ARTIFICIAL INTELLIGENCE AND TELIMEDICINE: AN EFFECTIVE DIGITALIZATION IN HEALTHCARE AND PHARMACEUTICAL SECTORS

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Abstract

The convergence of Artificial Intelligence (AI) and Telemedicine has ushered in a transformative era for the pharmaceutical sector. This review delves into the key aspects of this groundbreaking synergy, exploring the integration of AI technologies and telemedicine practices, and its profound impact on the pharmaceutical sector. The utilization of AI and telemedicine has redefined the landscape of patient care, drug development, conduct clinical trials, and overall healthcare management. In drug development, AI driven systems have transformed the traditional research and development process. Advanced AI algorithms analyze vast datasets to find drug targets, forecast interactions, and optimize clinical trials, thereby significantly reducing both the time and cost associated with bringing new pharmaceuticals to market. The digitalization of the pharmaceutical industry through AI and telemedicine has revolutionized the patient-doctor relationship. Telemedicine platforms powered by AI algorithms enable remote consultations, personalized treatment plans, and real-time health monitoring, transcending geographical barriers and improving access to medical expertise. The seamless integration of these technologies has not only enhanced patient engagement but has also expedited diagnostic accuracy, leading to early detection of diseases and improved health outcomes. While the benefits of AI and telemedicine integration in the pharmaceutical sector are extensive, several challenges and ethical considerations must be addressed. Ensuring data privacy, maintaining the security of patient information, and promoting regulatory compliance are critical factors to be carefully managed in this digitized landscape. In conclusion, the symbiosis of AI and telemedicine has revolutionized the pharmaceutical industry, shaping a future where patient-centric care, rapid drug development, and data-driven decision-making are the norm. Embracing this transformation not only promises enhanced healthcare outcomes but also paves the way for a more efficient, accessible, and innovative pharmaceutical sector.

Key Words: Artificial Intelligence (AI), Telemedicine, Drug development, Healthcare and Pharmaceutical sector.

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INTRODUCTION

The study and development of intelligent machines, notably computer programs, falls under the umbrella term "artificial intelligence" (AI). It's when a computer or robot equipped with a computer is able to learn, make decisions, and solve issues in a way that's strikingly comparable to how humans focus their attention. AI is a branch of computer science with an overarching goal of designing smart machines. The study of AI requires a high level of technical expertise and specialization[1].

Artificial intelligence (AI) integrates a wide range of sensing, acting, and learning technologies. It's a broad area of computer science focused on making machines and programs as smart as humans in terms of problem-solving and learning. This includes not only Natural Learning Process (NLP), but also pattern recognition, interpretation, visual verification, and decision making. Building computational methods to execute the work automatically is part of the AI process. Like humans, machines can learn from the past and improve with experience[2].

Presumably the first use of a computer in a pharmacy occurred in the 1980s; and since then, they have been used for a wide range of tasks, including data collection, retail pharmacy management, clinical research, drug storage, pharmacy education, clinical pharmacy, and lots more, and with the rise of artificial intelligence, there is no telling just how much the Pharmacy sector will evolve in the long run. A number of expert systems have been created in medicine to aid doctors in making diagnoses[3]. Several drug-based treatment plans have been published in recent years[4]. They are used to make decisions about drug formularies, drug therapy monitoring, and drug interactions. Since Artificial Intelligence may have far-reaching effects on the pharmaceutical industry, pharmacists should give careful consideration to the topic before the technology becomes ubiquitous.

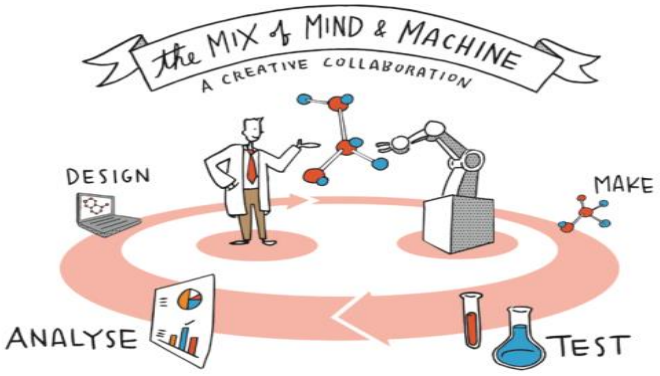

Fig.-1: Artificial Intelligence, the Mix of Mind and Machine

Telemedicine: An effective integration of Information and Communications Technology (ICT) with medical science has given rise to a new field in medicine called telemedicine, which holds great promise for improving access to medical care in underserved areas. Telemedicine also has numerous potentials uses in the areas of healthcare education, administration, and management. According to World Health Organization (WHO), telemedicine the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities[5]. Telemedicine means "distance healing" because of its focus on using technology to treat patients. Definition of Telemedicine by Oxford University Press: "the remote diagnosis and treatment of patients by means of telecommunications technology."

HISTORY OF AI:

Alan Turing initially described the idea of programming a computer to emulate behavioral intelligence and critical thought in 1950[6]. In his book Computers and intelligence, Alan Turing proposed a simple test, commonly known as the "Turing test," to evaluate if a computer could do tasks normally associated with human intellect[7]. Six more years passed before John McCarthy created the term "artificial intelligence" (AI), defining it as "the science and engineering of making intelligent machines[8]. Logic Theorist, developed by Herbert Simon and Allen Newell in

December 1955, was the first piece of artificial intelligence software. Over the course of several decades, AI has progressed from a simple series of "if, then rules" to encompass increasingly complex algorithms that work in a manner analogous to that of the human brain.

MILESTONES IN AI:

