2020). Cell line parameters and time of perturbation that have included in samples of

different drugconcentration. There are 12 therapeutic categories derived from the medical subject headings (MeSH) that have linked to the samples (Mesh et al., 2020). Anti-inflammatory, hematologic, cardiovascular, central nervous system, urological, respiratory system, reproductive control, dermatological, gastrointestinal, anti-infective, antineoplastic, and lipid regulation (A.A. Buzdin, Zhavoronkov, Zenin, Smirnov, Front & Borisov., 2014). Kinnings et al. was performed other indirect approach for drug repurposing by the help of SVM model discussed in section. Those drugs which extracted from protein data bank (PDB) that approved by 962 protein structure co-crystallized with 274 FDA to identify potential lead compounds that inhibit inhA, and a binding site comparison with ihhA which performed with SMAP (Xie, Bourne & Bioinform.,2007 &

P.E Bourne., 2009). SMAP values is inaccordance with strong connections were accepted with inhA and phosphodiesterase 5 (PDE5) inhibitors. In this series 303 PDE inhibitors, extracted from the Binding database and SVM models were used to develop these inhibitors. Stokes ET al. was performed a remarkable work which impact the discovery of new antibiotic that have predict antibacterial activities against E. coli (Corsello, Liu, Bittker, Gould, Wong, Vrcic, John Ston & Khan., 2017). This theory encourages the role of artificial intelligence how it can help in discovery of new compounds against emergent antibiotic-resistance bacteria (K.M. Gayvert, Madhukar & Elemento.,2016).

AI IN QUALITY CONTROL AND QUALITY ASSURANCE

Manufacturing of the raw material includes a balance of various parameters (Gams, Horvat, Ojek & Gradisek., 2014). The products check the quality is used to quality control test, as well as maintenance of consistency. This might be not best method in each case, the need for AI implementation at the stage (Rantane, J & Khinest., 2015). The food and drug administration modified the current Good Manufacturing Practice (cMGP). By introducing a quality by design approach, the understand the critical operation and the specific criteria that govern the final quality of the pharmaceutical products (Aksu, Paradkar, Mats, Ozer & Ork., 2013). Gams et al. used a combine of human efforts and artificial intelligence, where primary data from production batches were decision development of trees and analyzed. These were various translated into rules and analyzed by the production cycle in future (Gams, Horvat, Ojek & Gradisek., 2014). Artificial intelligence can also use tool for the manufacturing process and achieve desire effect of standard products. Goh et al. was studied profile of dissolution, an indicator is used to consistency of theophylline pellets with the aid of ANN, which truly foretell the dissolution of formulation of error < 8% (Goh, Lim, Peh & Subari., 2002).

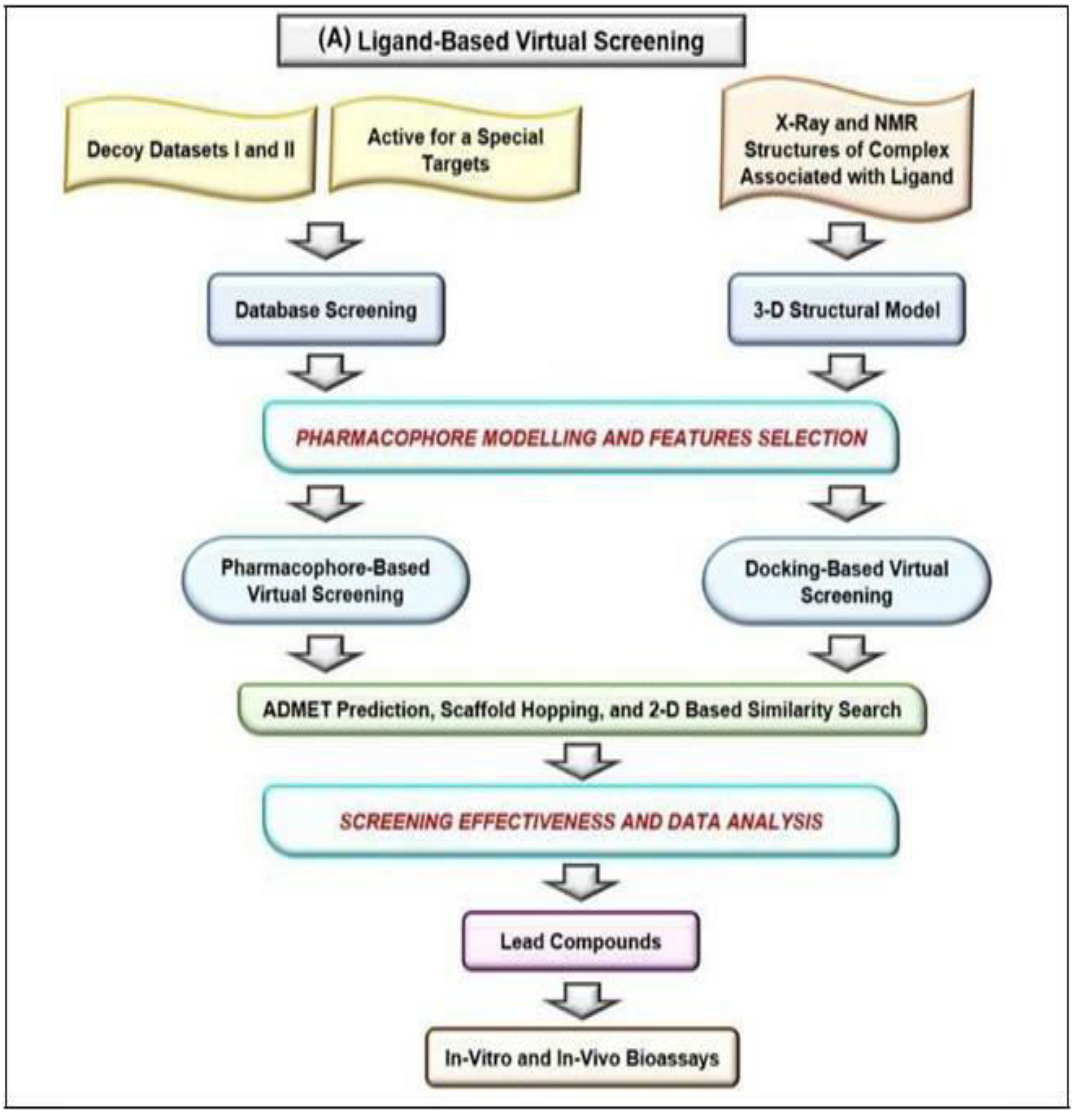
STRUCUTURE BASED AND LIGAND BASED VIRTUAL SCREENING

Virtual screenings are one of the most crucial methods of CADD in drug discovery and drug design. It is binding a drug target and refer to identification of small chemical compounds. Virtual screening is modern method to purifier therapeutic compounds from a pool (Lavecchia & Giovanni., 2013). Thus, it becomes an important tool in high throughput screenings, which is solving the problem of high expensive, high effectiveness and low accuracy rate. The rise of artificial intelligence algorithmsin pharma-industry and health care area, different tools and models have been developed for both LBVs and SBVs. For example, such as Compscore, Geaux dock, MTi-open screen, Play Molecule BindScope, Gypsum-Dl and ENRI have been developed by SBVs. There are twoimportant types of virtual screening such as- Structure-Based virtual screening (SBVs) and Ligand based virtual screening (LBVs) (Ganczarek, Tomczak & Zareba., 2018).

LIGAND BASED VIRTUAL SCREENING

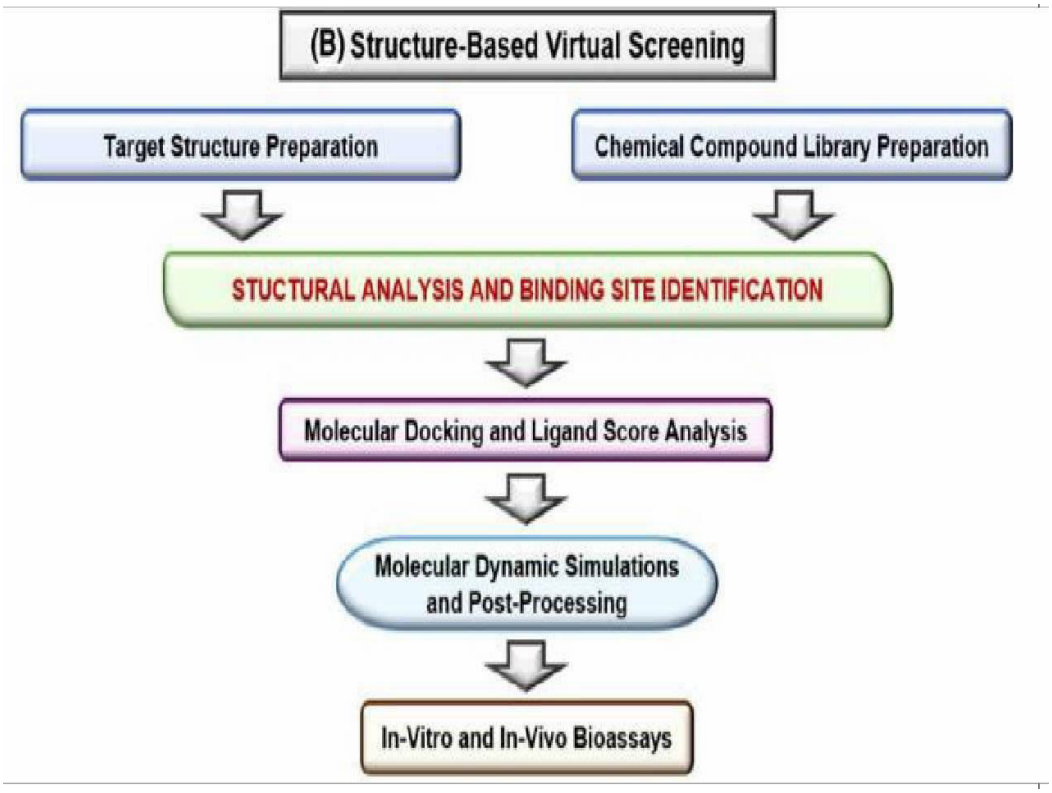
The ligand based virtual screening depends on the empirical data of both active and inactive ligands and chemical structure, which is used to chemical and physiochemical. The ligand

based virtual screening is based on active ligand to foretell the other inactive ligands from a compound with high bioactivity.



STRUCTURE BASED VIRTUAL SCREENING

Structure based virtual screening has beendepending on tools. Protein targets elucidated either through in vitro or vivo experiment or 3D structure in formation of protein and through computational modeling. It is general method used to predict the interaction between active ligands and predict the amino acid which is used binding a protein targets. The precision and high accuracy are comparison between LBVs and SBVs (Melville, Burke & Hirst., 2009). The structure based virtual screening is associated the increasing number of protein diseases and they are complicated. The SBVs should be filtered comprising between active and inactive compounds with the help of machine learning and virtual screening. Some training data are used to model of train with several learning techniques. Artificial intelligence and Machine learning based on scorings algorithms have been developed such as C-score, SVR- score, NN-score and ID-score (Serafm, Kronenberger & Oliveira., 2020). SBVs have been formation to predict protein ligands by using different methods are ML and DL. Artificial intelligence has been developed for dynamic molecules in SBVs (Vallster & Siedleki., 2017).



IMPLEMENTATION OF AI IN DE-NOVO DRUG DESIGNING

The continual process to design 3D structure of receptors to produce a novel molecule is known as De- Novo designing which is help to produced new designing (Hartenfeller & Schneider., 2011). The de novo drug designing plays a pivot role in the field of medication disclosure. Artificial intelligence and Machine learning are important techniques which coordinates the VR for drugs. SVM, DNNs and RF are the machine learning models which have been used to improve the drug discovery and development for analyzing the pharmaceutical products (Ekins, Puhl & Zorm., 2019).

AI IN CLINICAL TRIAL DESIGN

Clinical trials are used to establishing the safety and efficacy of a drug product in human against the disease condition and it require 6-7 year along with financial investment. During the trials, only one out of ten molecules which pass the phase which is a heavy loses for industry (Hay, Thomas, Craighead & Rosenthal., 2014). This loss can result from the shortage of technical requirements, inappropriate patient's selection and poor infrastructure. Implementation of AI which helps to reduce the failures and loses (Harrer, Shah, Antony & Hu., 2019). However broad scope of AI has developed new approaches that can help to improve and optimize drug discovery. AI can regulate and manage the preclinical and clinical pharmacology data to accelerate the progress of drug discovery and development (Niel & Bastard et al., 2019). When a drug passes all preclinical tests successfully then it goes under the clinical trials, which classified by three phases: Phase (i), drug safety testing with small amount of people; Phase (ii), drug efficacy testing in those humans who affected by a particular disease; Phase(iii), efficacy studies in a large number of patient and after the passing those phases, FDA review it for approval and commercialization (Rubin & Gilliland et al.,2012). AI techniques also reduces the cost of clinical trials by increasing success rate by analyzing side effect, toxicity and other related parameters. AI technology, further help to enhancing the management of clinical trials (Fogel et al., 2018).

