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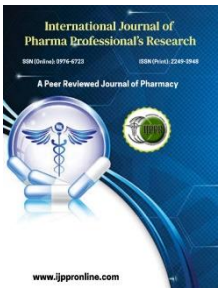

A REVIEW PAPER ON INDUSTRIES REVOLUTION 4.0 POWERING THE FUTURE OF HEALTH CARE SECTOR

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ABSTRACT:
In the age of globalisation and digitization, the ability of computers to perform tasks normally associated with intelligent beings is known as artificial intelligence (AI), which can play a critical role in assisting in dealing with every type of business and function of human resource management in a proficient and timely manner. The unparalleled data processing capabilities of AI and ML in the pharmaceutical industry serve as a harness in the enhancement and improvement of efficiency in diagnostic assistance and clinical trials, pharmaceutical marketing, foster innovation, quality control, reduce materials waste, improve production reuse, perform predictive maintenance, and improve decision-making skills. The Fourth Industrial Revolution (industries 4.0) in Health Sector implement artificial technologies to performed functions by machines and small robotic systems programmed to do human-like tasks result great potential to transform drug discovery by accelerating the research and development timeline. This technology is being adopted by many pharmaceutical companies to help with the drug discovery and development process, which will enable them to work on a variety of research-oriented projects to improve health facilities and easily cure the diseases in the future. With the development of artificial intelligence and machine learning, the pharmaceutical industry is undergoing significant advancement like decrease the time interval gap from development of a drug product to its commercialization. We will discuss the various roles of AI and ML in health care sector and challenges in this article. As a result, this clearly demonstrates that artificial intelligence has a positive impact on the pharmaceutical industries.

Introduction:

On today worldwide, we have seen growing interest in engineering approaches to health care delivery in concerned with rapid development in medical devices, clinical advancement, data analytics, and information technology. Recent breakthroughs in digital health technologies (e.g., electronic health records, health monitoring and wearable devices) are not only transformative for reengineering care processes and improving health care outcomes such as care quality and patient safety.so, 21thcentury generation peoples are more curious and conscious about their health-related issues moreover come forward to implement advanced AI techniques gadgets in their life. The pharma sector plays a vital role to achieve the goal of autonomous working systems probably help in decreasing the risk factors related to maintain health care and also have impact on socio-economic, likewise 20% of the US GDP is dedicated to health expenditures.

With the help of the "Industry 4.0" revolution, production can now be done in a more intelligent, cyberized, and sustainable way. This has led to significant gains in productivity, quality, and customer satisfaction for processes, goods, and services. Artificial intelligence (AI) is a branch of science that studies the technologies that allow computers to carry out a wide range of sophisticated tasks, such as the ability to see, understand, and translate spoken and written language, analyse data, and make recommendations. AI has enormous applications in business, healthcare, and other fields. Modern computer innovation is built on AI, which helps automate processes and provide insights into massive datasets to generate value for both consumers and enterprises. Every element of our society can be significantly impacted by such radical changes, including the health care system, which has, which has started to embrace these technological innovations. (1)

During the past few years, machine learning (ML) and artificial intelligence (AI) have grown tremendously, with numerous variations being accepted and included by industries in their manufacturing processes to significantly boost the efficiency of the product molecules. Despite the fact that the pharmaceutical industry and the health sector have been greatly impacted by the Fourth Industrial Revolution, it is now easy to upgrade and produce medical tools and devices. Automation at the workplace by machines designed to perform human-like tasks has also become the norm.

Human resource management division faces endless challenges to deal with time management from preformulations studies to marketed the products. Therefore, artificial intelligence (AI) can assume a fundamental part to help them in dealing with these things in a keen and timely manner. The ability of digital computers to accomplish tasks that are usually associated with intelligent beings is known as artificial intelligence (AI) and the role and impact of AI and machine learning was multiplied and more popularized in pharma industry during COVID-19. Pharm industry also co-operated the power of AI and ML in health services to develop and improve the patient care and diagnostics assist. Its unparalleled data processing capabilities of artificial intelligence which can help in improve the efficiency of research and clinical trials, foster innovation, and enhance decision-making skills. Machine learning is being increasingly adopted in the healthcare industry, credit to wearable devices and sensors such as wearable fitness trackers, smart health watches, etc. All such devices monitor users' health data to assess their health in real-time. To analyze huge volumes of health data efficiently, the pharmaceutical sector badly needs digital transformation and innovative technology. (2)

Last few years, the revolutions in industries show high impact on medical practitioners in analyzing trends or flagging events that may help in improved patient diagnosis and treatment. Industry 1.0 represents the first industrial revolution, starting in 18th civilization era emerging technologies of steam engine, sewing machines, steel making, and railroads, a mechanization revolution facilitated the societal move from agriculture to industrialization.