Table 1: Milestones in the history of AI

IMPROVEMENT OF ARTIFICIAL INTELLIGENCE (1943-1952)	
Year	**Milestone**
1943	The field of AI has come a long way since Warren McCulloch and Walter pits did their pioneering work in 1943. They put forth a theory based on artificial neurons.
1949	To modify the synaptic connection between neurons, Donald Hebb showed an updating rule. This rule is named after him as Hebbian learning.
1950	Alan Turing, the English mathematician who, in 1950, laid the groundwork for machine learning. The "Computing Machinery and Intelligence" paper by Alan Turing, in which he proposed the "Turing Test," is published. If a machine can pass the Turing test, it means it can act intelligently like a human being.
BIRTH OF ARTIFICIAL INTELLIGENCE (1952-1956)	
1955	Allen Newell and Herbert A. Simon created the "first artificial intelligence program," dubbed "Logic Theorist," which confirmed 38 out of 52 mathematical theorems and found new and more elegant proofs for several of the theorems.
1956	American computer scientist John McCarthy initially used the phrase "Artificial Intelligence" to refer to an academic discipline at the Dartmouth Conference.
GOLDEN YEARS-EARLY ENTHUSIASM (1956-1974)	
1966	Mathematical problem-solving algorithms have been a major focus of research ever since Joseph Weizenbaum, in 1966, developed the first Chabot (called ELIZA).
1972	The first intelligent humanoid robot created in Japan and was named as WABOT-1.
A BOOM OF AI (1980-1987)	
1980	After AI winter duration, the "Expert System" is AI's comeback. Expert systems were programmed that emulate the decision-making ability of a human expert. Stanford University convened the inaugural national conference of the American Association for Artificial Intelligence in 1980.
1986	Geoffrey Hinton is credited with designing the back propagation algorithm currently commonly employed in deep learning.
RISE OF INTELLIGENT AGENTS (1993-2011)	
1997	IBM Deep Blue becomes the first computer to beat a world chess champion, Gary Kasparov.
2002	Vacuum cleaner Roomba marked the first appliance to bring AI into people's homes.
2006	AI came into the Business world in the year 2006. This included social media giants like Facebook, Twitter, and Netflix also started using AI[10, 11].
DEEP LEARNING, BIG DATA AND ARTIFICIAL GENERAL INTELLIGENCE (2011-PRESENT)	
2011	Watson from IBM was able to win the quiz program Jeopardy by demonstrating its ability to interpret natural language and quickly solve hard questions and puzzles.
2012	Google's "Google now" is a new function available on Android devices that can forecast what the user might want to know next.
2014	Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."
2016	Google Deep Mind, software Alpha Go defeated the Go Champion Lee Sedol.
2018	IBM's "Project Debater" debated with two human experts on difficult themes, and it did extremely well. AI algorithm "Duplex" demonstrated by Google took a hairdresser appointment over the phone and the other party didn't even realize she was talking to a computer[12].
2020	During the early phases of the SARS-CoV-2 (COVID-19) pandemic, Baidu released the Linear Fold AI algorithm to scientific and medical teams working on a vaccine. This algorithm can predict the RNA sequence of the virus in only 27 seconds, which is 120 times faster than other methods.

TYPES OF ARTIFICIAL INTELLIGENCE:

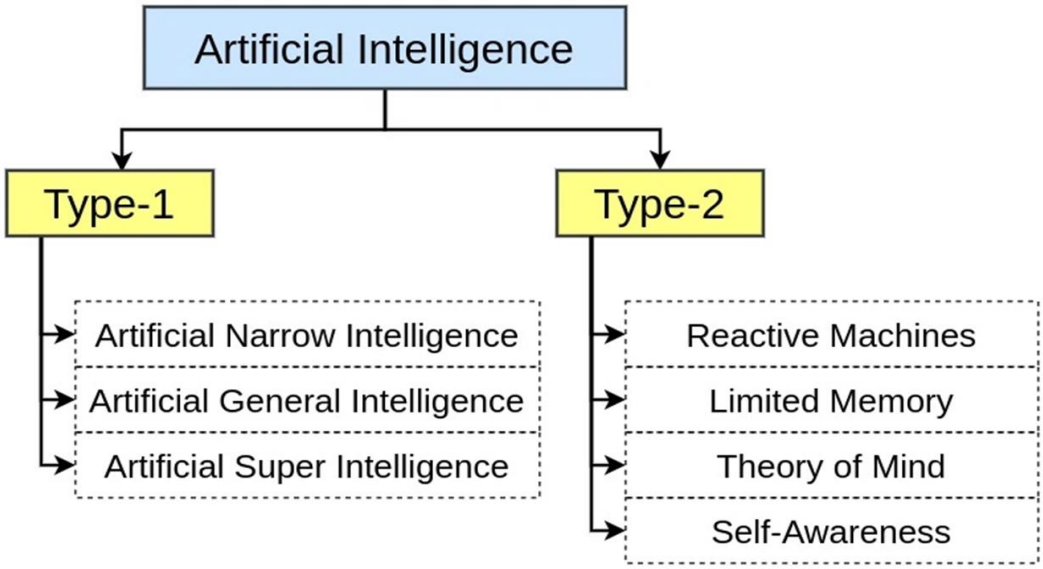

Fig.-2: Classification of Artificial Intelligence[13]

AI TYPE-1: BASED ON CAPABILITIES:

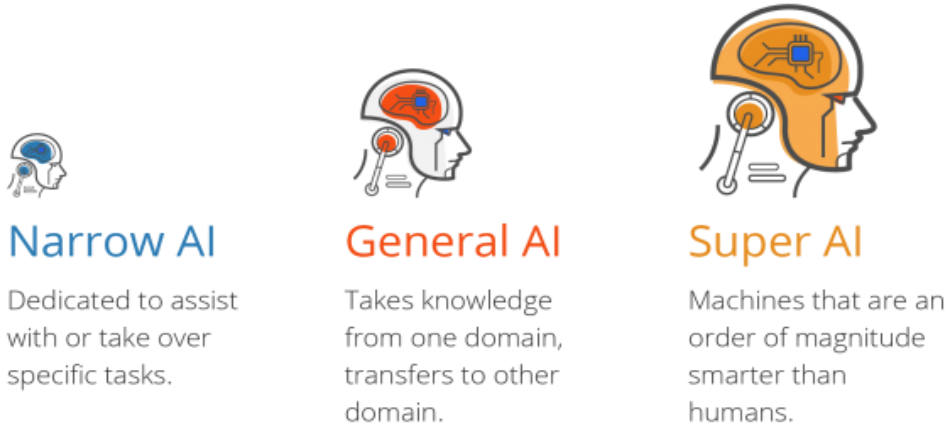

Fig.-3: Difference between Narrow AI, General AI and Super AI

Weak intelligence or Narrow Artificial intelligence (ANI):
Narrow AI is a type of AI that can intelligently execute a specialized task. Narrow AI is the most widely used and accessible form of AI in the world right now. Narrow AI is limited in its capabilities because it is only taught to complete one specific task. So it's also called 'weak AI' for that reason. This system is built and programmed to do a certain task, such as traffic signaling, driving, chess, or facial recognition, among others. Tagging in social media and Apple's SIRI virtual assistant are two good examples.

Artificial General Intelligence (AGI):
When we talk about robots or computer systems having artificial general intelligence (AGI), we mean that they can do any intellectual work that a human can. Strong AI is another name for AGI because it is programmed to carry out a variety of tasks that normally need human intelligence. To this day, AGI remains a theoretical idea with limited practical applications. In order to develop artificial general intelligence, we need to design algorithms that can mimic human thought processes. While AGI could transform many sectors, it also raises ethical questions regarding its potential social impact.