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IMPACT OF ARTIFICIAL INTELLIGENCE ON DIGITAL MARKETING DUE TO TECHNOLOGICALADVANCEMENTS

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ABSTRACT

In order to maximise the activity of advertising and sales generation, digital marketing incorporates both marketing activity and computer science. In this study, a thorough evaluation of the aspect of technological development in artificial intelligence and its implications for digital marketing activities is undertaken. This article discusses many digital marketing strategies that help contemporary businesses achieve successful client engagement through face-to-face communication. Recently, it has been discovered that a lot of strategies, including SEO, PPC, Chatbots, SMM, and others, have been employed to optimise marketing operations in the global market. AI has a vital role to play in enhancing the aforementioned strategies and enhancing the online marketing process. When customers search for products, AI helps business entities collect customer data. AI employs techniques like picture recognition, time series forecasting, and brain modelling to provide more pertinent information to commercial organisations about consumer behaviour and purchase intent. Another crucial component in this context is augmented reality, which enables clients to see and touch things provided by businesses, increasing the volume of sales in the targeted market. Such technology development aids in assessing how customers view products and services, which enables marketers to put effective plans in place to satisfy consumer wants. It can be accomplished by improving the level of customer service and goods by setting them apart from competing offerings in the same market. In order to increase sales volume in the target market through efficient technological improvements, AI influences to better product promotion approach.

Keywords: Artificial Intelligence, Digital Marketing, Technology, Software, Customer, Competitive advantage

1. INTRODUCTION

The methodologies, methods, approaches, perspectives, and tactics for communicating the value of a brand, service, or product to the consumer market in order of selling and promoting the aforementioned service, product, or brand can be conceptualised as a generic definition for the term and discipline of "marketing." It is evident from this definition and from actual experience that marketing is a field of modern corporate practise that is constantly changing. The following statement is supported by the widespread use of technology in marketing over time. Digital technologies, which are at the forefront of marketing's progress today, are gradually and steadily leading to a newer understanding of so-called "new age" or digital marketing (Jain & Yadav, 2017, Foroudi et al., 2017). Artificial Intelligence is one of the many unique digital technologies that are available today (AI).

AI is essentially the demonstration of intelligence by machines, which is generally linked to inherently human abilities. Technically speaking, it is the area of computer science that is concerned with creating "smart machines" that are capable of performing activities that traditionally require human intelligence (Brynjolfsson & Mcafee, 2017). In general, four academic and professional viewpoints—rational action, humanly action, rational thinking, and humanly thinking—have historically and now defined the subject of artificial intelligence (Brynjolfsson & Mcafee, 2017). These research areas have led to the development of two major kinds of AI, referred to as narrow or weak AI and strong AI, which is officially known as Artificial General Intelligence (AGI) (Brynjolfsson & Mcafee, 2017). As evidenced by a variety

of current use cases like AI personal assistants, semi-autonomous vehicles, IBM's Watson, Google search, and image recognition software, the vast majority of tangible results and developments in AI as a digital technology come from narrow AI that operates within a limited context to simulate human intelligence (Brynjolfsson & Mcafee, 2017). AGI, on the other hand, refers to AI-powered computers with human-level intellect that could be used for any challenging work. Despite substantial and widespread efforts, the scientific search for AGI has mainly proven unsuccessful so far. In this sense, machine learning (ML), deep learning (DL), signal processing, and natural language processing, understanding, and generation (NLP, NLU, NLG) are some of the most significant narrow AI fields and technologies now available (Brynjolfsson & Mcafee, 2017). Voice recognition, picture recognition, and computer vision are only a few examples of the revolutionary applications that each of the aforementioned disciplinesproduces.

The above-described integration of AI-powered tools and technology into the field and practise of marketing has the potential to have significant effects on current marketing practises. Ai has the ability to significantly improve current marketing strategies as well as introduce whole new channels for connecting with and providing value to the consumer market (Brynjolfsson & Mcafee, 2017). Importantly, among marketing organisations and practitioners, enthusiasm for such meaningful integrations has progressively moved beyond just theoretical insights to real application, notably as of the decade starting in the year 2010. (Dimitrieska et al., 2018). Notably, numerous empirical studies show that marketing is one of the industries that uses AI resources most effectively, and current polls support this claim by showing that marketing is one of the industries that uses AI technologies most effectively (Sterne, 2017). However, despite this potentially profound impact, a review of the present body of information on the relationship between AI and marketing indicates a paucity of literature, which is probably due to the relatively recent development of this field of study (Brynjolfsson & Mcafee, 2017, Sterne, 2017).

2. DIGITAL MARKETING

Technology advancement and the growth of digital marketing go hand in hand. Ray Tomlinson sent the first email in 1971, and his invention created the framework that made it possible for users to transmit and receive information using various equipment. Computers' storage capacities were already sufficient in the 1980s to accommodate massive amounts of client data. Companies were deciding against limited list brokers in favour of online strategies like database marketing.

These databases changed the way that buyers and sellers interacted by enabling businesses to track client information more efficiently. The manual procedure, however, was not very effective. With the introduction of server/client architecture and the widespread use of personal computers in the 1990s, when the phrase "digital marketing" was first used, Customer Relationship Management (CRM) software emerged as a key component of marketing technology. Vendors were compelled by fierce competition to include more services, such as apps for marketing, sales, and service, into their software. After the creation of the Internet, marketers were also able to hold vast amounts of online customer data through e CRM software. Companies might receive the priority of customer experience and update data on customer wants. Due to this, the "You Will" campaign by AT&T, which was the first clickable banner ad, went online in 1994. In the first four months after it went live, 44% of all viewers clicked on the ad.

The diversification of marketing technologies was improved by the shift in consumer behaviour. Particularly since 2013, the term "digital marketing" has become the most used worldwide. Digital advertising spending increased by 48% in 2010, with an estimated 4.5 trillion internet ads served annually. Businesses that utilise Online Behavioral Advertising (OBA) to target

advertising at internet users account for an increasing share of advertising, yet OBA creates issues with consumer privacy and data security. Following are some of most important methods of digital marketing.

i. Search Engine Optimization (SEO): This is the process of improving your website's "rank" in search engine results, which will increase the quantity of natural (or free) traffic that your website receives. Sites like blogs, infographics, and websites all benefit from SEO.

ii. Social Media Marketing: This method advertises your company's name and content on social media platforms to build brand recognition, attract customers, and enhance lead generation for your company. You can utilise Facebook, Twitter, LinkedIn, Instagram, Snap Chat, Pinterest, and Google+ as social media marketing channels.

iii. Content Marketing: It refers to the development and marketing of content assets with the aim of increasing traffic, lead generation, brand awareness, and customer base. Your content marketing plan can use a variety of channels, such as blog postings, whitepapers and e-books, infographics, online brochures, and look books.

iv. Affiliate Marketing: This is a form of performance-based advertising in which you get paid to promote the goods and services of others on your website. Hosting video adverts through the YouTube Partner Program and posting affiliate links from your social media accounts are examples of affiliate marketing channels.

v. Native Advertising: Native advertising is the term for commercials that are mostly driven by content and displayed on a platform next to unpaid content. Buzz Feed sponsored posts are a good example, but many people also view Facebook and Instagram advertising as "native" social media advertising.

vi. Marketing Automation: The software that helps you automate your fundamental marketing activities is referred to as marketing automation. A lot of marketing departments may automate repetitive processes that they would otherwise have to do by hand, such sending out email newsletters, planning social media posts, updating contact lists, creating workflows for nurturing leads, and tracking and reporting on campaigns.

vii. Email Marketing: Companies communicate with their audiences by using email marketing. Email is frequently used to advertise events, promotions, and special material, as well as to point customers toward a company's website. Blog subscription newsletters, follow-up emails to website visitors who downloaded something, customer welcome emails, holiday promotions to loyalty programme members, and tips or similar series emails for customer nurturing are some of the types of emails you might send during an email marketing campaign.

viii. Inbound Marketing: The "full-funnel" strategy of using online content to attract, engage, and delight customers is known as inbound marketing. Each of the aforementioned digital marketing techniques can be used as part of an inbound marketing plan.

ix. Pay-Per-Click (PPC): PPC is a strategy for increasing website traffic that involves paying a publisher each time their ad is clicked. Google Ad Words, one of the most popular PPC models, enables you to pay for prominent positions on Google's search engine results pages at a cost "per click" of the links you insert. Paid channels are the key additional channels where you can employ PPC.

3. THE TECHNIQUES USED BY AI IN DIGITAL MARKETING

Currently, companies like Google, Spotify, Apple, Amazon, Netflix, and others are adopting AI technologies to improve their marketing initiatives. With the development of new technologies, there is an infinite amount of potential for AI in the field of digital marketing. It becomes more

appealing after the recent example of honed machine learning and smart bidding, and fields that were previously thought to be inflexible to automation are now embracing the shift.

The four important locations where AI approaches are applied in digital marketing.

3.1 Content creation:

The goal of content development is to provide the intended audience with pertinent content that could result in real conversions. To do this, one must reflect on the information at hand, including popular stories and measures like CTR. AI may help producers by helping them quickly identify the pertinent content that resonates effectively with the audience rather than having to sit and sift through vast amounts of information for potential critical thoughts. Companies can plan for content marketing with the aid of chatbots, as demonstrated by the striking example of "Heliograf," which was developed and employed by the Washington Post forreporting procedures in 2017.

3.2 Chatbots:

This AI-powered programme is designed to make it easier for you to communicate with your consumers about particular topics (Kaczorowska-Spychalska, 2019). They can be designed to respond to inquiries with specified responses (FAQ). Chatbots can accomplish the work for you rather than wasting your time and energy repeatedly answering the same inquiry. It is a sensible strategy for enhancing consumer communication. Chatbots automate a portion of the marketing process, allowing your team to focus on more important tasks. In the beginning stages of the marketing process, chatbots are helpful. This entails gathering contact information, responding tofrequently asked questions, and resolving basic technical problems.

Chatbots can increase the amount of marketing dialogues.

A significant portion of the marketing process may be automated by chatbots, giving you and your marketing team more time to perform more creative tasks and increase the amount of marketing dialogues, which will increase conversion.

Chatbots link sales and marketing together.

Generally speaking, including everyone in your chatbot strategy can aid in bringing strategy and marketing into alignment.

3.3 Prediction and email marketing:

Predictions are made by artificial intelligence (AI) using data. Predictive analysis uses a variety of methods, including data, statistical analysis, and machine learning. Using artificial intelligence, businesses may adapt email marketing campaigns and so improve their SEO marketing services by sending emails in response to particular user actions. Brands are adjusting their emails to their target audience with the use of AI. The behaviour and tastes of customers can now be used to tailor information. With subject lines, product recommendations, and messages all customised according to the customer's preferences, this aids them in sending pertinent emails to consumers' inboxes and increasing their email marketing performance metrics.

3.4 Machine learning and smart bidding:

Through the use of machine learning, computer systems may adapt to the changes, just like humans do when they draw lessons from their past behaviour and alter it. For this goal, specialised programming is not necessary, but the system can still learn from experience thanks to its current capabilities. Machine learning has an impact on how the world of digital marketing functions because of its limitless potential. Smart bidding, a subset of automated bid methods, is another extremely popular artificial intelligence tool right now. The smart bidding

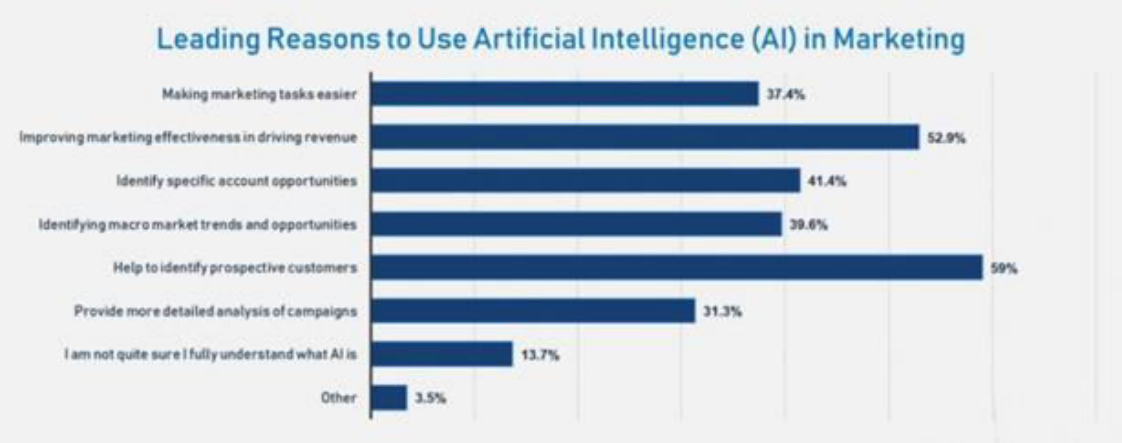
will examine contextual data and previous behaviour patterns to forecast potential conversion. When it determines the conversion, it then raises automated bids.