In the beginning of the 20thcentury, the second industry revolution 2.0, introduced a paradigm change from individual or small-scale manufacturing to large-volume mass production, due to the paramount usage of electricity. The Henry Ford assembly lines enabled systematic allocation and connection of numerous operations and machines efficiently, which completely changed manufacturing processes. (3)

During the last few decades of the 20th century, the rapid development of electronics, computer, and robotic technology has led to massive applications of

automation systems, characterized by digitalization and networking of manufacturing and business processes. Computer-integrated and flexible manufacturing systems, manufacturing executive systems, as well as material resource planning and enterprise resource planning, have been widely adopted, which marked the third industry revolution, i.e., Industry 3.0, and also led to the dawn of the fourth revolution.

In 21th century Industry 4.0 represents the fourth industry revolution and aims to integrate cyber-physical systems with information, process, equipment, and operation technologies. The Internet of Things (IoT) and associated services are extensively distributed and used in conjunction with big data analytics and artificial intelligence techniques. (4)

The confluence of human intelligence and computer processing is AI technology. It is a more sophisticated sort of computer assisted technique that involves gathering data from many sources, developing rules to be followed for managing the needed data, and then considering potential outcomes to choose the best outcomes and conclusions.

In order for computer software and processes to approximate human behaviour, a lot of statistical techniques and data analytics are being used in AI and ML. Small robots systems are also being developed for maintenance diagnostic support. It is made up of components like machine learning and deep learning that make working with neural networks simple. All of these require the use of artificial intelligence approaches, starting with the identification of popular television shows, moving on to the discovery of lead molecules, and concluding with the creation of therapeutic molecules including clinical trials. Therefore, it is crucial to encourage innovation in the pharmaceutical industry so that medicines can be produced more precisely and quickly. (5)

The consolidation of ever-increasing computing power, machine learning and big data analytics has reshaped the world around us. Today' Artificial intelligence (AI) and Machine Learning (ML) is the mimicking of human intelligence patterns and processes by Small Robotics systems and computer systems. (6,7)

As a general rule, AI frameworks operated by breaking down large amounts of specified training data for correlations and patterns, and using these informative formats to make forecasts about future states.

- AI programming focuses on the following cognitive skills:
- Learning
- Reasoning
- Self-correction
- Planning
- Self- Presentation
- Knowledge representation
- enhancement of decision-making
- Timer saver
- minimization loss of values

In cognitive and neural sciences have led to deep learning and machine learning and are changing the way knowledge economy works.(8)

There is a sweeping shift in the immersive automation and mechanization driven by artificial intelligence into goods and services, manufacturing, transport, utilities and changing human dynamics. Technology has moved beyond analytical to predictive to prescriptive applications with the advances in artificial intelligence. Healthcare professionals have changed their focus on patient-centric care delivery services and started to provide services that manage overall patients' health and not just disease treatment, for providing timely, personalized and efficient care to the patients' providers are motivated to adopt novel technologies like mHealth and IoT, where it is possible to disseminate the machine learning-enabled personalized monitoring. Sensor-enabled personal digital assistants to have the immense capability of measuring and transmitting real-time physiological data Furthermore, the COVID-19 pandemic hampered the supply chain management across the sectors including drug and vaccine production. An examples of artificial technologies like neural networks employ computational and mathematical models to infer the connections between the input data without requiring the user to have any prior knowledge of the desired data. Instead of making predictions, it generates a variety of results that would best fit the experimental data and, therefore, meet its stated criteria. To further address issues with pharmaceutical research,

development, and formulation of high efficiency and stable pharmaceutical products, this technique is enhanced to create Artificial Neural Networks (ANN). (9)

Another example is, of AI data base programming software is SPIDER is an useful approach which help in determining the role of natural products and their utilization in drug discovery and development. A more advanced technique is developed under Artificial intelligence like Read Across Structure Activity Relationship (RASAR) is being used to determine the toxicity and harmful effects of unknown compounds. It is a predominant tool which is being elevated on the basis of creating and identifying the link between molecular structure and its properties that would lead to toxicity. (10)