Artificial Super Intelligence (ASI):
Artificial Super Intelligence (ASI) is a type of artificial intelligence (AI) that outperforms human intelligence in all fields. It's a wild speculation that belongs more to science fiction than reality at this point. It is brainpower, which is more active than intelligent people in areas such as sketching, mathematics, space exploration, etc.; in disciplines ranging from science to art. The spectrum is from a computer being only slightly intelligent than a person to a trillion times smarter[14].

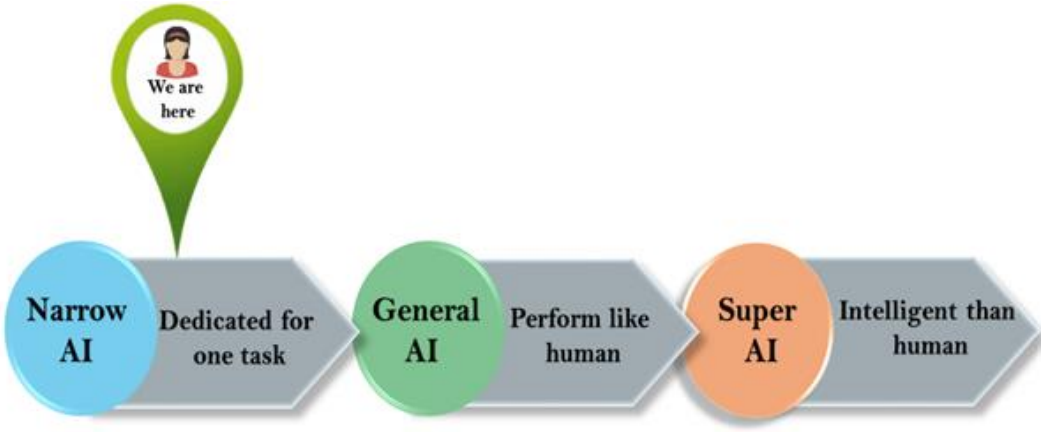

Fig.-4: Stages of Artificial Intelligence

AI TYPE-2: BASED ON FUNCTIONALITY:

Reactive Machines:
Reactive machines are the building blocks of AI. These AIs do not engage in learning or memory storage for use in the present or the future. They think solely of the here and now, and behave accordingly. Machines like Google's Alpha Go and IBM's Deep Blue are examples of reactive machines.

Limited Memory:
Machines with limited memory can only temporarily preserve information or memories from the past. One of the best illustrations of Limited Memory systems is self-driving automobiles. Vehicles can remember the speeds of other vehicles in the area, the distance to other vehicles, the speed limit, and other useful data for safe driving.

Theory of Mind:
Theory of Mind AI should have the same emotional intelligence, knowledge of people and their views, and social skills as humans. Although such AI robots do not yet exist, researchers are devoting significant time and resources to their development.

Self-Awareness:
The next step for AI is to develop self-awareness. These machines will be extremely smart and will be able to think for themselves and have feelings. The intelligence of these machines will surpass that of humans. The concept of self-aware artificial intelligence remains theoretical at this time.

Advantages of AI technology:
AI's nature and applications are intricate. Math, computer science, and other disciplines are all thrown into the mix. Machines are able to mimic human cognition thanks to increasingly complex computer code[15, 16].

Error Reduction – Human mistake can be minimized with AI's assistance, and the likelihood of success in achieving accuracy is improved. Due to their metal frames, resistance, and increased capacity to survive the harsh atmospheric conditions of space, intelligent robots are a good choice for sending on space exploration missions.

Exploration in Harsh Conditions-It has applications in the mining and fuel exploration industries. To go beyond what humans can accomplish, AI systems may be suited for ocean exploration. The programming of robots allows them to execute more difficult and demanding tasks without becoming tired.

Daily Application -AI has practical applications in our everyday lives. The global positioning system (GPS) is frequently used because of its usefulness on long trips. Artificial intelligence (AI) in androids makes predictions about what the user intends to type and fixes typos as they go. Robots like Cortana and Lady SIRI are good examples.

Digital Assistants -Advanced businesses often replace human workers with digital assistants, or the "avatar" models of AI systems. Avatars are devoid of emotions, allowing them to make rational decisions. Emotions are typically linked to states of mind that impair decision making and decrease productivity. Machine intelligence has not shown this shortcoming.

Repetitive Jobs -Positions that require constant repetition are not suited to the human brain. Machines have the ability to multitask and can process information far more quickly than humans. Dangerous work once reserved for humans can now be done by machines with controllable factors like speed and time.

Applications in medicine -Doctors now routinely use AI to assist them diagnose patients and analyze potential health problems. The doctors are learning from AI software about the benefits and risks of certain medications. Artificial surgery simulators are aiding in the education of future surgeons. Artificial surgery simulators such as brain simulators, heart simulators, gastrointestinal tract simulators, etc. are used for their training.

No Breaks -With only two or three breaks every day, humans can work for eight hours. Machines, in contrast to human workers, have no need for regular rest and food breaks. Machines may be set to operate for extended periods of time without getting lost in thought or tiring of the task at hand since they are pre-programmed to do so. They consistently deliver results.

Increase technological Growth Rate - AI Accelerate the pace of technological progress by breaking into the frontier of cutting-edge AI developments. To aid in the discovery of new chemical substances and entities, the AI system has the potential to produce millions of computer modeling programs. Consider the terms QSAR and QSPR.

No risk of harm -when humans work at fire stations, any incident causes harm to the workers. Machines, on the other hand, are emotionless and devoid of feeling. It is also feasible to reuse the components of broken devices.

Disadvantages of AI technology:

High Cost - The complicated design of AI gear, together with repair and maintenance, means that bringing the technology to market requires a substantial financial investment. The machine's software has to be regularly updated. The time and resources required to reinstall and recover the machine are substantial. The time it takes the R&D department to create a single AI machine is considerable. Thus, there is a greater outlay of resources.

No Replicating Humans -Robots with AI can mimic human thought processes, but they lack human emotions and ethics, so there's no point in trying to create copies of people. Therefore, they carry out the duty as instructed and lack the ability to make decisions. It can become a major issue at times. Robots can't make a call if they don't understand the issue. They either give a bogus report or have a breakdown during that moment.

No Improvement with Experience- Machines using AI technology cannot improve with experience in the way that humans do. Machines do not feel love, compassion, or a sense of community. They can't tell the difference between a diligent worker and a slacker.