3.5 Augmented Reality (AR)

A developing trend in marketing and sales tactics is augmented reality (AR). With the simplicity of utilizing their mobile devices, it enables firms to provide clients with distinctive experiences. When it comes to boosting brand value and boosting sales through mobile devices, AR offers another instrument. Because augmented reality is getting more and more popular, brands may utilise it to let customer's trial things before they buy them.

4. THE CURRENT AND POTENTIAL CONTRIBUTION OF AI TOMARKETING

Between 2020 and 2027, AI is expected to grow at an annual rate of 33.2%. Globally, 4.2 billion digital voice assistants will be in use in 2020. By 2024, the number of people using digital assistants is anticipated to double to 8.4 billion. Customer engagement is the most significant application of AI in the retail sector (chatbots, predictive behaviour analysis, hyper-personalization). Due to advanced AI technology, 52% of people are sure that revealing personal information online poses no risk to their online security. Machine intelligence identifies at least half of the 300 billion emails received each day as spam. Currently, there are more than 4 billion voice assistants in use.



5. THE IMPLICATIONS OF AI FOR THE DISCIPLINE AND PRACTICE OF CONTEMPORARY MARKETING

Through the use of virtual assistants and recommendations based on machine learning technologies, AI has the capacity to build simulation models and customise purchasing processes. Artificial intelligence has been embraced by several businesses to interact with their consumers. Similar to how Amazon utilises AI to suggest things based on customers' prior views, searches, and purchases.

Currently, Marketing Automation works with a number of CRMs to manage data and offer efficient customer service. According to projections, commercial applications of AI solutions, marketing techniques, and more efficient than present ones would account for 45% of economic earnings by 2030.

6. CONCLUSION

Artificial intelligence today has such a significant impact on digital marketing that well-designed algorithms can forecast consumer behaviour, target the appropriate people with the correct offers, and even advance alongside cutting-edge innovations like blockchain. Chatbots are increasingly a crucial component of online commerce since they bring value insights through data mining techniques. Our daily lives and technology have been integrated with artificial intelligence, making it simple for us as customers to profit from its advantages.

However, in order to improve customer experiences, increase brand loyalty, and increase revenue, marketers must take advantage of AI's potential.

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EMERGING ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

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ABSTRACT
Artificial intelligence (AI) refers to the intelligence of computers or virtual software, as well as their ability to perform basic and advanced human tasks. According to the findings of the study, AI has been widely used in education, notably by educational institutions, in various forms. Assessment methods of AI include rules-based and machine learning. The former generates a suggestion or a solution using decision-making rules. It is the most fundamental shape in this sense. An intelligent teaching system (ITS), which can give learners detailed and targeted feedback, is an illustration of this kind of technology. In the beginning, AI was represented by computers and computer-related technologies. It then evolved into web-based and online intelligent education systems, and then, with the use of embedded computer systems & various other technologies, human robots and web-based text or voice messages (chatbots) were used to execute the responsibilities and functions of instructors either alone or in collaboration with instructors. Utilizing these platforms, teachers have been able to accomplish many administrative responsibilities in a more effective and efficient manner, such as evaluating and assessing students' assignments to achieve improved quality in their teaching activities. It is also involved in promoting research, with the goal of supporting the use of AI education and the development of cognitive and pedagogical abilities. Numerous nations throughout the world have also formulated relevant policies to support the use of AI technology in the educational field. This paper briefly discusses the prospects, benefits, the development of AI technology, and its application in the field of education including effective teaching and learning innovations, new approaches, and smart campus lifestyles.

Keywords - *Artificial intelligence, Education, AI influence, Educational Application, Teaching, Research field*

INTRODUCTION
In recent years, artificial intelligence has gained a lot of advantages across all industries and nations. Artificial intelligence is the term used to describe the computer or virtual software intelligence and its capacity to do both simple and complex human tasks. It is discovered to be the catalyst in every field because related events like academic conferences, scientific research, and technical competitions cause such a buzz among the younger generation. Artificial intelligence also has many more propensities to work than humans, which has sped up the development of technology and applications. People's lives and workplaces are significantly made more convenient and innovative by artificial intelligence. Numerous AI concepts have grown as a result of robotics research, and a variety of technologies can be applied to artificial intelligence to advance it further and reach its zenith. [1, 2] Now that artificial intelligence has entered an unheard-of age of rapid growth and has completely transformed all facets of life, ithas been discovered to be valuable if we include it in our most significant and prestigious area, namely the sector of education. Although there have been difficulties and ethical concerns with its implementation in the educational sector, it is nevertheless determined to be always advantageous if applied carefully. [3, 4]

Education is the transfer of any knowledge or skill from the older generation to the younger one, regardless of whether it is knowledge, skill, or something else along these lines. It is one of the pillars and a crucial component of society, thus with and after it, a person can advance both personally and socially. We have established that artificial intelligence has had a significant positive impact on education in recent years and that this impact is both good and necessary.

For instance, the current intelligent computer-assisted instruction (ICAI) systems tutor or teach a wide range of disciplines and have a very favorable impact on both society and the pupils. The younger generation is becoming obsessed with faster things, which are only possible withadvancements in technology. For example, horses were faster in the past, but today many of the fastest cars are being introduced with the support of technology, replacing horses with cars. At the same time, education is being improved through the use of AI or machine learning, which is more effective than human teaching and tutors. [5]

Artificial Intelligence in Education

In the future, AI will have an impact on all aspects of our lives, but the education sector will be particularly affected because teaching and learning are important aspects of life and the existing educational system leaves a lot to be desired. Older schooling was less adaptable than what the future of AI in education will offer. The teachers who are most crucial to the educational system are both pricey and not scalable. Teachers are underestimated and given a lot of paperwork in some nations. By providing each person with a customized curriculum based on their interest andskill assessments, AI can assist them individually. [6]

When it comes to education, artificial intelligence offers a lot of advantages, but it also has drawbacks. There are three stages to understanding how artificial intelligence works.

Stage 1 – Basic

It refers to the routine use of the fundamental tools and procedures for computers and other IT equipment, such as internet browsing, data management, and retrieval, connecting and detaching devices, basic problem-solving, data processing activities, etc.

Stage 2 – Intermediate

The user is updated to manage, produce data, install, uninstall software, troubleshooting tools, and perform other routine and necessary tasks using computers during this level.

Stage 3 – Advanced

Using computer applications, managing, and controlling data, improving personal learning database applications, analyzing data, solving problems, graphical and audio-visual communication, completing projects using online resources, using documentation and presentations, etc. are more commonly referred to as stage 3.

Although AI was not widely employed in education when it was initially introduced, it is now, and the educational system is operating fairly as a result. Future implementations of AI in education will apply the same methodology because it is becoming more sophisticated and superior to past eras. For instance, it made the previously required 2D math courses necessary in 3D, and a variety of animations help the students to make the lectures more interesting and effective than ever before. And following the creation of a machine learning layer in the academics of the pupils through a number of educational AI apps. [8]

Methodologies involved in Artificial Intelligence

The study used a variety of techniques, mostly interviews and literature reviews, to examine the advantages and disadvantages of using AI in education.

1. **Interviews** in which a variety of academic interviewees are evaluated by educational scientists for their familiarity with AI and knowledge beyond education, the AI and many teachers can't even go to match that level, and some are found to believe that the incorporation of AI in education is an ethical issue because the students may get off the track with the aid of AI and their morals may be destroyed.
2. **Literature reviews** are conducted to examine the legal implications of the interviews and the extent to which the implementation of AI has affected education. All technical

possibilities, legal issues, and scientific literature are discussed, and finally, the proper framing of AI implementation in education is completed so that the legal implications are introduced to the benefit of the education sector through AI.

AI Education Model

AI learning model is created in such a way to analyze the behavior and interests of an individual.Computers can also analyze a person's interests and learning styles, plan a learning model that best suits those styles even after the learning styles have been mapped, and regularly develop an education model that considers all the other factors that affect education, such as study materials,resources, and teaching methods [9].

The student interface is structured in such a way that the student is a learner model, which is likely to behave positively. AI systems are always ready to offer assistance using the built-in teaching theories of the tutoring model. The user interface also evaluates students' performance using a variety of input methods (speech, typing, and clicking), and it produces results (texts, figures, cartoons, and agencies). The teaching model aids in identifying the guidelines for information availability, allowing teachers to customize their teaching methods and interventions. Advanced human-machine interfaces support AI-related features like speech recognition, natural language interaction, and learner emotion detection [10].

The effects of AI on administration, instruction, and learning in the field of education may be promptly assessed, and the advantages, drawbacks, and challenges of recently emerging AI in education can be quickly calculated. This is crucial since online learning has improved significantly since the Covid-19 outbreak and has been found to be a revolution in the lives of many students. It also sparked the creation of numerous intuitions, some of which are more ancient but would become ingrained in students' daily routines or essential practices after the epidemic, such as physics wallah, unacademy, Vedantu, BYJU'S, and Ruangguru [11].

Advantages of AI in Education [6-7]

The introduction of AI in education was done to maintain the social balance. Various advantages of AI in education include:

1. **Gesture Recognition Technology:** Using this technology, AI aids in our understanding of the students' attitudes or comfort levels during lectures. As AI develops, it can now read a student's facial expressions or hand movements to determine whether they are finding the lecture difficult to understand. If so, the machine can adjust the course so that the student can easily follow along.
2. **E-Learning:** With the use of AI tools, worldwide classrooms can accommodate students who have hearing or vision impairments. Students who are ill and unable to attend class can also benefit from this. The teacher marks the pupils in the traditional educational system based on their assignments and tests, which takes a lot of time. When AI intervenes in this situation, it would quickly completes this kind of job. Additionally, it aids in providing advice on how to close learning gaps.

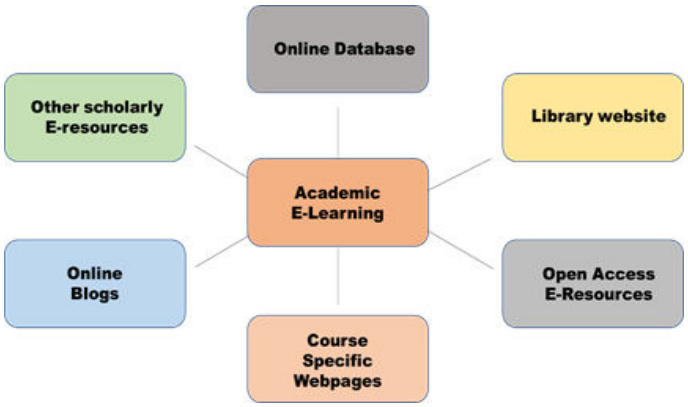

Figure 1: Academic e-learning Model

3. **Presentation Translator:** People who speak different languages or have hearing or vision issues can access a variety of resources thanks to AI. The AI-based software tool Presentation Translator delivers subtitles in real-time mode. Students can read and hear in their native language, for instance, with the aid of Google Translate. Modern technologies like VR and gamification are useful for more participatory meetings.
4. Machines can grade written answers such as sentences and paragraphs. As a result, a teacher's job is made simpler, there is no time wasted, and the time saved can be used to focus more on the growth and assessment of each individual student.
5. It may also be used to handle admissions and enrollment procedures, while its full potential is still untapped. AI can aid students in their home study habits and exam planning. Future AI will be able to respond to various learning styles. The development of more sophisticated tutoring and study programs is entirely due to artificial intelligence. Applications for AI in education are currently being explored, such as AI mentors for students.
6. **Adaptive Group Formation:** Students can be divided into groups by AI that are most suited for specific assignments. Software using artificial intelligence that can evaluate student essays right away. These essays are added to a central database, and the database's prior essays can be used to compare future articles.
7. **Voice Assistant:** This is a ground-breaking use of AI. This comprises Google Assistant, Microsoft's Cortana, Apple's Siri, and Amazon's Alexa. Without the assistance of their teacher, these voice assistants allow students to communicate directly with the instructional materials that are available on the internet and on the installed devices.