Types of Artificial Intelligence:

- Most artificial intelligence solutions used in healthcare today are based on human-created **Data science algorithms.** This is basically used a concept of multivariate data analytics supported by past experiential evidence. For example, population-based treatment outcomes with individual patient's clinical data and medical history to create treatment alternatives and recommend drug combinations.
- **Machine learning (ML)** is a small disciplined application of artificial intelligence (AI) that provides machines with the ability to automatically learn from data and past experiences while identifying patterns to make predictions with minimal human intervention. Machine learning uses data-driven algorithms that enable software applications to become highly accurate in predicting outcomes without any need for explicit programming. (11)
- Another one level in AI is **Deep learning,** which is also act as neural networks, but differ is it involved a combination of separate layers of calculations along with combined signals. Deep learning has great potential for diagnostic uses, being able to accurately analyze images (such photos of skin conditions or radiology scans) in combination with pathology data and historical treatment outcomes. (12)

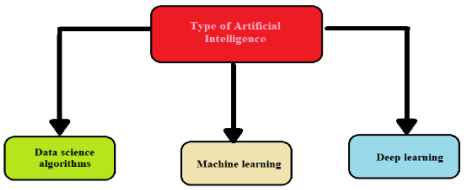

Fig: - 1 Types of Artificial Intelligences

- **<u>various aspects of AI and ML implanted in pharm sectors, some of which are listed below</u>: -**

1. **Drug discovery** –

   One of the most time-consuming processes in the pharmaceutical industry can benefit immensely from AI and ML applications. There are more than 10^{60} drug-like molecules and experimental studies can only test 10^{5} components per day. AI and computational drug discovery can speed up this process and end up cutting a lot of time and cost involved in the process.AI and ML can facilitate rapid new drug discoveries and create protocols for the synthesis of these new compounds along with the forecast of the preferred chemical structure and an understanding of possible drug–target interactions. Artificial Intelligence also involve in properties prediction of the molecules in drug discovery, clinical candidate molecules must meet asset of different criteria because compound optimization is a multidimensional challenge. For this, several machine learning technologies have been successfully used, such as support vector machines (SVM), Random Forests (RF) or Bayesian learning. (13)

2. **Artificial Intelligence for de novo Design** - De novo design aiming to generate new active molecules without reference compounds was developed earlier. Numerous approaches and software solutions have been introduced but de novo design has not seen a widespread use in drug discovery. The field has seen some revival recently due to developments in the

field of artificial intelligence. An interesting approach is the variational autoencoder, which consists of two neural networks, an encoder network and a decoder network. The encoder network translates the chemical structures defined by SMILES representation into a real-value continuous vector as a latent space. (14) The decoder part is capable to translate vectors from that latent space into chemical structures. This feature was used to search for optimal solutions in latent space by an in-silico model and to back translate these vectors into real molecules by the decoder network. The authors used the latent space representation to train a model based on the QED drug-likeness score and the synthetic accessibility score (SAS) for improved molecules target properties. (15)

3. Role of artificial intelligence in clinical research

It has been analysis that most of the time number of drugs are fail during clinical trials. (16) The percentage of drugs that enter the market is very low but somehow Certain drug products pass the clinical trials processes but when they are introduced in the market, various problems are arise.so, by the help pf advance AI a particular digital platform has to be developed for resolving such issues. Though artificial intelligence has many applications, due to lack of scientific proofs, the use of AI in clinical research is limited till date.AI plays a significant role in clinical research as it has great impact on the following aspects:

- ✓ Success or failure rate of drug product.
- ✓ Reduction in the cost of product development in terms of absolute values.
- ✓ Reduction of time taken by the drug product to enter the market.
- ✓ Decrease in the number of product recalls.

Artificial Intelligence also focuses on the following three major objectives of clinical research:

- ❖ Signals which are predictive and affect the disease pathology.
- ❖ The different steps and methods used for intervention.
- ❖ The effect of time on patient's condition and the way in which it defines the quality of life.