No Original Creativity -Machines can't think outside the box since they lack human emotions. A machine can't see, hear, feel, or think the way a human can. Humans are the only creatures capable of original ideas since machines cannot read our minds. Natural human abilities are fundamental and cannot be duplicated.

Unemployment –Large-scale joblessness if machines are employed to replace humans in all economic areas. People have a tendency to rely heavily on others. This causes them to become unmotivated and unable to think outside the box. There have been two recent studies on this topic[17, 18].

DIGITALIZATION OF THE PHARMACEUTICAL INDUSTRY:

It is the integration of digital technologies and data-driven approaches into various aspects of drug discovery, development, manufacturing, and commercialization. Big data analytics, AI, machine learning, robotics, and other cutting-edge technologies are being used to boost productivity, precision, and creativity in the sector[19]. There are several ways in which digitalization can help businesses of all sizes[20].To comply with upcoming serialization laws, for instance, the digitalization can be used in the creation of counterfeit-proof pharmaceuticals with trackable serial numbers along the supply chain should guarantee quality[21, 22]. Digitalization can also help pharmaceutical companies meet the anticipated increase in demand from international markets. They can utilize digitalization to stay in line with regulations, find ways to cut costs in production, and communicate with their distributors and suppliers more quickly through the use of cloud-based information exchanges[23]. Real-time production of medicines may also be possible with the help of automation, smart sensors, social media, and health applications for monitoring patient adherence and predicting regional demand[24]. The healthcare sector, like many others, is having trouble getting digital tools into the hands of patients and other end users[25]. Several sectors within the health care industry have seen significant changes to their business models as a result of the digital revolution. Yet traditionally, the pharmaceutical industry has been slow to adopt

change and digital solutions. Because of this, the pharmaceutical industry's adoption of digital services has been delayed[26].Digitalization appears to be the greatest solution to guarantee that all people have access to safe medicines in the face of the enormous worries and ongoing threat posed by the Covid-19 pandemic[27]. There is no denying the need for the pharmaceutical business to adopt digitalization strategies. To keep supplying pharmaceuticals and medical supplies to meet the ever-evolving needs of a global population, digitization is essential. The pharmaceutical industry has very little and sometimes sluggish digitalization experience, in contrast to other sectors which demonstrate successful digitalization experiences.

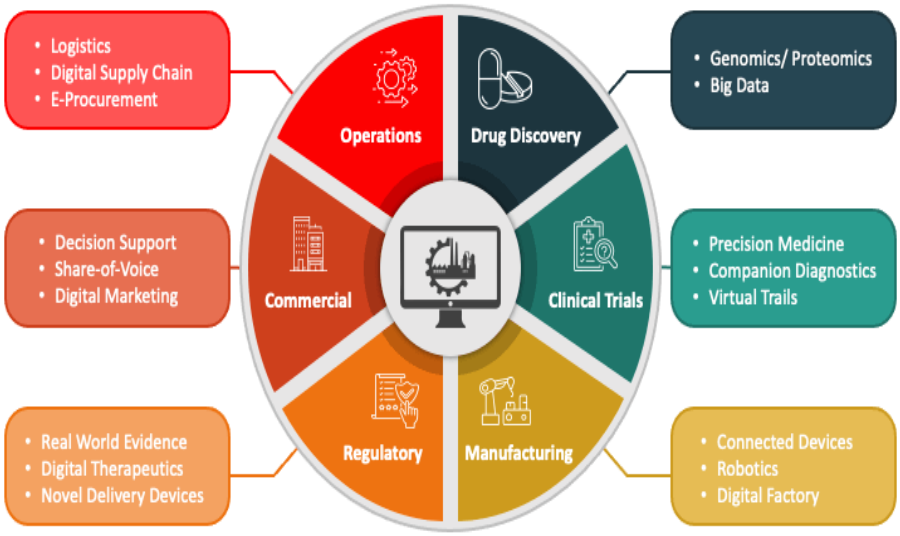

Fig.-5: Key areas of digitalization impacting the pharmaceutical industry

AI IN DIGITALIZATION OF PHARMACEUTICAL INDUSTRY:

Pharmaceutical businesses have access to a wide variety of chemicals that show promise in the treatment of a wide variety of ailments. However, businesses lack the resources necessary to reliably identify them as such. Drug research and production is a complex process that can take a pharmaceutical business 12–14 years and up to $2.6 billion to complete. Here is where AI really helps out the pharmaceutical industry. Artificial intelligence shortens the duration of medication development, which in turn lowers development costs, increases returns on investment, and perhaps lowers end-user prices[28]. The primary advantage of AI is that it is far more proficient at data analysis than people are, and it can process massive amounts of data that would overwhelm traditional computers. Artificial intelligence is currently only applied in academic settings. Artificial intelligence (AI) has greater processing power than any other tools now accessible and is being increasingly used in research, particularly in the study of gene mutation[29].

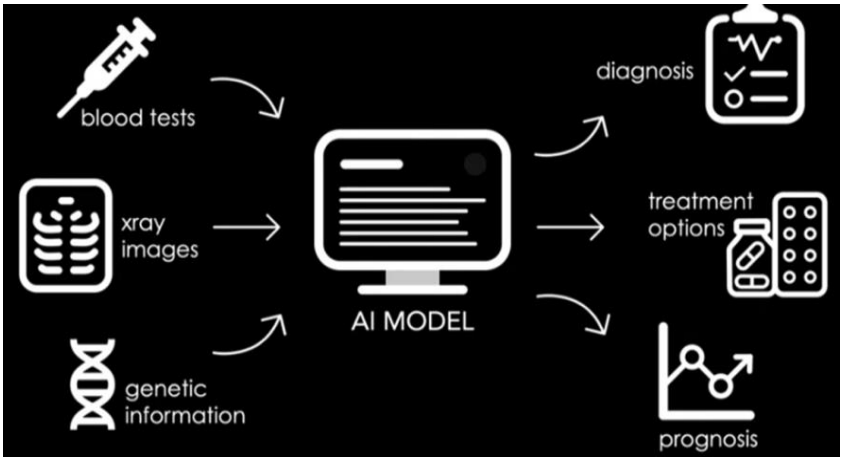

Fig.-6: Digitalization in various fields of pharmacy

TABLE - 2: Milestones of AI in Healthcare And Medicine

YEAR	MILESTONE
1963	Computer diagnosis of primary bone tumors.
1983	First computer digitized x-ray developed for radiology.
2000	The Da Vinci robotic surgical system was launched by Intuitive Surgical.
2001	The first automatic, non-invasive glucose monitoring system (GlucoWatch) was approved by the FDA.
2011	IBM Watson beats human contestants at jeopardy game show.
2012	AliveCor's first smartphone ECG has been certified by the FDA.
2013	IBM Watson begins testing oncologists to recommend treatment for lung cancer.
2016	FDA approves the first AI software for patients care (Arterys).
2017	The FDA launches the digital health software pre-cert program.
2018	The American medical association publishes its AI policy. The FDA approves the first medical device for patient care without physician oversight.
2019	An AI startup (BlueDot) reports about COVID-19 before global agencies.
2020	FDA approves the first AI guided portable ultrasound device. The US announced the first reimbursement to hospital for use of AI. The first database of FDA approved; AI based medical technologies (The Medical Futurist Institute).
2021	The FDA published its database of approved, AI based medical technologies.