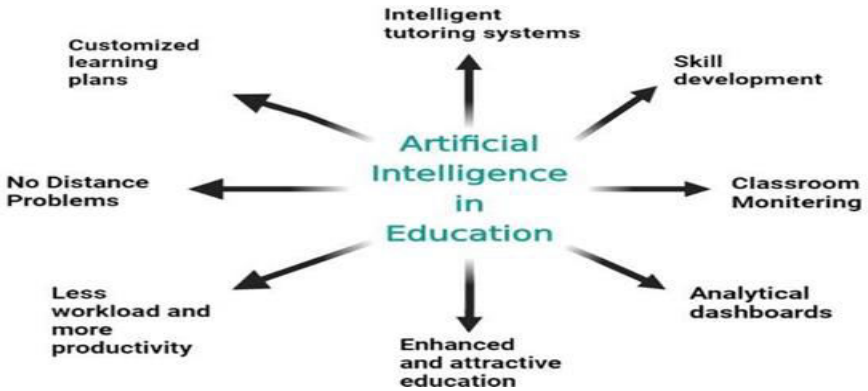

Figure 1: Applications of AI in Education [6]

Disadvantages of AI in Education [12]

1. **High cost:** This will cause problems for various institutions and raise financial concerns about introducing AI to their students.
2. **Unemployment:** Teachers will lose their jobs, which will result in unemployment, students won't be able to handle this abrupt and drastic change, educational systems will be disrupted and won't be able to maintain such rapid progress, and so on.
3. The new generation is completely covered by AI; they are all machines, and if it is compromised, the entire educational system could be destroyed or damaged.
4. Additionally, students' privacy would be blocked, AI would be present in every aspect of their lives and ethics would be less and less regulated, and students might interact with AI in ways that would be detrimental rather than beneficial.

Impacts of Artificial Intelligence [13-17]

1. Educational institutions:

AI falls under the category of a digital learning tool. Similar conditions must be met for AI to be successfully used. There needs to be a strong digital infrastructure at the base level. A broadband internet connection and gadgets for students and teachers are the minimum components of the digital infrastructure. For AI models to be trained, data must also be accessible. Data from administrative systems, (meta)data regarding educational resources and data produced by the usage of (digital) educational resources are some examples of this type of information.

To employ AI technologies properly, teachers, school leaders, and administrators must also be able to recognize their additional value. Staff in the education industry must possess the required digital skills for this. Then, subject-specific AI applications can be included in the classroom. Finally, an institution can start integrating various AI systems once users have had enough experience using AI responsibly.

2. Students:

The effects of AI will vary depending on the type of educational setting. In primary education, AI may result in a situation where kids are more likely to receive a personalized explanation of the material based on their skill level and learning preferences rather than a lecture on the subject. This will result in more time being spent by pupils using computers in the classroom (or at least a screen). However, we anticipate that there will still be a lot of one-on-one interaction (necessary) between the student and the teacher.

The effects of AI on students will be less pronounced in secondary school than in basic education. Applications for AI will mostly be found in the autonomous educational techniques that are presently in use. AI systems are particularly well-suited for learning and testing factual information at the time (and in the near future).

The impact of AI will be stronger for science, technology, engineering, and math (STEM) disciplines than for 'alpha' subjects because of the distinct nature of these fields. An AI is better at determining whether a mathematical problem has been solved correctly than it isat evaluating the essay's arguments.

The influence of MOOCs in higher education could be very significant. It is not unlikely that the same abilities and knowledge may be obtained through a MOOC when they incorporate AI: quicker, cheaper, and from a more reputable educational institution than through conventional higher education. If this is the case, students will be able to follow the classes run by international universities without having to physically be present in a classroom.

3. Teachers:

The teacher is a key player in the educational system. The lesson's structure is left up to the teacher's discretion. Therefore, design thinking must be used to approach the creation of an AI. The user's demands are crucial to design thinking when creating new technologies. AI needs to be adaptable in its use and compatible with the various teaching methods used by teachers in order to be successfully implemented in the educational setting. In addition to the program's end users (pupils and students), teachers will be the group who will be most impacted by AI.

AI will be able to automate some instructional jobs, some of the current tasks will grow in importance, and new tasks will also be developed. We primarily see the selection of course materials and evaluation among the responsibilities that can be delegated.

Artificial intelligence (AI) may also take over the task of giving the pupil feedback. This gives the teacher more time to focus on things that are challenging or impossible to automate with AI because some of the duties can be done by an AI (e.g., social tasks such as guidance and coaching). New tasks will be created as a result of the AI application. An educator must be able to analyze AI output and convert it into actionable items in order to employ AI appropriately.

4. The educational system:

AI may have a significant impact on the educational system. Students are divided into competency-based groups under the existing educational system due to practical considerations. This makes it simpler for teachers to introduce a subject at a specific degree of difficulty. The emphasis will change from generalized "education levels" to an emphasis on subjects when an AI is utilized for individualized learning.

The requirement for standardized assessments may be removed by AI. Standardized tests have been criticized for being snapshots of students' performance that are not necessarily accurate. A learner's performance can be tracked using AI throughout the learning process. This reduces the requirement for testing at times and improves the understanding of a student's performance.

Current Scenario of AI in Education

Only 15% of educators in public schools are good with computers, even though the educational system has changed and the quality of instruction has improved, according to several surveys and articles. Compared to over 50% of teachers in public and private schools in Goa, Punjab, and Maharashtra, only 3% of teachers in government and private schools in states like Bihar, MadhyaPradesh, and Mizoram were found to have computer training. According to the Ministry of Education-UDISE study, only a very limited number of teachers in India have been identified and trained to manage the technology-driven teaching-learning process (2019-20). Only 22.28 percent of management schools in India had access to the internet. Additionally, just 38.54% of schools overall have access to computers on-premise, including barely 30.03% of government, 62.97% of government-aided, and 59.88% of private schools. It was found that 61.84% of schools in India have suitable computer facilities. [8]

As a result, artificial intelligence is now only used sparingly in our educational system. Supercomputers come to mind when thinking about the use of AI in education. introduce impassive skills such as adaptive behavior, sensors, adaptive capabilities, human recognition and functional abilities, and a fully automated large architectural structure comprised of all these computers and intellectual abilities. Since the use of AI in education is still in its early stages, numerous scientists and researchers are working very hard to develop it and fully realize its promise. [5]

Future Aspects of AI in Education

A small portion of our educational system was launched with AI's assistance, and from there it developed to automate schooling more or completely. general expectations for data prediction

and analysis, intelligent education, cutting-edge virtual learning, and AI-assisted education Basically, studying will be easier and more pleasurable for the kids due to its more appealing [audio-visual approaches]. These intelligent learning systems have been found to be helpful for tutors and pupils, and as research is progressing, the future will get more intriguing going forward as 4D or holographic methods will replace audio-visual ones. [11]

Cobots (robotic colleagues and tutors) are always brighter and more knowledgeable than a singleindividual since they are computers and artificially intelligent, and they are more capable than either individuals or humans. Additionally, cobots are built with a number of computer technologies, especially those that are related to machine learning, and can support multidisciplinary learning. [11-12]

The World Economic Forum predicts that by 2022, a disproportionate number of businesses will have adopted technologies like machine learning, which strongly encourages governments and educational institutions to focus on quickly raising standards of education and skill development with an emphasis on both STEM (science, technology, engineering, and mathematics) and non- cognitive soft skills in order to meet this urgent need. [12] According to a recent study by Microsoft, by the time students graduate in 2030, they may be required to know both sides of thisnew world:

- Understand how to use evolving technology.
- Know how to collaborate with others in a team to solve problems successfully.

It will start early to get students ready for the future of AI. Teaching children the skills they will need to succeed in a digital workplace is essential since by the time they reach college age, the majority of children are comfortable using digital technology. The force of the longer term will be higher prepared to tackle the unknown difficulties of AI integration in schooling. [11-12, 18]

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EMERGENCE OF TRANSMISSIBLE DISEASE- HOW MACHINE LEARNING HELPS?

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ABSTRACT

Following a century of frequently successful preventative and control initiatives, transmissible diseases continue to be a major global public health issue, resulting in over 13 million annual deaths. It is caused by microorganisms such as bacteria, viruses, fungus, and parasites like tuberculosis, Covid-19, Swine Flu, HIV, and Ebola. Direct or indirect transmission of these infections can cause epidemics or even pandemics. Despite medical advancements, infectious illnesses continue to be a primary cause of death globally, particularly in developing nations. Machine learning has increased the use of evidence-based decision-making in a variety of fields, such as health care, manufacturing, education, financial modeling, law enforcement, and marketing. It is not only related to collection of laboratory information but can exploit multiple data streams, to give physicians with predictive and actionable outcomes. This review focus on key aspects of AI in Transmissible disease: diagnosis, transmission, drug and vaccine development response to treatment, management, patient records, and social distancing. We presume that extreme values be used as a point of interest for future improvement in the field of transmissible disease.

Keywords: *Artificial intelligence, tuberculosis, covid-19, medical advancements, AI applications, machine learning*

ABBREVIATIONS

AI- Artificial intelligence

MTB- Mycobacterium tuberculosis

ML- Machine learning

LTB- Latent Tuberculosis

INTRODUCTION

Artificial intelligence, often known as machine learning, is an area of computer science that may function similarly to humans, reducing the effort of human beings. There are four broad types of artificial intelligence (AI) systems are machine learning, deep learning, expert systems, and search algorithms. Artificial intelligence (AI) has been identified as the most effective and desirable analytical tool for humanity among existing analytical technologies [1].Through analysis of the patients' prior data, it can also predict the chance of mortality. It can aid in the battle against the transmissible disease by providing population screening, medical assistance, alerts, and infection control advice. As an evidence-based medical tool, this technology has the potential to improve patient's planning, treatment, and reported outcomes [2]. It also aid in understanding the protein structures of pathogen and used to predict how well a vaccination will work to build antibodies that will fight against the pathogens [3].With the use of strong tools like mathematical modeling and simulations, artificial intelligence can support the developments in structural biology. Mathematical modeling of various viruses and diseases can aid in understanding the dynamics of the pathogens in order to comprehend the varied pictures. In addition to analyzing enormous amounts of data to provide real-time insights on the spread of illness.AI can assist in forecasting the future pandemic epicenters in addition to helping to

provide real-time insights into the spread of illness by analyzing massive amounts of data. Artificial intelligence (AI) systems that make use of cognitive computing, convolutional neural networks, and machine learning can be extremely helpful in the detection, monitoring, and reduction of the workload on medical staff. Virtual reality which is a part of AI can help people manage their chronic pain more effectively, can be used to cure phobias and fears, or can even be used to assist people survive difficult medical procedures like delivery or immunization [4]. The scientific community vigorously debates AI. It could help us comprehend the disease's process better. Furthermore, it could open up new avenues for medical research into their care. Infectious illnesses are caused by harmful microorganisms such as bacteria, viruses, parasites, or fungus. Infections can be either symptomatic or asymptomatic. But certain transmissible infections, like the human immunodeficiency virus (HIV), are largely asymptomatic at first, they can have devastating effects if left unchecked in time [5]. Different microorganisms have different ways of spreading infectious illnesses. For instance, some viruses, like HIV, can only be spread by intimate physical contact (sexual or blood contact), but influenza virus infection can be spread within a few meters of each other through droplets that are released after sneezing, coughing, or speaking [6].

This review paper's concise the literature that is urgency of artificial intelligence in social distancing, drug and vaccine development, management, transmission, patient records, and response to treatment.(Figure:1)

COVID-19

The medical community is searching for novel methods to track and contain the COVID19 (Corona virus) pandemic during this current global health emergency. One such piece of technology that makes it simple to monitor the virus' transmission, identify people at high risk, and apply real-time infection management is AI. Through population screening, medical assistance alerts, and recommendations for infection management, also analysis of the patients' prior data, additionally it may also forecast the chance of mortality [7].

Digital technologies like Artificial Intelligence (AI) are becoming increasingly important in research investigations, medicinal tests, and clinical trials throughout the world while the world waits for a COVID-19 viral vaccine.

KEY USES OF AI IN THE COVID-19 EPIDEMIC

1. Early Diagnosis and Identification

AI can rapidly assess unusual symptoms and other ‘reflags,' alerting patients and healthcare providers. With the use of medical imaging technologies like as computed tomography (CT) and magnetic resonance imaging (MRI) scans of human body parts, AI can assist in the identification of infected patients. Based on visual 2D and 3D data derived from volumetric chest CT scans, researchers have discovered a deep learning model named COVID-19 detection neural network (COVNet) to distinguish between COVID-19 and community-acquired pneumonia [8, 9].

2. Treatment monitoring

AI can create an intelligent platform for autonomous monitoring and prediction of the virus's spread. By significantly accelerating the lead identification, virtual screening, and validation procedures, AI approaches can support and enhance conventional technologies by lowering the amount of time needed to develop a medicine from bench to bed. A Scientist may not be able to evaluate the features of existing approved and validated pharmaceuticals based on molecular characteristics and properties, but AI can speed up the process by generating meaningful data for drug repositioning or repurposing [10]. Using AI, Insilco Medicine has discovered numerous small compounds that are effective against COVID-19 [11].