Most frequent value added of AI and digitization in pharm sector development of drug via clinical trials is that these trials are no longer geo restricted and the outcome will be more globally representative rather than to a particular ethnic cohort. (17)

AL is adopted in clinical trials parameters as, it is basically used in screening the pathological data of patients, various lab results of medical examinations and the drugs being requested based on the patient's report. This would help in distinguishing patient's condition from normal condition. The artificial neural network frameworks have been utilized to study the results of various diagnostic tests such as magnetic resonance imaging (MRI), X- ray and Computed Tomography (CT) scan. The AI technology can also be used to predict allergic as well as adverse drug reactions with the help of its automated software's that help in reporting and providing data regarding any on toward reaction. (18) AI can prove to be instrumental in Quality Control, Quality Assurance, and manufacturing automation protocol, thereby preventing wastages and streamlining pharmaceutical manufacturing processes and supply chains. (19)

4. **Marketing** – Like all industries, the pharmaceutical industry also developing marketing strategies. AI is already used in e-

commerce sites for effective marketing in health care sectors. AI can help to map the customer journey, thereby allowing companies to see which marketing technique led visitors to their site (lead conversion) and ultimately pushed the converted visitors to purchase from them. In this way, pharma companies can focus more on those marketing strategies that lead to most conversions and increase revenues.

AI tools can analyze past marketing campaigns and compare the results to allows the companies make design for the present marketing campaigns accordingly, while also reducing time and saving money. Furthermore, AI systems can even accurately predict the success or failure rate of marketing campaigns, the integration and adoption of AI and ML demand industry expertise and skills, is not readily available. However, the process of AI adoption in the pharma sector can be made easy by taking these steps:

- Partnering and collaborating with academic institutions that specialize in AI R&D to guide pharma companies with AI adoption.
- Collaborate with companies that specialize in AI-driven medicine discovery to reap the benefits of expert assistance, advanced tools, and industry experience.
- Train R&D and manufacturing teams to use and implement AI tools and techniques in the proper way for optimal productivity.

5. **Pharmacovigilance** – AI and ML can and will play a pivotal role in speedy and cost-effective processing of ICSR (Individual Case Safety Report) and PMS (Post Marketing Surveillance) data, enabling better drug safety, and personalized therapy. Ever-increasing ADR (adverse drug reaction) data further demands the need for AI/ML to process all that data.

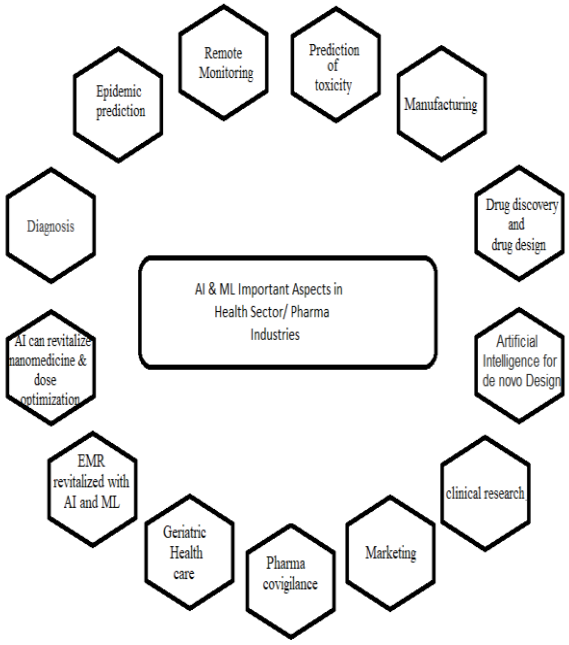

Fig: - AI & ML various aspects in healthcare sectors

6. **Geriatric Health care** –In today lifestyle, geriatric population need to get personalize dosages and formulations for optimizing therapeutic effects and minimizing toxicities. If AI and ML tools are developed and provided with relevant data, they can help in achieving optimal dosages and formulations for our geriatric population and streamline the health-care delivery for them, which often is a very challenging process.

   AI-powered smart robotic systems are also being introduced in the area of assisted living for the elderly, these systems can perform a few mundane tasks such as reminders for doctor's appointments and timely reminders for prescription drugs and can even ~~book~~ a cab to medical facilities. In the near future, these robotic systems may even detect medical emergencies and alert rapid health-care response systems.