AI TECHNOLOGIES USED IN HEALTHCARE

Following are various technologies or algorithms of Artificial Intelligence used in healthcare industries:

Machine Learning (Neural Network and Deep Learning): Precision medicine is the primary use of machine learning in healthcare; this refers to the practice of determining which treatment procedures have the greatest chance of being effective for a given patient, taking into account a wide range of individual and contextual factors.

Natural Language Processing: Natural language processing (NLP) is primarily employed for the purposes of creating, comprehending, and categorizing healthcare documents and published research. It is also useful for preparing reports and doing analyses on unstructured patient clinical notes.

Robotics: Artificial intelligence (AI) is being integrated into a wide range of physical robots used in the healthcare industry. These days, surgical robots are utilized to aid surgeons in a variety of ways, including making it easier for them to see, stitch up wounds, and so on. Robotic surgery is used for a variety of surgical procedures, including gynecologic, prostate, and head and neck treatments.

Rule-based expert System: The rule-based expert system is primarily utilized in business since it is built on a set of it-then rules. Additionally, EHRs employ it to enforce a predetermined set of guidelines for patient care. Human experts and knowledge engineers develop a set of rules, and then use those rules to build a straightforward rule-based expert system. This rule's complexity and execution time are directly related to the breadth and depth of the information at hand. Therefore, AI is being implemented in the healthcare industry to address this limitation of rule-based expert systems.

Robotic process automation (RPA): Robotic process automation is utilized in the healthcare industry for routine tasks like patient record updates and billing. When paired with other methods, it can be utilized to retrieve information.

AI-BASED HEALTHCARE SYSTEM VS. TRADITIONAL HEALTHCARE SYSTEM

AI-based Healthcare system:

For the purpose of preventing, diagnosing, and treating diseases, illness, and other physical and mental impairments in humans, artificial intelligence helps to forecast and analyze data through electronic health records.

Traditional Healthcare System:

- Current medical practice relies only on the results of the most recent research.
- Finding a doctor who takes the time to get to know you is quite difficult.
- Lack of knowledge
- Unexpected death resulting from human errors.

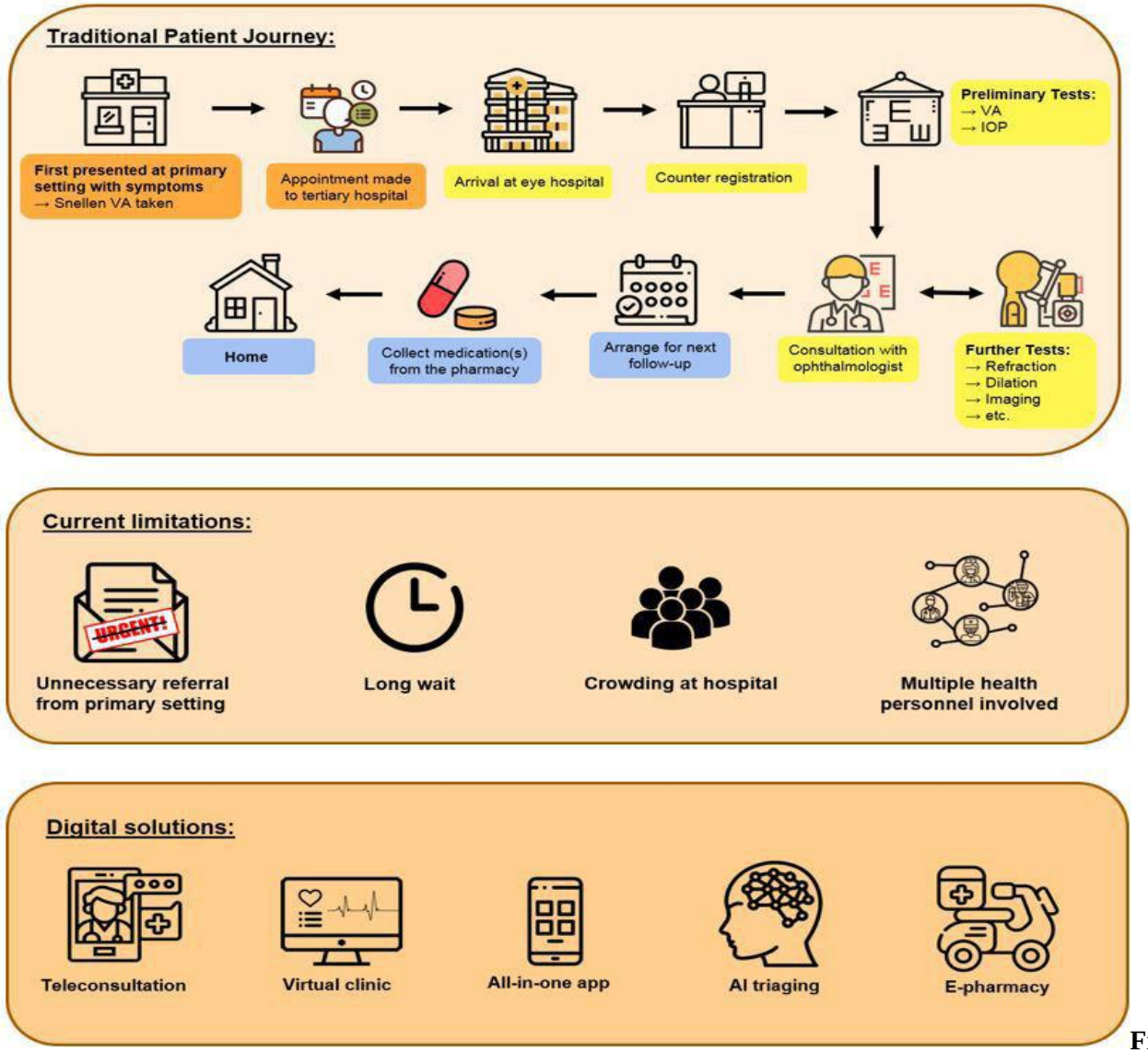

Fig.-7: Diagrams depicting the traditional model's shortcomings and the proposed digital alternatives to address them.