3. Individuals' contact information tracing
Through the identification of groups and "hot spots" and the effective contact tracking and monitoring of the individuals, AI can assist in analyzing the extent of the viral infection. It has the ability to forecast this disease's progress and potential for recurrence [12]. AI can support mobile health apps where gadgets like watches, phones, cameras, and a variety of wearable's may be used for detection, contact tracking, and effective monitoring in COVID-19[13].

4. Case and mortality rates
AI can track and anticipate the characteristics of the virus based on accessible data, social media, and media platforms, as well as the risks of infection and its potential propagation. It may also anticipate the number of positive cases and deaths in any location. AI can assist in identifying the most vulnerable locations, individuals, countries and taking appropriate action [12].

5. Drug and vaccine development
Artificial intelligence (AI)-based algorithms have changed drug development in general during the last decade [14, 15, 16].

AI has also led to the development of several RV virtual frameworks, which are commonly categorized as rule-based filtering models [17, 18]. Machine learning (ML) enables the development of models that can predict conclusions from previously unrecognized data as well as learn and generalise patterns within the given data. As the introduction of deep learning (DL), the learning technique may now comprise automated feature extraction from raw data [19].

Furthermore, it has recently been discovered that deep learning's feature extraction can result in greater performance as compared to existing computer-aided models [20, 21, 22].It can aid in the identification of helpful medications for the treatment of COVID-19 patients. It has evolved into a valuable tool for developing diagnostic tests and [23, 24, 25]. AI aids in the creation of vaccines and therapies at a far faster rate than previously possible, as well as clinical trials during vaccine development.

6. Reduce health providers' burden
Artificial intelligence (AI) is being utilised to lessen the workload of healthcare personnel [26, 27, 28]. It aids in early detection and treatment of this emerging illness by using digital techniques and decision science, and it provides the finest training to students and professionals. AI has the ability to improve future patient care and handle more possible difficulties, reducing doctors' burden [29, 30].

7. Controlling the diseases
AI can give up-to-date knowledge that can aid in the prevention of this disease. It may be used to forecast potential infection areas, viral influx, and the requirement for beds and healthcare workers during this crisis. AI is useful for future viral and illness avoidance by using previously mentored data over data common at various times. It identifies characteristics, causes, and motivations for infection dissemination. In the future, this will be a critical technology in the battle against additional diseases and pandemics.

An Indian government-launched smartphone app called "Arogya Setu" will be utilised as a real-time data platform for Internet of Things (IoT) solutions [31]. Figure 1 depicts the role and use of AI in areas.

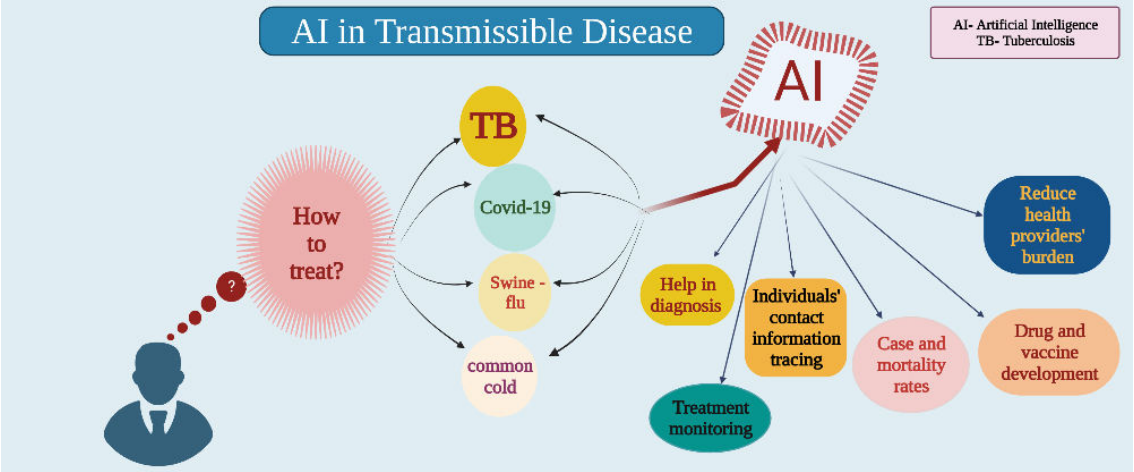

Fig1: Role of AI in different areas

TUBERCULOSIS

TB is an infectious illness that is spread through the air [32]. In 1822, Robert Koch identified Mycobacterium Tuberculosis, the causal organism of tuberculosis. He proved that due to the high lipid content in the microorganism's cellular wall; it was difficult to detect using standard stains [33]. There has been a dramatic decline in TB cases since the discovery of vaccinations. Many measures for controlling and preventing tuberculosis were developed as a result. . "World TB Day" is held annually on March 24th to commemorate Koch's discovery. Tuberculosis is remains one of the leading causes of death globally. According to the World Health Organization (WHO), 10.4 million people were diagnosed with tuberculosis (TB) in 2015, with 1.8 million death rate (WHO 2016 report). TB can be spread through sheep, goats, cats, cattle, and dogs [34]. Typically, the bacterium affects the lungs, although it has also been shown to occasionally impact the brain, spine, and kidney ("facts. Centers for Disease Control and Prevention website," 2013).

Based on the sites that MTB affects, there are two basic categories for TB. Pulmonary tuberculosis develops when the lungs and the areas around them are affected by the bacterium (PTB). Extra pulmonary tuberculosis is the term used when the bacterium affects and spreads to other regions of the body [35].

The symptoms of TB include a cough that lasts for more than two weeks, followed by chest discomfort, appetite loss, weight loss, weakness, exhaustion, chills, and nighttime sweating [36].

DIAGNOSIS OF TUBERCULOSIS

Some of the common techniques that can be used for diagnosis of tuberculosis are:

1. A positive sputum smear culture,
2. A positive blood test,
3. A chest X-ray, or
4. A combination of all above mentioned tests

After remaining dormant for many years, an individual infected with latent TB may become active. TB skin tests or TB blood tests can be used to diagnose LTB because it cannot be transmitted to other people [37].

AI IN TUBERCULOSIS

This section provides an overview of several AI approaches used in the diagnosis of tuberculosis. Several researches have been conducted using AI algorithms for the diagnosis of TB. El-Solh said that they were the first to use AI to diagnose tuberculosis [38]. Later, a variety of strategies were used to diagnose TB with the greatest precision possible. Artificial intelligence (AI) employs predictive methods including are

A. A ubiquitous method in medical diagnosis using AI

B. Data mining approaches

C. Neural Network with Multilayer

D. Genetic Algorithm

E. Fuzzy Logic

F. Artificial Immune System (AIS)

G. Convolutional Neural Networks

MANAGEMENT OF TB WITH THE HELP OF AI

When it comes to the management of TB patients, the National TB Elimination Programme (NTEP) has been at the forefront of adopting modern technology. Artificial intelligence (AI) presents a special potential for the healthcare industry by improving efficiency, conserving resources, improving the quality of service delivery, and bringing accuracy to interpretation. Its application in this field has a lot of potentials to provide better results, particularly when resources are few. When it comes to patient care, monitoring, program administration, training, and communication, nations that want to decrease their TB burden by 2035 to the levels envisioned by the WHO End TB Strategy must innovate. One such method is digital health (electronic and mobile health). It also stated how many experts predicted the impending change in how healthcare services are delivered. In light of this, program managers in India will need to embrace these digital technologies wholeheartedly [39]. Although treatment adherence has received a lot of attention, digital technology might enhance TB patient care in other ways. For instance, "clip-on" hardware enables the transformation of a smartphone into a medical device [40]. Clinical decision support systems may use algorithms powered by cognitive computing (systems that learn at scale, reason with intent, and naturally interact with humans) to assist physicians in making diagnostic and therapeutic choices [41]. Artificial neural networks have been used in contexts with limited diagnostic alternatives to help diagnose clinical conditions that still present diagnostic challenges, for microscopy sputum smear-negative TB and pleural TB [42]. The potential contribution of computerization to radiology, another important field in TB diagnostics was first recognized decades ago [43]. Nonetheless, the automated detection of TB on digital chest radiographs has yet to become more clinically relevant, although efforts are continuously being on to try it and collaborate with existing clinical information.

The traditional model of the patient-provider relationship can be challenged by telemedicine and remote consultations, which offer healthcare via a home computer or mobile device. To a degree that would be unthinkable even in situations where qualified staff is present, portable and wearable devices with artificial intelligence-enhanced software can monitor patients and send alarms without causing weariness. These advancements will accelerate the shift to home-based care and decrease the need for healthcare institutions. In Brazil, TB treatment covers 87% of the population with a success rate of 72%. The WHO goal is to achieve more than 90% by 2025 for all countries. It is estimated that an appropriate diagnosis and treatment of TB prevented 54 million deaths between 2000 and 2017. The use of smartphones for monitoring medication intake via video (VDOT) is a growing phenomenon in Brazil. VDOT is a more acceptable and

cost-effective option than the traditional (Directly Observed Treatment, Short Course) DOT (in person) but requires a professional to check all medication intake daily. An initiative aims to replace the verifying agent with an artificial intelligence tool capable of validating it automatically through computer vision techniques [44].

CONCLUSION

AI technologies are becoming a necessary part of our daily lives as they revolutionize the healthcare industry for the benefit of global populations. It can assist medical scientists in creating novel medical vaccines and treatments while assuring the medicine's effectiveness, accuracy, and efficiency for patient safety. The application of AI through the use of both existing and novel machine learning algorithms can be crucial in tackling infectious diseases. It is also useful in facilitating studies on pathogens by analyzing accessible data. AI can aid in the development of effective treatment regimens, prevention initiatives, and the development of and vaccines and drugs. It can also be used as the future perspective in terms of transmissible diseases.

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COMPARISON OF ARTIFICIAL INTELLIGENCE AND HUMAN BRAIN AND ITS APPLICATION IN PHARMACEUTICAL AND OTHER SECTORS

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ABSTRACT
Artificial intelligence (AI) is intelligence—perceiving, synthesizing, and inferring information—demonstrated by machines, as opposed to intelligence displayed by humans. The article aims to explain the true meaning of Artificial Intelligence (AI) along with its types and the principles used by them to perform the specific functions. AI concentrates on how computers analyze the data and perform accordingly to provide the desired outcome. This briefly describes the history, development and current scenario of Artificial Intelligence in India. It specifies the advantages, disadvantages of AI and also differentiates the potentials of human brain and Artificial Intelligence on various fields. Now a day's artificial intelligence is emerging in almost every field and has various functions in different sectors of the society. Artificial Intelligence (AI) has already been implemented widely in the medical field in the recent years. This review article highlights the effective use of AI in diverse areas of the pharmaceutical sectors viz., pharmaceutical industry and healthcare, pharmaceutical marketing, drug discovery, in clinical trial design and radiotherapy, etc.

Keywords- *Artificial Intelligence, Chatbot, Algorithms, Heuristic Searches, Bandwidth, Scalability, Intellectual*

INTRODUCTION
Artificial intelligence (AI) is described as the ability of a machine or artificial organism to exhibit intelligence in order to solve complex problems. The integration of computer science and physiology is known as artificial intelligence. To put it more simply, intelligence is the computational component of the capacity to do tasks in the real world. Intelligence is the capacity for thought, creation, memorization, comprehension, pattern recognition, decision-making, adaptation to change, and learning through experience. Artificial intelligence is focused with teaching machines to behave more naturally and quickly than a person would. Because of this, it is known as artificial intelligence.

Artificial intelligence can be divided into parts according to philosophy of AI.

a) Strong AI

b) Weak AI

Strong AI
Strong AI is based on the idea that, in the future, robots may be made to think, or, to put it another way, may replace for human minds. According to Strong AI, in the not too distant future, people will be surrounded by machines that can function just like humans and may even possess intelligence similar to that of humans. If so, then such machines would be able to reason, think, and perform all of the tasks that humans can. Strong AI is yet far from being possible with current research, and there is a heated discussion about whether it is even possible.

Weak AI
Weak AI is based on the simple idea that it is possible to programme machines to behave intelligently. Weak AI only states that it is simple to add mental abilities to computers in order to make them more effective tools, and that this has already begun to happen. A human player may believe that the machine is genuinely making impressive moves when playing chess versus

a computer, for instance. However, thought and planning are in no way involved in the game of chess. A person inputs every move it makes into the computer beforehand, ensuring that the programme will perform the appropriate moves at the appropriate moments. More examples of Weak AI are witness expert systems, drive by wires cars and speech recognisation systems.[1]

Strong AI	Weak AI
Strong AI can successfully imitate human intelligence and is at the core of advanced robotics.	Weak AI can only predict specific characteristics that resemble human intelligence.
Strong AI has a complex algorithm that helps in act in different situations.	While all the actions in weak AIs are preprogrammed by a human.
Strong AI-powered machines have a mind of their own.	Narrow AI has limited memory and does not have any experience.
AutoX, Drive.ai, Optimus Ride, Waymo, Zoox and Tesla are examples of Strong AI.	Alexa and Siri are excellent examples of weak AI.