7. **Electronic medical records (EMRs) revitalized with AI and ML** –

   Many large tech companies are developing AI and ML tools to convert audio and text medical records into EMRs. A robust system designed in this way can be a boon to

developing nations where EMRs are virtually non-existent. Big tech firm such as Amazon, using its Amazon Web Services platform is also working on such protocols**.**

8. **AI data programming induced in nanomedicine and dose optimization** –

A patient's unique disease profile is put together using diagnostic nanomaterials, and it is then used in conjunction with a number of therapeutic nanotechnologies to enhance the effectiveness of treatment. (6)·(7) Using pattern analysis and classification algorithms integrated with AI techniques to increase diagnostic and treatment accuracy can help to get around challenges and barriers in patient-specific approaches. By optimising material qualities in accordance with expected interactions with the target medication, biological fluids, immune system, vasculature, and cell membranes, which all affect therapeutic efficacy, AI can also improve the design process for nanomedicine.

9. **Manufacturing:**

The pharmaceutical industry has advanced the use of AI and ML to automate labour-intensive, time-consuming processes that require a lot of human judgement and carry a significant risk of error. But, after the adoption of data-driven, machine-learning-based equipment, these problems have decreased. For the manufacturing of tablets, capsules, etc., many machines are controlled and run by AI data programming. For Examples: - RMG for granulation processes during tablet manufacturing; - FBD for drying purposes of powders and Blender automation utilised for mixing.

10. **Diagnosis:**

Large volumes of patient healthcare data may be collected, processed, and analysed by doctors using cutting-edge machine learning algorithms. Sensitive patient data is being safely stored in the cloud or other centralised storage systems by healthcare providers all over the world utilising ML technology. The term "electronic medical records" refers to this (EMRs).

EMR data can be used by machine learning (ML) systems to provide real-time predictions for diagnosis and treatment recommendations to patients.

A recent medical device called GI Genius utilises an AI algorithm and machine learning to detect the early stages of colon cancer. During a colonoscopy, it is possible to identify areas of the colon that may contain lesions with the aid of this instrument.

11. **Epidemic prediction**

Many pharmaceutical businesses and healthcare providers now utilise AI and ML to track and predict epidemic outbreaks around the world. These technologies draw information from numerous online sources, examine the effects of geological, environmental, and biological elements on human health in various regions, and attempt to establish a causal link between these factors and previous epidemic outbreaks. Such AI/ML models are especially beneficial for developing nations without the financial and medical infrastructure needed to handle an epidemic outbreak. The ML Based Outbreak Prediction Model, which serves as a warning tool for any potential malaria outbreak and assists healthcare workers in choosing the best course of action to combat it, is a nice example of this AI application. (20)

12.Remote Monitoring

Remote monitoring is a development in the pharmaceutical and healthcare fields. In order to remotely monitor patients with critical illnesses, many pharmaceutical companies have already developed wearables using AI algorithms.

For instance, Together Tentent Holdings and medodap created AI technology that reduces the time required to do a motor function assessment from 30 minutes to three minutes and enables remote monitoring of patients with Parkinson's disease. By combining this AI technology with smartphone apps, it is feasible to remotely monitor a patient's hands' opening and shutting actions and alert the doctor and schedule a check-up if the symptoms deteriorate and demand an upgrade in therapy.

Patients can avoid the inconvenience of travelling to the doctor's office and waiting by using this type of remote arrangement instead of going back and forth. (21)

13.Prediction of toxicity –

To prevent negative effects, medication molecules' toxicity must be predicted. Animal studies are frequently used as a reference point after in vitro cell research to ascertain a compound's toxicity. Drug discovery is more expensive as a result of this approach. These processes may most certainly be automated using artificial intelligence and machine learning methods, which would be faster, more effective, and less expensive.

❖ CHALLENGES TO REALIZING INDUSTRY 4.0 IN PHARMACEUTICAL MANUFACTURING

Adoption of cutting-edge manufacturing technology and the resolution of logistical, technical, and regulatory difficulties are necessary for the realisation of Industry 4.0. With each advancement towards a manufacturing environment aligned with Industries 4.0, manufacturing systems should become more autonomous, have better process controls, and have a more developed quality management system. With these modifications, there should be less variation between lots and a more reliable supply of products. While many pharmaceutical manufacturers are comfortable with the fundamental tools of PAT (process analytical technology) and QbD (quality by design), fewer are prepared to take the following steps to implement cutting-edge technologies in support of smart manufacturing. The extensive institutional and regulatory knowledge amassed on existing platform technologies is a fundamental factor in the delay in adopting newer technology. Several businesses are eager to take the "first to be second" strategy by watching how competitors adopt new manufacturing technologies and how regulators react due to the absence of precedent in the sector, the costs associated with development, and the perceived unpredictability of regulations. (21)

✓ Regulatory challenges

Regarding regulatory obstacles, functioning within the current regulatory frameworks might be seen as a real or tangible difficulty for technical innovation. Absence of regulatory precedent may cause the industry to stick with outdated practises even when new ones might ultimately result in less regulation overall and higher quality. Even currently used Industry 3.0 technologies, such those for continuous manufacturing and adaptive control systems for product release, have put the prevailing paradigms for process validation from the previous 50 years to the test.