Applications Of Ai In Pharmaceutical Industry:

AI in drug discovery process[30]:

Deep learning and Natural Language Processing (NLP) are being used by the chemical and pharmaceutical industries to analyze and make sense of the massive amounts of patents and genomic data science material at their disposal. Deep learning software such as "NVIDIA DGX-1" is being used in the manufacturing sector. Artificial intelligence supercomputers take in all the data, analyze it to find the connection between the molecules, and then suggest a new drug candidate[31]. From the time a drug discovery project is initiated to the time it reaches the market is usually around 15 years. Over $1 billion is being spent on each new medicine by industry. The development of a new medicine typically takes 14 years and costs $2.6 billion. Of all the possible pharmacologically active chemical entities, picking a novel medication molecule that works well is the most difficult. To quickly and readily obtain therapeutically effective candidates, AI employs Benevolent AI to produce fewer molecules with greater certainty about their attributes. Insilco medicine is getting next generation AI to solve problems. Generative adversarial networks (GANs) can be used to create new chemical structures for pharmaceuticals. Google's artificial intelligence team created this deep learning system in 2014. This technology helps create visually accurate images from written descriptions. Based on existing data, it can simulate or generate new data. Recently developed AI techniques have proven their efficacy in resolving previously intractable issues.

AI AI-based digital therapies and individualized medical care:

Artificial intelligence (AI) has the ability to extract a useful relationship from the raw datasheets that can be applied to illness diagnosis, treatment, and prevention. The advancement of medical AI has aided doctors in resolving previously intractable medical issues. Healthcare personnel can benefit from using intelligent systems such artificial neural networks (ANNs), evolutionary computational systems, fuzzy expert systems, and hybrid systems to manage and handle data[32]. The ANN is Biological nervous system principles are the foundation of the artificial neural network[33]. Neurons are a type of computer processor that are part of a larger network and can execute parallel computations for data processing. The ANN has been implemented in the interpretation of data, analysis of waveforms, and analysis of diagnostic images.

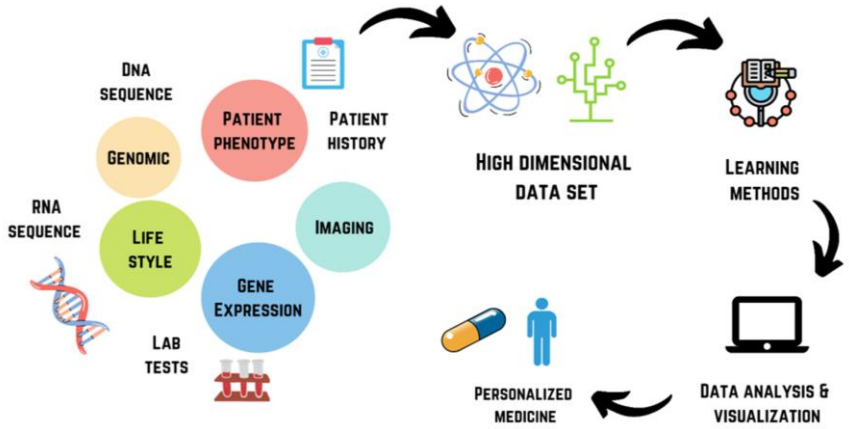

Fig.-8: The use of AI to collect and analyze patient data for the purpose of providing individualized care.

AI in Radiotherapy:

Automated treatment planning is a cutting-edge technology that has shown great promise in the field of radiation. The quality, consistency, and mistake rate of treatment plans are all being significantly enhanced through automation. The system may perform an analysis of the patient's anatomy and physiology and simulate the reasoning process that is typically used in manual therapy planning. Promising accuracy has been demonstrated in three-dimensional dose distribution and dose models for spatial dose[34]. Multiple imaging biomarkers aid in radiomics' ability to provide comprehensive tumor data. Individual patient radiation therapy outcomes and toxicity can be predicted using a radiation genomics approach[35].

AI in the field of gastroenterology:

Over the past decade, artificial intelligence has seen rapid growth in the field of gastroenterology. In order to better detect and distinguish between benign and malignant colon polyps, colonoscopy can benefit from computer-assisted diagnosis[36]. Prediction models for prognosis and therapy response can also be constructed using DL. In gastroenterology, several ANNs have been developed and evaluated as diagnostic and prognostic models. A total of 45 clinical factors were utilized to correctly diagnose GERD in a retrospective analysis of 150 patients[37]. The survival rate of patients with esophageal adenocarcinoma has been predicted using[38]; inflammatory bowel disease relapse and severity have been predicted using AI[39]; and the likelihood of distant metastases in esophageal squamous cell carcinoma has been informed using AI[40].

AI-Assisted endoscopy:

The field of AI-assisted endoscopy is one with great potential. Computer-assisted diagnosis (CAD) was initially used to distinguish between cancerous and benign polyps in the colon[41]. During the withdrawal phase of a colonoscopy, the 2019 CNN-based system ENDOANGEL (Wuhan EndoAngel Medical Technology Company, Wuhan, China) can offer an objective assessment of bowel preparation every 30 seconds with an accuracy of 91.89%[42]. Medtronic's GI Genius (Minneapolis, Minnesota) is an AI-enhanced endoscopy assistance gadget designed to help doctors spot colorectal polyps in real time during an examination. It has received marketing authorization in Europe and is currently being tested in humans in the United States. Polyps were found by GI Genius 82% of the time before they were found by endoscopists, according to a validation study[43].

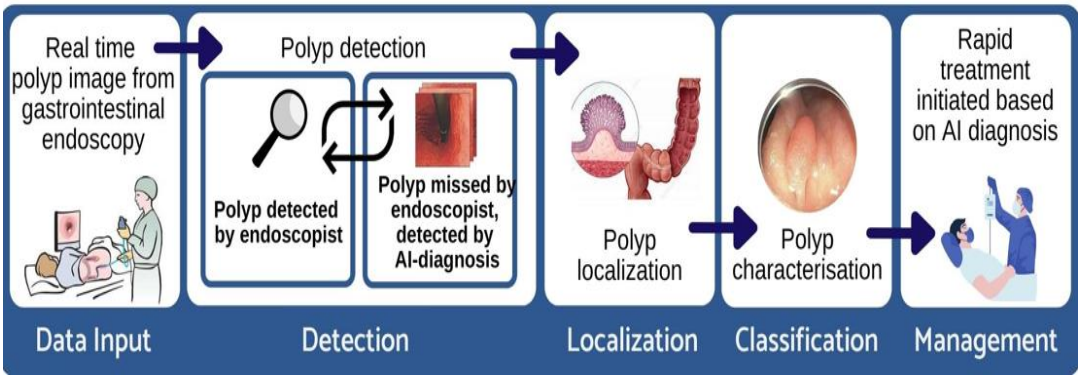

Fig.-9: AI for Recognizing Polyps in the Colon during Intestinal Endoscopy.