[2]

History of Artificial Intelligence:

1940's: the history of AI began by the creation of computers, next in 1950's researchers gave a try to construct the machines which could mimic humans. And during the period of 1980's, it underwent second birth, when its ability was discovered. Then slowly software products were produced. And at that time machine learning, a part of AI was developed .The origin of AI is based on fiction and imagination. AI is influenced by inventions in electronics, engineering. Early development includes work in problem solving which consists basic work in learning, knowledge representation. McCarthy was the first person to introduce the term artificial intelligence in 1956. It has many successes .They are: heuristic searches, character recognition and facial recognition systems and so on. In the year 1990, there was a large progress in technological settings, mainly in AI field. Now in 21st century it is having a great impact on organizations and industries.[3]

Advantages of Artificial Intelligence:

- Artificial intelligence offers humans a number of benefits, such as stimulating problem-solving and decision-making abilities.
- It provides the advantage of permanency, reliability and cost effectiveness.
- It takes less time to solve a problem or reach to a decision. Artificial intelligence can make faster decision by automating the process of decision making process.
- Artificial Intelligence can produce solutions to complex problems through gathering data, screening, processing.[4]
- In an AI, knowledge transfer happens considerably more quickly. Unlike when a person needs to be trained in a particular field of knowledge, an AI can teach new information to other machines in a matter of seconds.
- Unlike humans AI systems do not get tired, thus increasing the number of hours worked. This is especially helpful in Manufacturing and Production sector.
- AI is able to solve even the complex problems easily and in a short amount of time. The probability of success is high as well. The calculations are prone to have fewer errors. Multiple problems can also be solved at the same time.[5]

Disadvantages of AI:

- Software development is slow and expensive, which makes it difficult to deploy AI software. A small pool of knowledgeable programmers is available to develop artificial intelligence software.
- When employed improperly, AI has the potential to cause massive amounts of devastation.
- As a result of human job loss, the problem of unemployment is getting worse.
- If a machine is implemented improperly and the outcomes are dangerous for people, it can easily end in devastation.
- Making people lazy through application automation's heavy lifting.
- As AI replaces the majority of basic chores with robots, human interference is declining, which might pose a big issue for the utilisation requirements. Every company wants to replace its least trained workers with AI machines that can complete related duties more quickly.
- Creative tasks are not designed for artificial intelligence. Therefore, it should be clear that AIs lack originality and innovation. Even though they can help in creating something original, they will never be able to match the human brain.
- The outcomes of existing artificial intelligence technologies are still restricted to particular intellectual disciplines, such as speech recognition, picture recognition, and conversation response.[6]

Advantages	**Disadvantages**
Can do repetitive mundane work efficiently.	Cannot do creative work.
Eliminates human errors.	Increase laziness of humans.
Can perform risky jobs.	High cost of development.
Can work tirelessly 24*7 with full accuracy.	Cause unemployment.
Makes fastest decisions accurately.	High cost of maintenance.

[7]

How does AI function?

Large volumes of labelled training data are ingested by AI systems, which then examine the data for correlations and patterns before employing these patterns to forecast future states. An image recognition programme may learn to identify and describe items in images by studying millions of examples, much as a chatbot can learn to have realistic conversations with humans by analyzing examples of text chats.

Three cognitive abilities—learning, reasoning, and self-correction—are the main topics of AI programming.

- **Learning: This area of AI programming is concerned with collecting data and creating the rules that will enable the data to be transformed into useful knowledge. The guidelines, also known as algorithms, give computer devices detailed instructions on how to carry out a certain activity.**
- **Reasoning: This area of AI programming is concerned with selecting the best algorithm to achieve a particular result.**
- **Self-correction: This feature of AI programming is to continuously improve algorithms and make sure they deliver the most precise results.[8]**

Fundamental Differences between Biological and Artificial Intelligence:

AI systems are already considerably more effective than humans in gathering (selecting) and processing (weighing, prioritising, analysing, and combining) massive volumes of data in a logical and mathematically sound manner. They perform this swiftly, precisely, and consistently. They also exhibit greater stability (consistency) than humans, lack stress and emotions, excellent tenacity, and superior knowledge and skill retention. They operate as a machine, entirely serving others with no "self-interest" or "own secret motive." Based on these characteristics, AI systems could be able to replace humans in certain tasks or task-related activities. In order for humans to be able to take over or react properly if the machine system malfunctions, it is still imperative that people retain some level of skill in these duties.[9]

A few key distinctions between natural and artificial intelligence are briefly listed below:

-Basic structure: As opposed to artificial (silicon-based) intelligence, biological (carbon) intelligence is built on neuronal "wetware," which is fundamentally different. In contrast to biological wetware, silicon-based or digital systems have separate "hardware" and "software" components. A biological system will be tied to itself after it has acquired a new talent. The underlying algorithms, on the other hand, may be directly replicated to all other digital systems that are identical after an AI system has learnt a given talent.

-Speed: AI system signals spread at nearly the speed of light. In humans, nerve conduction velocity moves at a maximum rate of 120 m/s, which is incredibly sluggish by computer standards.

-Connectivity and communication: Individuals are unable to speak with one another directly. They have a small bandwidth for communication and only use words and gestures. Compared to direct connectivity-based AI system communication, this is slower and more challenging. They are able to work together using integrated algorithms because of this direct link.

-Updatability and scalability: AI systems are incredibly flexible when it comes to updating, scaling up, and/or reconfiguring them to have the appropriate algorithms and data processing and storage capacity for the jobs they need to do. People hardly ever have this ability for quick, structural development and instant improvement.

Contrarily, nature makes a lot of things out of little: biological brains are millions of times more energy-efficient than computers. Compared to a supercomputer with equivalent processing speed, the human brain uses less energy than a light bulb while using enough electricity to run a large village.

These kinds of differences in basic structure, speed, connectivity, updatability, scalability, and energy consumption will necessarily also lead to different qualities and limitations between human and artificial intelligence. For instance, we respond to simple stimuli thousands of times more slowly than artificial systems. Direct connections between computers are fairly simple to establish, allowing them to function as a single integrated system. This means that AI systems do not have to be seen as individual entities that can easily work alongside each other or have mutual misunderstandings. And if two AI systems are engaged in a task then they run a minimal risk to make a mistake because of miscommunications After all, they are intrinsically connected parts of the same system and the same algorithm.[10]

Other advantages of AI with their Applications:

AI has provided benefits in a vast number of sectors such as healthcare, education, management, and security.

- **In the healthcare industry**, AI may aid in the collection of large amounts of data from several sources. For instance, the Childhood Cancer Data Lab, a medical research organization, is working to create software that will be helpful to medical professionals.
- **In the field of education:** students have reaped several rewards, such as the ability to study anywhere with just a smartphone—free or not. They are allowed to select their preferred teacher, which will allow them to feel at ease and have access to study resources anytime they need it. The ability to teach on such platforms from the comfort of their own homes enhances the demand for qualified educators. Additionally, by using animations and other creative approaches, students and teachers may communicate in a more creative way.
- **In business:** As one's business grows they need better technology and systems for maintenance security and production for their businesses. AI integrated systems provide this better quality and this also results in reduction of human error for management. In the pharmaceutical sector they can use this technology for drug discovery data analysis and retailers can use this to strengthen their marketing methods.
- **Security:** Whether it be physical or virtual (on digital media), whether it be for a person or any business, security is highly vital. With this, the term "cybersecurity" has been often used. The advantages it offers in cyber security include the ability to retain vast volumes of data and to detect risks that are designed as everyday actions for big or mid-sized organisations. AI plays a vital part in making it easier. Cybersecurity powered by AI has the advantage of being able to learn over time. As a result, AI systems eventually pick up on typical traffic patterns and can detect departures from them.

In the legal field, artificial intelligence may help with crime prevention and law enforcement. One of the most basic instances is the storing of criminal information and their DNA in a system that is effective and can be used to match it in the future.

Other applications of AI: AI systems can also help authorities to find if any goods are being illegally transported outside the country. Face detection software are also widely used in police work and are very useful for identifications. Surveying scenes of crime can be done using AI cameras. [11]

Use of AI in Healthcare and Pharma Industry:

Artificial intelligence is being used in the healthcare industry and is changing how biological research is conducted. It could be viewed as a group of technologies that enable machines to sense, perceive, analyse, and produce data so they can carry out administrative and clinical healthcare tasks. It aids in research and training efforts as well. Artificial intelligence systems have been created to help healthcare workers with their daily responsibilities and tasks by utilising the information gained through data analysis. [12] The use of AI tools in medical research and healthcare delivery is becoming ever more obvious. Studies have highlighted the efficacy and potential of AI-enabled health applications. These technical developments are now being matched by significant investment in the application of AI in healthcare by governments and technology companies and the United States Food and Drug Administration is actively facilitating introduction of AI-enabled medical devices in the market. [13] Machine learning which a subset of Artificial intelligence, can be utilized to address the problem of reporting e-health records and redirect these records towards predictive modeling and analysis. With the help of artificial knowledge, we can mix an individual's – omic [proteome, metabolome, microbiome, and genome] data and it can be merged with his/her e-healthcare record to predict the probability of developing a certain disease, which can then be addressed with help of preventative therapy. [14]

AI in Pharmaceutical Marketing:

Sales are the driving force in the pharmaceutical sector, and AI may be a useful tool in pharma marketing. Pharma companies can investigate and produce unique marketing tactics with AI that promise strong sales and brand recognition. AI can assist in mapping the customer journey, enabling businesses to determine which marketing strategy influenced customers to make a purchase. Pharma businesses may therefore concentrate more on the marketing tactics that provide the highest conversions and revenue growth. AI systems may evaluate and compare the outcomes of previous marketing initiatives to determine which ones continued to be the most successful. This saves time and money while also enabling businesses to design their current marketing strategies properly.

The process of AI adoption in the pharma sector can be made easy by taking these steps:

- Collaborating and partnering with academic institutions that are experts in AI R&D to help pharmaceutical businesses embrace AI.
- Work together with businesses that specialise in AI-driven medical discovery to gain access to professional help, cutting-edge equipment, and industry knowledge.
- Teach R&D and production teams how to properly use and apply AI tools and methodologies for maximum efficiency. [15]

AI in Drug Discovery:

The drug development process is limited by the lack of new technology, which makes it a time-consuming and expensive operation that can be handled by AI. AI is capable of recognizing lead compounds, and it speed up therapeutic target validation and structural design optimization. Drug design, polypharmacology, chemical synthesis, drug repurposing, and drug screening are some of the several ways AI is used in the drug discovery process. AI is used in drug design to predict the target protein's 3D structure, predict drug-protein interactions, and assess drug activity. In polypharmacology, AI aids in the design of biospecific drug molecules and multitarget drug molecules. AI is used in chemical synthesis to plan methods for the synthesis, predict reaction yields, and retrosynthesis processes. As opposed to drug screening for toxicity, bioactivity, physicochemical properties, and identification and categorization of target cells, AI in drug repurposing aids in the identification of the therapeutic target and prediction of the new therapeutic usage.[16]

The use of QSAR modelling software, which have developed into AI-based QSAR methodologies including linear discriminant analysis (LDA), support vector machines (SVMs), random forests (RF), and decision trees, has been used to identify potential medication candidates. King et al. found a negligible statistical difference when the ability of six AI algorithms to rank anonymous compounds in terms of biological activity was compared with that of traditional approaches. [17]

AI in clinical trial design:

A type of study called clinical trials examines novel diagnostic and therapeutic approaches and assesses how they effect patient outcomes. Clinical trials including the testing of medications, cells and other biological products, surgical techniques, radiological techniques, gadgets, behavioural therapies, and preventative care are conducted with the help of volunteers. Before they can begin, these must be carefully planned, reviewed, and completed. Clinical trials are open to participants of various ages, even young toddlers.[18]