The goal of the current approaches to process validation is to gather data to show that a process is in control and able to consistently produce high-quality products for the commercial market for the duration of a given drug product. These approaches follow the FDA guidelines that various industries have adopted to accomplish this. In a world of Industry 4.0, the first of the three stages of process validation - process design is started by a series of process qualification runs (stage 2) at the start of the product-process lifecycle. (22) Such exercises provide a snapshot of process performance at the process launch stage, whereas ongoing process verification (stage 3), which is driven by the availability of large data sets and the capacity to continue collecting high-quality data with frequency, drives process improvement over the lifecycle. Regulating a sector where some pharmaceutical manufacturers adhere to Industry 2.0 principles while others move to Industry 4.0 will be a major difficulty since it will create a situation where the regulated sector combines elements of Industry 2.0, 3.0, and 4.0. for example, the FDA has launched an effort to identify and implement changes in the regulatory structure that are necessary (FDA, 2019b). (23)

✓ Technical challenges

Early adopters will be responsible for identifying and resolving any technological issues that arise during the implementation of Industry 4.0. The current manufacturing paradigm has some technical limitations,

including rigid process parameters, the use of extensive offline testing (especially for sterile products), and the frequent involvement of humans in manufacturing operations, even though some manufacturers might not be eager to take on these challenges. Some of these restrictions may be the result of the legislative frameworks in place today and the lack of readily available technologies. For instance, analytical methods might not be able to enable the real-time release of pharmaceutical goods. Yet, state-of-the-art PAT combined with a cloud-based infrastructure may allow for end-to-end automation, client demand-driven manufacturing, operations, even dispensing, and advanced computational capability to deploy artificial intelligence.

Industry 4.0 calls for a state-of-the-art data and computing infrastructure that combines software and hardware in order to swiftly deliver the information about a process or product that is necessary. (24) One of the issues of the technology is deciding how to use knowledge and insights obtained from big data, which could be used for internal auditing, product release choices, marketing, and/or sharing with regulatory agencies. In a crucial way, big data provides the framework for machine and device interaction, communication, and mutual learning. Finding and explaining the purpose of the data will be a big technical issue in Industry 4.0. (25)

In an Industry 4.0 setting, future will require that data and system architectures are fortified against disruptions or threats to operations involving networked devices and manufacturing equipment.

✓ **Logistical challenges**

The pharmaceutical and healthcare industries will face logistical difficulties as a result of Industry 4.0, and in some situations, they may compete for the same scarce resources. On the route to the complete implementation of Industry 4.0 strategies, manufacturers and regulators will need to make cultural changes and innovations to manage diverse data, computing, and automation threats. Knowledge and training gaps will need to be solved in order to adopt a new paradigm and industry infrastructure based on digitalized and networked enterprise systems that rely on processing power, communications technologies, cybersecurity, and improved controls in order to reach optimal. A range of skills beyond the usual biology, chemistry, and process engineering will be needed to implement AI in pharmaceutical manufacture. At least initially, regulators and business may be vying for the same tiny skill pool in these fields. There will undoubtedly be a need for comprehensive training programmes when new labour force training requirements emerge.

The use of AI-based mathematical models is a fundamental component of Pharma 4.0. The collection of historical data from innovative production techniques like continuous manufacturing is the first step in turning the concept of AI control into reality. This is because AI-based methods must use real data for model training, much as people do when they first learn by doing. For instance, the model needs to be trained with sufficient historical data linking process control parameters with process performance characteristics in order to construct an AI-based digital twin for a biological or chemical process. For the creation of a comprehensive process, pertinent data must be gathered from each individual process unit. Machine learning may be easier if manufacturers adopt collaborative, precompetitive, or open innovation models to share these historical process data.