AI in Cancer:

Artificial intelligence's broad range of potential uses has led to its rising profile in the domains of cancer diagnosis and treatment. Gene expression data was used to train a multilayer perceptron neural network to identify non-Hodgkin lymphoma subtypes. The input layer of the neural network is made up of 20,863 genes, and the output layer is made up of lymphoma subtypes. Mantle cell lymphoma (MCL), follicular lymphoma, diffuse large B-cell lymphoma (DLBCL), marginal zone lymphoma, and Burkitt lymphoma are all subtypes of lymphoma. Lymphoma subtypes were accurately predicted using an artificial neural network[44].

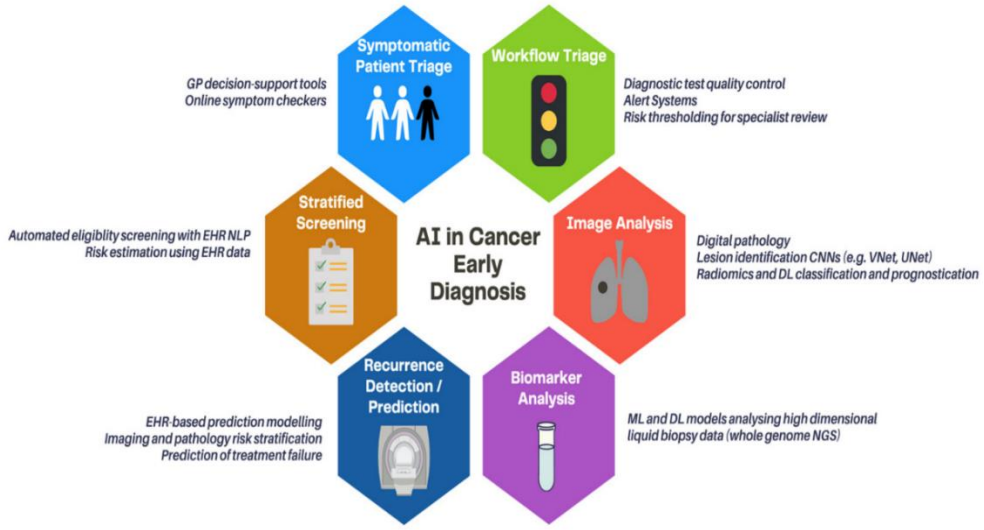

Fig.-10: Clinical applications of AI in early cancer diagnosis

AI in Retina:

The high-quality retinal imaging has significantly expanded the ability to evaluate people's health. Highly individualized data can be extracted from a single snapshot of the retina; using high-definition medications, the ophthalmologist/retinologist can develop a specific therapy and set up a constantly evolving adaptive healthcare system [45].

Electronic Healthcare Records:

Patient medical record keeping is a complicated process. Data collection, normalization, and tracking are simplified with the help of the AI system. The medical records can be quickly uncovered with the help of the Google Deep Mind health initiative. This project will help improve and speed up medical care, hence it is worthwhile. This project aids the National Health Service (NHS) Moor fields Eye hospital in its efforts to provide better eye care.

Assisting in repetitive tasks:

The examination of X-ray images, radiography, ECHO, ECG, etc., for the detection and identification of diseases or disorders is one example of a repetitive task that can benefit from the use of artificial intelligence technology[46] describe IBM's recently released Medical Sieve algorithm as a "cognitive assistant" with strong analytic and deductive capabilities. A medical business can speed up the healing process by combining deep learning with medical data. Each

organ system has its own dedicated computer program for use in treating various diseases. Almost every imaging analysis, including X-ray, CT scan, ECHO, ECG, etc., can benefit from the use of deep learning.

Manufacturing:
Artificial intelligence can be used by the pharmaceutical industry to speed up drug production, increase efficiency, and boost productivity. The manufacturing process can benefit greatly from the use of artificial intelligence in the areas of QC, quality assurance, predictive maintenance, decrease in waste, optimizing of designs, and process automation.

Marketing:
AI can be a useful asset in pharma marketing because the pharmaceutical industry is so sales-focused. Innovative pharmaceutical marketing techniques that generate significant profits and raise brand recognition can now be developed with the help of AI.

Artificial intelligence for pandemic and epidemic prediction:
A pandemic has no limits and can result in widespread illness and death. Globally, there have been several pandemic outbreaks, to name a few, Black Death, Spanish flu, Cholera, Influenzas, AIDS, COVID-19, and they are capable of causing social and economic interruption[47]. Surveillance is a key component in achieving early detection[48]. Active surveillance demands huge resources, manpower and time. In practice, predicting the epidemic and pandemic is a challenge. However, with the current advancements studying the propagation of dreadful diseases is made possible. To do monitoring while making optimal use of available resources, AI is your best option. When compared to human resources, machine learning and deep learning are proving to be invaluable in many areas of the healthcare industry[49].

TOP PHARMACEUTICAL COMPANIES IN THE WORLD USING AI

- **Pfizer:** Immunotherapy for cancer.
- **Roche:** In macular edema caused by diabetes.
- **Novartis**: interpret pictures of cancer tissue.
- **Johnson Johnson:** Death due to stoke, skin scanner Merck & co MSD: focus on diabetic and cancer prevention.
- **Sanofi:** The process of repurposing drugs reveals novel applications for molecules with proven clinical efficacy in treating genetic diseases.
- **GlaxoSmithKline:** drug discovery has AI unit, Insilco drug discovery unit.
- **Amgen:** precision medicine in GNS health care medical research.
- **Gilead sciences**: drug discovery in April 2019.