Clinical trials take around 6-7 years to complete and include a substantial financial outlay in order to determine the safety and effectiveness of a medicinal product in people for a specific illness condition. However, just one out of every 10 molecules examined successfully clears, which is an extremely low success rate, which is a massive loss for the industry. These failures

may be the result of poor infrastructure, poor technological requirements, and poor patient selection. One-third of the time required for a clinical study is spent on patient enrollment. The selection of qualified participants can prevent the 86% failure rate that would otherwise occur in clinical trials. By applying patient-specific genome-exposome profile analysis, AI may help in the selection of just a certain diseased population for recruitment in Phase II and III of clinical trials. This analysis can help in the early prediction of the available drug targets in the patients selected.[19] Researchers can identify, forecast, and avoid a lot of risks associated with clinical research using machine learning. Machine learning may contribute to improving the dependability, quality, and safety of clinical trials as a result of the data it produces during trial monitoring and decision-making. The agile platform can assess and use data from a variety of sources, including electronic trial master files, electronic medical records, and electronic patient care outcomes or reports. These sources include e-Consent and e-Source technological advancements, central lab data or safety information, electronic clinical outcomes or reviews, electronic data acquisition infrastructures, and smartwatch data. This platform uses visualised data or format to reduce risk in clinical studies, so there won't be any more expensive data warehouse updates or maintenance hassles. [20]

AI in Radiotherapy:

A significant part of treating cancer is radiation, which is administered to about half of all cancer patients at some point throughout their disease. The seven areas into which radiotherapy may be subdivided are imaging, treatment planning (TP), simulation, radiotherapy accessories, radiation delivery, radiotherapy verification, and patient monitoring. [21] A contemporary technique that is very helpful in radiation treatment planning is automated treatment planning. Treatment planning that is automated effectively reduces the mistake rate, consistency, and quality of the plans. With the use of many imaging biomarkers, radiological therapy may provide detailed information on tumors. Radiomics can be used to predict the effects and toxicity of radiation therapy for individual people. [22]

DISCUSSION

Better insights are provided by artificial intelligence, which supports everyday jobs. Artificial intelligence will be used to create machines and computers that are far more sophisticated than those we have right now. Speech recognition systems will function at much higher levels and be able to interact verbally and via writing with humans in unstructured English. It is still unknown if these machines will incorporate human awareness. Future robots will be able to perform every task and will be quicker and more effective than humans at it. Additionally, it is anticipated to have aspects of the human brain including cognition, perception, and learning through experience. There will be a great future some day for expert system applications in all aspects of health care, in both clinical and administrative areas, in improving patient care and in allocation of financial, social, and other resources. The AI has made its growth in pharmaceutical sector to a greater extent whether in marketing, drug discovery, clinical trial design or in radiotherapy. Till that is achieved, no one can make a decision of whether our future will be affected positively or negatively by Artificial Intelligence.

CONCLUSION

This entire thing leads us to the conclusion that artificial intelligence is now a regular part of our lives. It has certain benefits and drawbacks, but it also greatly advances humankind by simplifying a lot of work and transforming it into a computer process. Every domain has seen a fairly dramatic increase in artificial intelligence. Starting with its history, it was quite challenging for humans to comprehend artificial intelligence during a time when it was unheard by everyone. But as time passed around, it demonstrated an amazing advancement in its ability to reach the entire world. Artificial intelligence is now both widely used and well regarded globally. There is not a single field where either the devices or the technology of artificial

intelligence is not used, either it is in the field of science, government, security and surveillance, manufacturing and production, medical care, entertainment or in the education. The AI has also influenced the area of healthcare by playing a major role in clinical research and lead to the development of various technologies and software that would improve the health management strategies. Artificial Intelligence has reduced the cost and time of drug discovery. In drug discovery, thousands of synthetic molecules are generated that binds to the target and modify its activity for particular disease. So a computer-aided drug design and quantitative structure–activity relationship (QSAR) are used to determine the potential drug candidates. From above article it is observed that AI plays a key role in clinical trials by reducing the total duration and cost of recording and maintaining the records and is also used in improving the quality of trial design, patient selection, patient adherence and trial monitoring. Other application of AI in pharmaceutical like radiomics in radiotherapy has improved its expansion by giving deep information about tumors and toxicity for individual patient's radiation therapy. In the last it is concluded that development in AI technologies are constantly evolving. Thus, AI-enabled techniques will be opening up many opportunities in various sectors of healthcare and pharmaceutical research, and it would be a game changer in futuristic research.

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ARTIFICIAL INTELLIGENCE BASED MEDICAL DEVICES & CLINICAL SUPPORT SYSTEM

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ABSTRACT

Healthcare is going digital with the assistance of Artificial Intelligence (AI) and Machine Learning (ML). Machines can stimulate human minds in learning, applying knowledge, doing analysis and thus helps in problem solving. This article reviews the applications of AI in framing medical devices. AI solutions have the capability to improve commercial manufacturing, efficiency of diagnosis, technological advancements and automation of medical devices. It also helps in post market surveillance and regulatory assessment of medical devices. This will help in disease diagnosis, living assistance, information processing and biomedical research. It will help the readers to keep track of new scientific accomplishments and the enormous potential of AI in healthcare. Rodo, Kardia, IDx-DR are some of the notable AI assisted medical devices and intelligent systems. MoveECG, The Philips' wearable biosensor, Empatica, BioHarness 3.0, BodyGuardian MINI, Polar H7 Heart Rate Sensor, FreeStyle® Libre™ are some of the electronic, non-invasive wearable technology attached to patient's body or clothing. Apart from medical devices, there are many notable self-diagnosis healthcare apps which are based on Artificial Intelligence like Buoy Health, MedChat, Epocrates healthcare app, Atrial Fibrillation (AFib) History Feature. This article also reviews the various FDA approved Cardiovascular Disease related, Neurology Related and Ophthalmic Related AI/ML enabled medical devices and their characteristics and company manufacturing the devices.

INTRODUCTION

Human beings are intelligent creatures. As opposed to the intelligence of humans, Artificial Intelligence (AI) is defined as the intelligence of machines[i]. This term was first coined by John McCarthy at the Dartmouth Conference in 1956[ii].AI can also be defined as any agent or device that can perceive and understand its surroundings and accordingly take appropriate actions to achieve its objectives. There are such situations wherein machines can stimulate human minds in learning, applying knowledge and analysis and thus can help in problem solving. This kind of intelligence is also referred to as Machine Learning.[iii], [iv]Artificial Intelligence helps to achieve major healthcare goals like predictive, preventive and participatory[v]. It has emerged as a powerful tool for clinical studies and biomedicine etc. PathAI, BenevolentAI, Spring Health, Tempus, Vicarious Surgical, Accuray, Buoy Health, Kaia Health are the various companies which are using AI in healthcare. In the 1970s, Artificial Intelligence in Medicine (AIM) [vi]aimed to increase the efficiency of medical diagnosis and treatment. In the early stages of development, algorithms were proposed and neural networks continued to develop. It was followed by the emergence of support vector machines and the concept of deep learning. Currently the technology is advancing day by day However; the ability to communicate with people still needs to be improved. Therefore, we are still in the stage of "weak" AI [vii, viii],

There are primarily two groups into which AI devices can be divided. The first group consists of machine learning (ML) methods that analyze structured data, including genetic, imaging, and

EP data. In the context of medical applications, ML techniques try to group patient characteristics or predict the likelihood that a disease would manifest[ix]. The second group of techniques comprises natural language processing (NLP) techniques that draw information from unstructured sources like clinical notes or medical journals in order to complement and enrich organized medical data[x]. The goal of NLP procedures is to convert texts into structured data that is machine readable and can be analyzed using ML methods[xi].

AI devices or techniques have been found useful in medical applications. It can be categorizes into three groups: the classical machine learning, deep learning techniques which are developed recently and the NLP methods. The classical ML constructs data analytical algorithms to extract information & features from data. Following are the inputs to ML algorithm

- Patient's Traits such as

1. Baseline Information such as age, gender, weight, disease history
2. Disease specific data such as diagnostic imaging, gene expressons, EP tests
3. Physical examination results
4. Clinical symptoms
5. Medication

- Medical Outcomes of Interests- These include disease indicators, patient's survival times and quantitative disease levels such as tumor sizes [xii]

Deep learning AI technique uses hidden layers so that algorithms can handle complex data with various structures. It is basically a modern extension of the classical neural network technique. Neural networks are a mimic to human brain which is an interconnected network of neurons. There are numerous communication channels between neurons[xiii]. As neurons can react to multiple stimuli from neighbors and change its state accordingly, in the same manner, the neural network can generate outputs as its responses to environmental stimuli. Neural networks can also be seen as an extension of linear regression to capture complex nonlinear relationships between input variables and an outcome[xiv].

Majority of clinical information are in the form of written texts, laboratory reports, details of operation and discharge summaries which are unstructured and incomprehensive for the computer program. NLP helps in clinical decision making by extracting useful information from the narrative texts[xv]. The NLP identifies a series of disease relevant words in the clinical notes based on the historical database through text processing. Then a subset of keywords is selected by examining their effects on the classification of normal and abnormal cases[xvi,xvii]

Apart from fabrication of medical devices, development of Ambient Clinical Intelligence (ACI) will be a critical application of AI in medicine which will help to create a sensitive, adaptive and responsive digital environment surrounding the physician and the patient[xviii]. It will be capable of analyzing the interview and automatically fill the patient's electronic health records[xix].

AI ASSISTED MEDICAL DEVICES AND INTELLIGENT SYSTEMS

Rudo is a kind of intelligent system which can help blind people to live together with sighted people.[xx]A ''smart assistant" based on AI for pregnant women can help them with dietary and other necessary advice during crucial stages of maternity. It provides suggestions through its own intelligence combined with ''cloud-based communication media between all people concerned[xxi]

One of the first uses of AI in medicine was the early diagnosis of atrial fibrillation. In 2014, the FDA approved AliveCor's mobile application Kardia. Thus Kardia is a FDA approved, simple

smartphone connected ECG device capable of doing ECG analysis, detecting atrial fibrillation and recording weight & medication. This device has backed up many clinical studies and it is popular among physicians, patients and researchers[xxii]. Additionally, Apple received FDA certification for the Apple Watch 4, which enables simple ECG acquisition and atrial fibrillation diagnosis that can be shared with the practitioner of choice via a smartphone. The use of wearable and portable ECG technology has drawn criticism from a number of sources, noting drawbacks such as the false positive rate caused by movement artifacts, and barriers in the adoption of wearable technology in the elderly patients that are more likely to suffer from atrial fibrillation.

High blood sugar damages the blood vessels in your retina and leads to vision loss. The FDA approved the first AI-based medical device for Diabetic Retinpathy in 2018, called IDx-DR[xxiii]. This is basically a software program that analyzes images of your eye to detect mild diabetic retinopathy. Some of the other AI/ML assisted medical devices related to cardiovascular[xxiv], ophthalmic[xxv] and neurology, duly approved by FDA are listed below[xxvi].

Artificial Intelligence and Machine Learning (AI/ML)-Enabled Medical Devices | FDA

S.No	Device	Company	Description
Cardiovascular Disease Related AI/ML Enabled Medical Devices			
1	DeepRhythmAI	Medicalgorithmics S.A.	It is cloud-based software for the assessment of cardiac arrhythmias using two lead ECG data in adult patients.
2	Study Watch with Irregular Pulse Monitor (Home), Study Watch with Irregular Pulse Monitor	Verily Life Sciences LLC	It is a miniaturized physiological data monitoring device. It is intended to record, store, transfer and display single-channel electrocardiogram (ECG) rhythms. It provides notification to the user in the event of an irregular pulse, such as atrial fibrillation (AF), and recommend acquisition of an ECG
3	ZEUS System (Zio Watch)	iRhythm Technologies, Inc.	It combines deep learned algorithms with advanced cardiac arrhythmia service and forms the AI algorithm and solution part of the Zio Watch. It is a sensor-based wearable for non-invasive continuous monitoring for atrial fibrillation
4	Eko Murmur Analysis Software (EMAS)	Eko Devices, Inc.	The software, which uses a cloud-based machine learning algorithm is able to analyze heart sounds, phonocardiogram and electrocardiogram (ECG) signals from Eko's smart stethoscopes. It can differentiate between innocent and structural heart murmurs and detect valvular heart disease.