❖ THE FUTURE OF AI IN THE PHARMA INDUSTRY

The pharmaceutical industry's recent uptick in using AI capabilities does not appear to be slowing down. Recent development in health care sector after advance AI techniques indicate that by 2025, about half of all global healthcare organisations plan to implement AI strategies and widely adopt the technology.

Particularly, international pharmaceutical and drug development companies will put more money into finding fresh treatments for cancer and chronic diseases.

In the US, chronic diseases are the main killers. As a result, businesses are using AI more and more to manage chronic diseases better, cut costs, and improve patient health.

Future applications of AI will focus on major 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 pharmaceuticals. AI helps ensure uptake by giving trial opportunities to the most qualified candidates by quickly analysing patients and identifying the best patients for a particular trial. (26)

The technology also aids in removing elements that might impair clinical trials, thereby minimising the need to make up for those elements with a large trial population. Businesses will continue to use AI to enhance patient screening and diagnosis. Professionals can use AI to extract more valuable information from pre-existing data, including MRI images and mammograms.

1- Finding patterns in enormous data sets.

Numerous sources, including clinical trials, academic papers, patient files, and patents, provide a vast amount of data. This volume of data cannot possibly be analysed by human intelligence to identify precise patterns. AI, on the other hand, has the ability to distinguish between various entities and show how they relate to one another. (27)

Atomwise is a company based in San Francisco, which is utilizing the analytical ability of artificial intelligence to determine patterns and computing new treatments for multiple sclerosis.

2-Faster discovery and development of new drugs:

AI can help pharmaceutical companies to speed up clinical development and cut cost. Drug companies spend $2.7 billion on every drug that comes on the market, and that explains why 90% of drugs fail in clinical trials.

If we look at the drug development stages, following are the processes in which AI is being adopted:

- Identification process of drug targets
- Finding ways to improve different molecular reactions

Arpeggio biosciences, a Colorado-based startup, which is using machine learning to discover new drugs by aggregating and synthesizing data.

3- AI can help in patient matching and archaic clinical trials:

Identifying an appropriate candidate for a clinical trial is a crucial barrier to the commercialization of drugs. AI is able to retrieve medical records and find the right patients for clinical trials faster.

Deep6 AI uses natural language processing (NLP) software which is a subset of AI to find patients who match intricate trial requirements in no time.

4- Vaccine design & development:

It takes years for vaccines to be designed and developed before they can be sold. There are two phases that it goes through. Finding the ideal set of molecules for the vaccine from a vast array of options is the first step. The second is made up of clinical trials that require qualified candidates. AI can efficiently produce vaccines at a lower cost and in less time. Since the dawn of the year 2020, the world has faced COVID 19 pandemic. Researchers are utilizing AI models to accelerate the vaccine designing process and relieving the world from the viral outbreak. *Vaxine Pty Ltd*, a biotech company based in South Australia, is working with Microsoft to develop its COVAX-19 vaccine using artificial intelligence-based technologies.

5-Drug Repurposing:

With the development of AI, drug repurposing has become more alluring and practical. The idea of using an existing treatment for a new disease is known as "drug repurposing," which aids pharmaceutical companies in cutting costs.

IBM applies machine learning algorithms on large data sets with the assistance of ‘IBM Watson health’ to test drug candidates for repurposing in different areas.

LIST OF PHARMA INDUSTRIES ADOPTING AI & ML TO MODULATE HEALTH CARE SERVICES: -

1.PFIZER

In April 2019, Pfizer joined with Concerto HealthAI to use AI and real-world data in oncology. The collaboration will conduct novel synthetic control arm and prospective Real World Data outcomes study designs for therapeutics that are both pre- and post-approval. (28-39)

In September 2019, Pharmaceutical giant Pfizer announced plans to launch a one-year pilot program with the robotics company Catalia Health, maker of Mabu, a home robot that coaches patients on health and prescription drugs. The main idea behind this collaboration is to understand patients' clinical journeys using artificial intelligence.

2.ROCHE

Roche has developed a machine learning diagnostic technique for diabetic macular edema, a complication of diabetes that causes a thickening of the retina and lead to blindness. (39-43)

In February 2018, Roche acquired Flatiron Health, an oncology-focused electronic health records company. Flatiron's massive amount of oncology data provides Roche with a tremendous asset for machine learning.

Roche is working with medical research machine learning startups like Owkin and Exscientia.

3. NOVARTIS

In June 2019, the MELLODDY (Machine Learning Ledger Orchestration for Drug Discovery) consortium created by 17 partners across Europe and Novartis was one of its members. Through this platform companies will develop more accurate models to predict which compounds could be promising in the later stages of drug discovery and development.

On September 2019, Novartis and Microsoft announced a multiyear alliance which will leverage data &Artificial Intelligence (AI) to transform how medicines are discovered, developed and commercialized. Novartis is also establishing an AI Innovation Lab to empower associates to use AI across their business. Joint research activities will include co-working environments on Novartis Campus (Switzerland), at Novartis Global Service Center in Dublin, and at Microsoft Research Labs (UK) – starting with tackling personalized therapies for macular degeneration; cell & gene therapy; and drug design.

4.**JOHNSON&JOHNSON**

Johnson & Johnson by adopting AI Modern Techniques released the findings of a new real-world study that showed newly diagnosed NVAF patients taking XARELTO® (rivaroxaban) had significantly fewer strokes, significantly fewer severe strokes, and significantly fewer stroke-related deaths than those taking warfarin. In April 2019, Janssen collaborate with AI-driven drug design startup Iktos to use Iktos' virtual drug design technology on small molecule drug discovery projects.

5.MSD(Merck&Co.,Inc.,Kenilworth,N.J.,USA)

Merck and Wayra UK are working together (part of Spanish telecoms business Telefonica) under the banner of the 'Velocity Health' programme. The Velocity Health programmes focused on prevention in healthcare with an emphasis on diabetes prevention and cancer prevention.

Merck (MSD) and Accenture in collaboration with Amazon Web Services (AWS), launched a cloud-based informatics research platform to improve productivity, efficiency and innovation in the early stages of drug development.

6.SANOFI

Sanofi Genzyme, the specialty care global business unit of Sanofi joined with Recursion Pharmaceuticals to deploy its drug repurposing platform to identify new uses for Sanofi's clinical stage molecules across dozens of genetic diseases.

In June 2019, Sanofi joined with Google to establish a new virtual Innovation Lab. Through this partnership, they will leverage deep analytics across data sets to better understand key diseases and extract related patient insights. They were also planned to apply artificial intelligence (AI) across diverse datasets to better forecast sales and supply chain efforts.

7.ABBVIE

Abbvie is very covertly using AI. It does, however, have a secret project listed with Atomwise. In September 2016, AbbVie and AiCure partnered to

improve adherence in a phase 2 schizophrenia trial by using AI-based patient monitoring software.

8.GLAXOSMITHKLINE(GSK)

GSK is very active to utilize artificial intelligence for drug development and they have created an in-house artificial intelligence unit. Initially it was called "Medicines Discovered Using Artificial Intelligence." And then renamed as "In silico Drug Discovery Unit." As of July 2019, GSK's AI team reportedly numbered about 50.

GSK joined along with Exscientia and they created a highly potent in vivo active lead molecule, targeting a novel pathway for the treatment of chronic obstructive pulmonary disease (COPD).

9.AMGEN

Amgen is an investor in precision medicine startup GNS Healthcare.In May 2018, MIT announced that Amgen was a member of its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium. Amgen is also working with medical research machine learning startup Owkin.

10.GILEADSCIENCES

Gilead's first publicly announced use of AI in drug discovery was in April 2019. This month, Gilead announced a strategic collaboration with stealthy startup Insitro. The collaboration will focus on non-alcoholic steatohepatitis (NASH). Gilead will use Insitro's platform to create disease models for NASH and find targets that affect the disease's progression and regression.

CONCLUSION

The human body is the most advanced machine that has ever been built. One area where artificial intelligence and robotics could have a hugely positive future impact is the healthcare and pharmaceutical industry. Artificial intelligence modulated the application of algorithms for analysis of learning and interpretation of data The transformation won't occur instantly though. Rather, it will happen gradually over the following 10 or 20 years. Both hardware (medical equipment, devices, and tools) and software (modeling, computation, evaluation, etc.) should be connected in the loop to save time and money while providing a better understanding of the relationships between different formulations and processes parameters, identification of diseases, radiology, clinical trial research, drug development, personalised medicine, and identification and treatment of rare diseases. The most significant areas of pharmaceutical and healthcare research will be bigger and gets more sophisticated required more technologically advanced infrastructure it will need. Currently, this technological revolution high optimum benefits in the development of health care services that could fundamentally alter how we view the world.

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