5	eMurmur Heart AI	CSD Labs GmbH	This FDA cleared software screening device is used to automate the detection of heart murmurs, classify both dangerous and healthy murmurs as well as absence of murmurs. It uses a smartphone, digital stethoscope and machine learning/artificial analytics features
6	AliveCor QT Service	AliveCor, Inc.	This is a prescription use only device intended to be used by trained healthcare professionals and ECG technicians.It is cloud based software as medical device that measures the QT and heart rate corrected QT (QTc) interval measurements from ECG. The QTc is a heart rate corrected interval that reflects the integrity of the heart's electrical recharging system.
7	DEEPVESSEL FFR .	KeyaMed NA Inc.	This software medical device is intended to perform a non-invasive physiological functional assessment of the coronary arteries using coronary computed tomography angiography (CTA) scans. This software applies deep learning technologies involving the latest advances in computer vision and medical image analysis.
9	IM007	Implicity, Inc.	It is a remote cardiac monitoring. It is used for the assessment of arrhythmia in Insertable Cardiac Monitor (ICM) ECG data
11	Feops HEARTguide	Feops NV	FEops HEARTguide™ is indicated for simulation of transcatheter left atrial appendage occlusion (LAAO) device implantation during procedural planning. This technology is patient specific.
12	LINQ II Insertable Cardiac Monitor, Zelda AI ECG Classification System	Medtronic, Inc.	It records subcutaneous ECG and is indicated for patients with clinical syndromes or situations at increased risk of cardiac arrhythmias and for patients who experience transient symptoms such as dizziness, palpitation, syncope, and chest pain that may suggest a cardiac arrhythmia. The device has not been tested specifically for pediatric use. This is an insertable automatically activated and patient-activated monitoring system

Ophthalmic Related AI/ML Enabled Medical Devices			
1	IDx-DR	Digital Diagnostics Inc.	This cloud based software AI diagnostic system. It is capable of detecting vision loss. It is also able to diagnose patients with diabetic retinopathy.
2	EyeArt	Eyenuk, Inc	EyeArt is the first FDA cleared AI technology for real time diabetic retinopathy screening in a quick and accurate manner.. It is capable of detection of both more than mild and vision threatening diabetic retinopathy.
3	CLARUS	Carl Zeiss Meditec, Inc	The Clarus 700 is an ophthalmic camera. It displays, annotates and stores images to aid in the diagnosis and monitoring of diseases of the retina, ocular surface and visible adnexa. Clarus 700 angiography is indicated as an aid in the visualization of vascular structures of the retina and the choroid.
4	RightEye Vision System	RightEye, LLC	RightEye Vision System records, views, analyzes and detects involuntary eye movement behavior for the purpose of visual tracking impairment in human subjects. It can be an aid in the assessment of Parkinson's disease.
5.	IRIS Intelligent Retinal Imaging System	IRIS Intelligent Retinal Imaging Systems, LLC	This is cloud based diagnostic retinal screening software used to screen diabetic retinopathy. It is a useful tool used in the early detection of eye disorders
Neurology Related AI/ML Enabled Medical Devices			
1	EarliPoint System	EarliTec Diagnostics, Inc.	It is the first objective measurement tool to assist clinicians in the diagnosis and assessment of Autism Spectrum Disorder (ASD) in an effective, safe and consistent manner. Clinical data show that it measures a child's level of social disability and cognitive ability.

2	EnsoSleep	EnsoData, Inc.	Powered by artificial intelligence (AI), EnsoSleep provides clinicians with one cloud-based platform for viewing, scoring, editing and reporting of Polysomnography (PSGs) and Home Sleep Apnea Testing (HSATs). This software based medical device is used under the supervision of clinicians to analyze physiological signals and automatically score sleep study results. It is intended for use for the diagnostic evaluation by physicians to assess sleep quality and as aid for the diagnosis of adult sleep and respiratory related sleep disorders.
3	Cognoa Asd Diagnosis Aid	Cognoa, Inc.	It is machine learning-based software intended to help health care providers diagnose ASD in children 18 months through 5 years of age who exhibit potential symptoms of the disorder.
4	7D Surgical System Cranial Biopsy and Ventricular Catheter Placement Application	7D Surgical Inc.	It is a stereotaxic image guidance system intended for the spatial positioning and orientation of neurosurgical instruments used by surgeons. It is also intended to be used as the primary surgical luminaire during image guided surgery. The device is indicated for cranial surgery where reference to a rigid anatomical structure can be identified.
5	Brainscope TBI	BrainScope Company, Inc.	This is the only FDA cleared, noninvasive medical device that can aid in detecting mild Traumatic Brain Injury (mTBI). It detects the likelihood of both brain bleeds and concussions at the point of care. It uses EEG inputs combined with AI-derived algorithms to determine the likelihood of structural and functional brain injury.
6	COMPLETE CONTROL System Gen2	Coapt, LLC	It is a true upper extremity pattern recognition system that allows a patient to fully take advantage of their prosthetic device's capabilities quickly and easily. It is easy to set up which helps in better patient outcomes.

7	EyeBOX	Oculogica, Inc.	The EyeBOX is intended to measure and analyze eye movements as an aid in the diagnosis of concussion within one week of head injury in patients 5 through 67 years of age in conjunction with a standard neurological assessment of concussion. It should not be used as a standalone assessment of concussion.
8	Embrace	Empatica Srl	It is the first smartwatch to be cleared by FDA for use in Neurology. It uses AI (advanced machine learning) to monitor for the most dangerous kinds of seizures, known as "grand mal " or "generalized tonic-clonic" seizures, and send an alert to caregivers and physicians.
9	Persyst 14 EEG Review And Analysis Software	Persyst Development Corporation	An electroencephalogram (EEG) is a recording of brain activity. This software provides the complete set of tools needed for C.A.R.E (Computer Assisted Review of EEG). It provides accurate, efficient and rapid review of EEG data and enables the highest level of comprehensive patient care.
10	Sense System with IBT Electrodes	Infinite Biomedical Technologies, LLC	The Sense System detects electromyography (EMG) signals using the IBT Electrodes. It is designed to enhance control of upper limb prosthetic devices. The electrode signals are then processed using a pattern recognition algorithm and translated to output signals that are standardized to be compatible with an array of connected prosthetic devices, such as hands, wrists or elbows.
11	Ahead 300	Brainscope Company Inc.	It provides multiple clinically relevant measures for assessing traumatic brain injury, including concussions. It helps in acute identification of structural brain injuries in the mTBI population.

12	BrainScope Ahead 100	BrainScope Company, Inc.	The device uses a patient's electroencephalograph (EEG) to provide an interpretation of the structural condition of the patient's brain after head injury. It can be used as an adjunct in clinical practice to aid in the evaluation of patients who are being considered for a head Computerized Tomography (CT) scan. It however should not be used as a substitute for a CT scan. It is to be used on patients who sustained a closed head injury within 24 hours, clinically present as a mild traumatic brain injury, and are between the ages of 18-80 years.

WEARABLE TECHNOLOGY

It is an electronic, autonomous and noninvasive device that is supported by or attached to a consumer's body or clothing. It is designed to collect health and fitness data of patients e.g. Fitness Trackers, Blood Pressure Monitors and Biosensors. It is capable of transmitting user's health information to a doctor/healthcare providers/Insurance companies in real time and guides wearers with further health & fitness recommendations by synchronizing with various smartphone apps.

MoveECG is a type of wearable ECG monitor with the capability to measure an electrocardiogram and detect atrial fibrillation. There is an automatic tracking for walking, running, swimming and other physical activities. The first wearable Blood Pressure Monitor launched by Omron Health Care in 2019 was named HealthGuide. This oscillometric blood pressure monitor can measure blood pressure and daily activities and calories burned. All readings of this device can be suitably transferred to a corresponding mobile app, HealthAdvisor for analysis and optimization of treatment. This data can be shared with physicians for further health recommendations.

The Philips' wearable biosensor is a self-adhesive patch that allows patients to move around while collecting data on their movement, heart rate, respiratory rate, and temperature.

Intelligent Seizure Detection Devices are the promising technologies that have the potential to improve seizure management through permanent ambulatory monitoring.

Empatica received FDA approval in 2018 for their wearable Embrace, which when associated with electrodermal captors can detect generalized epilepsy seizures and report to a mobile application that is able to alert close relatives and trusted physicians with complementary information about patient localization.[xxvii] A report focused on patient experience, revealed that, in contrast to heart monitoring wearable, patients suffering from epilepsy had no barriers in the adoption of seizure detection devices, and reported high interest in wearable usage.[xxviii]

The BioHarness 3.0 is a physiological tracking telemetry tool designed for tracking adults in residential, commercial, and industrial settings. It is a wireless chest based wearable device. The tool includes a chest strap and an electronics module that attaches to the strap. The tool stores and transmits essential signal records such as ECG, coronary heart rate, breathing rate, frame orientation, and activity. The BioHarness3.0 allows you to find and transmit single lead ECG indicators obtained from Bluetooth or USB-certified ECG instruments[xxix].

BodyGuardian MINI Remote Monitoring System is the smallest, reusable, waterproof wearable patch. It is made to be used with adult patients in both clinical and non-clinical situations in order to gather and communicate health parameters to medical experts for monitoring and evaluation. It is not used for diagnosis but a range of commercially available, external plug-in devices, including ECG sensors, weight scales, blood pressure meters, and pulse oximeters, are used to collect health parameters. This wearable patch can be moved and reapplied to make the patient feel comfortable, without jeopardizing data collection or requiring the participant to revisit clinic[xxx]

Polar H7 Heart Rate Sensor is used to gauge the patient's heart rate[xxxi]. It is also able to analyze heart rate variability at rest and during various exercise intensities including swimming. The wearable device incorporates chest strap and heart rate monitor into one device. The strap is fastened around the body under the patient's chest muscle. The H7 transmits information via Bluetooth to polar devices when using smartphone or magnetic data transmission technology when connected with gym equipments.[xxxii]

FreeStyle® Libre™ is a continuous glucose monitoring (CGM) device that is intended to replace blood glucose testing. It detect trends and track patterns that help in the detection of episodes of hyperglycemia and hypoglycemia and facilitate both acute and long-term therapy adjustments in people aged 18 years and older, with diabetes.[xxxiii] Prescription is required for its usage and is only meant for only one patient[xxxiv]. The device provides areal time feedback about therapeutic interventions and variations in lifestyle, current interstitial fluid glucose concentrations. It is also able to provide warnings when blood glucose concentrations become dangerously high or low

MOBILE SELF DIAGNOSIS APPS/HEALTHCARE APPS

Buoy Health is an AI-based symptom and cure checker that uses algorithms to diagnose and treat illness. A chatbot listens to a patient's symptoms and health concerns, then guides that patient to the correct care based on its diagnosis. Developed by a team out of Harvard Medical School, Buoy's AI helps diagnose and treat patients more quickly[xxxv].

MedChat is a cloud based modern Patient Access & Messaging platform that confirms to various regulatory standards. It helps to streamline communications, capture patient details, provides support services and automates workflows.

Another symptoms checker app is WebMD which not just help to check the symptom but also helps to analyses the adverse effects of patient by the online patient reviews. It also provides the first aid essentials, latest health news and check local health listings.

Epocrates healthcare app for pharmacists is a comprehensive archive of medical information, capable of checking drug interaction and a pill identification tool. It provides a platform for communication of physician and other healthcare professionals.

The Atrial Fibrillation (AFib) History Feature by Apple Incorporation is a medical application. It is a Photoplethysmograph Analysis Software For Over-The-Counter Use. It can be used with Apple Watch and the Health app on iPhone. This will allows users to estimate the frequency of signs of irregular and extremely rapid heartbeat. This software has received clearance from FDA and is intended for users 22 years of age and above who have a diagnosis of atrial fibrillation. The feature analyzes pulse rate to identify episodes of irregular heart rhythms, tracks and trends estimated atrial fibrillation burden over time. It also includes lifestyle data visualization to enable users to understand their lifestyle habits which are having impact on atrial fibrillation[xxxvi]. The Apple watch also have Irregular Rhythm Notification Feature (IRNF). This software based medical application analyses pulse rate data to detect episodes of irregular heart rhythms which are indicative of atrial fibrillation.

THE FUTURE OF AI BASED MEDICAL DEVICES

On one hand there is huge growth in the number of patients suffering from numerous deadly diseases, on the other hand healthcare system is suffering from the problems of shortage of trained healthcare professionals. AI can be of a big help in offering more efficient diagnosis to safer treatment. Some of the challenges related to digital healthcare are that healthcare professionals are not trained to read labeling for AI based products and digital therapeutics. There is a need to standardize this technology and make it more trustable, efficient, precise and robust. FDA's progressive decision to approve AI based medical devices has helped to expand this technology and make it more patients centered. We are entering in an era of digital healthcare. In this new age of uncertainties, the future of medical devices is Advanced Digital Health Care provided we ensure that AI remains representative of intended population and geographies.

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ABOUT THE BOOK

This book, entitled "Artificial Intelligence in Business, Management, and Pharmaceutical Technology," provides a comprehensive overview of the application of artificial intelligence (AI) in various fields, including business, management, and pharmaceutical technology. It highlights the latest research and advancements made in this field and provides a platform for students and researchers to present their recent studies. The book covers the role of AI in healthcare, drug discovery and development, clinical trial optimization, personalized medicine, and business and management. It discusses how AI can be used to analyze data, make predictions, automate repetitive tasks, and improve customer experiences through chatbots and personalization. Overall, the book is a valuable resource for anyone seeking to gain knowledge and insight into the various applications of AI in the fields of business, management, and pharmaceutical technology.

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