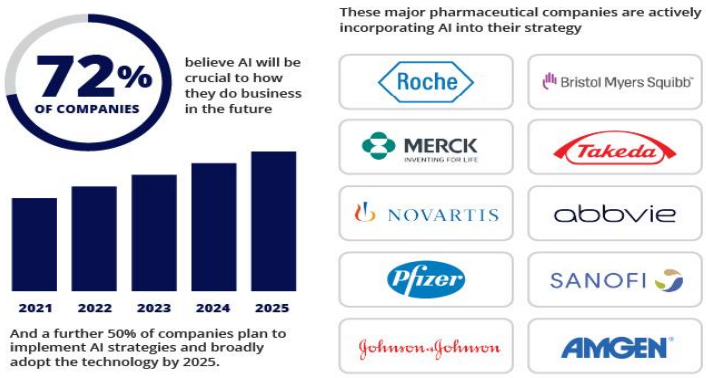

Fig.-11: Some Top pharmaceutical firms using AI

TELEMEDICINE IN DIGITALIZATION OF PHARMACEUTICAL INDUSTRY:
Telemedicine is transforming the way healthcare is delivered, and pharmaceutical companies are also benefiting from this technology. Telemedicine allows patients to receive care remotely, and this can increase patient engagement in clinical trials, improve adherence to medication regimens, and provide valuable insights into patient experiences and outcomes. Telemedicine also enables pharmaceutical companies to collect data from patients more efficiently, which can help to accelerate drug development and improve patient outcomes. But data privacy, cyber security, and regulatory frameworks are just some of the issues that need to be addressed as the pharmaceutical sector begins to fully embrace AI and telemedicine. However, these technologies have the ability to transform the way drugs are developed, delivered, and monitored, leading to more personalized and effective treatments for patients.

Table-3: Comparison of time frames before and after introduction of telemedicine.

BEFORE	AFTER
Take the patient to the hospital	Consultation is available immediately.
Increased expenses for patients/relatives	Least expenses for patients/relatives
Only one expert	More experts
Medical services in hospital	Medical care at home
Paper archive	Digital Data base+ Paper archive
Multiple visits	Reduction of visits
Patients access to specialists within easy reach of patients locally	Increased access to specialists on a nationwide scale for patients
Need for personal direct contact with a specialist from national level	Immediate distant consultation
Experts have little spare time.	Augmentation of creative work
Limited disease prevention	Unlimited

CLASSIFICCATION OF TELEMEDICINE:
There are five distinct categories of telemedicine[50]:

According to the information transmission timing:
Synchronous or real time telemedicine (in which information is transferred "live" between a sender and a receiver who are both online at the same moment.).

Asynchronous telemedicine or store-and-forward telemedicine in which the sender stores the information databases and delivers it to the receiver at an appropriate moment in time, and the receiver can review the data according to his or her own convenience).

Remote Monitoring type of telemedicine often referred to as self-monitoring or self-testing. When monitoring a patient's health and clinical indications from a distance, remote monitoring makes use of a wide variety of technical tools and gadgets.

According to the interaction between the individuals involved:
Health care professional to other health care professional (to facilitate easier access to specialized care, referral services, and consultations).

Health care professional to patient (providing healthcare to the unreached population by giving them direct access to a medical professional).

Advantages:
- Cost and time saving
- Improved quality care
- Easy access and engagement
- More patient Satisfaction

Disadvantages:
- Lack of Reimbursement
- Incomplete Diagnosis
- Privacy and Security issues
- Expensive Technology

APPLICATIONS OF TELEMEDICINE:
Teleconsultation: Telehealth counseling, or "teleconsultation," is one use case for TLM. Consultations with medical professionals, including psychiatrists and psychologists, are currently the most common use of this technology. A remote consultation can take place between a patient and their treating physician, between a patient and a psychiatrist or psychologist, or between any two or more clinicians. With remote consulting, you have the freedom to pick how you want to get in touch with the consultant. One should be aware that the internet is rife with fake doctors and websites that claim to provide medical advice but have no training or experience[51].

Treatment of chronic illnesses: Telemedicine is an efficient and low-cost method of keeping track on patients who are being treated for chronic conditions. Home monitoring devices enable patients to track vital indications such as blood pressure, levels of glucose, and heart rate on a regular basis. Doctors will benefit greatly from this kind of access in their ability to monitor their patients' health and respond quickly in the event of a medical emergency.

Follow-ups: Using telemedicine, doctors can check in on their patients remotely to make sure they're following their aftercare instructions. It's also helpful for follow-ups that don't necessarily require or warrant an in-person meeting. In addition to boosting a practice's bottom line, remote follow-ups have been shown to decrease the frequency of no-shows and cancellations.

No missed prescriptions: Thanks to the convenience of telemedicine, doctors can more frequently check in on their patients to verify they are following their treatment plans. It is possible to set up a reminder system to ensure that patients do not forget to renew their prescriptions on time. In order to minimize potential health problems, the fewer prescriptions that are skipped, the better.

Flexible practice: Benefits to both doctors and patients are numerous when using Telemedicine software. Since doctors can now perform health checks remotely, they can reduce their time spent in the clinic without sacrificing patient care. Without keeping the clinic open, they can maintain constant communication with the patient through direct means. Both sides are interested in this possibility because it will save them money on transportation costs.

Future Outlook Of Ai And Telemedicine:

AI: Hybrid models, in which professionals are provided support with diagnosis, risk factor identification, and treatment planning but retain ultimate responsibility for patient care, represent the most promising potential for AI in healthcare over the coming years. If this were the case, it would be much simpler for healthcare specialists to provide operational efficiency and measureable progress in patient results, and it would enable both patients and doctors accept these tools by examining the risk associated. Despite these obstacles, AI is quickly becoming a support system for healthcare workers, which will begin easing their workload. Patients who cannot afford to travel to major medical centers may soon be able to receive a diagnosis using AI technology. It would be simple to bring advanced medical care to underdeveloped regions. There is still an enormous amount of work to be done in AI, but the possible future of AI in this business appears exciting, feasible, and bright. AI treatments are more expensive, but once they are refined, they will provide excellent diagnostics in record time. Naturalistic simulations that give a real-time sense are something that even computer-driven algorithms can't do, thus this would make training medical students simple and enjoyable.

Telemedicine: It is not an exaggeration to say that telemedicine is going to serve a major role in the future of healthcare given the rapid expansion of the field in recent years. Some recent figures confirm this to be true: a 2021 analysis estimates that the worldwide telemedicine business would be worth $431.82 billion by 2030, up from $40.20 billion in 2020. Today, telemedicine is being used by the best healthcare mobile app developers and numerous medical software firms to increase efficiency. Basic telemedicine services are provided to patients at many hospitals that use Epic software and EHR device connections. Telemedicine continues to be the most promising new healthcare technology, and all of these indicators point to telemedicine's growing popularity as the finest new technology in healthcare. Telemedicine is, as has been declared by numerous authorities, the wave of the future in healthcare.

7. CONCLUSION

Digitalization has revolutionized the pharmaceutical industry by providing numerous benefits such as improved drug development, faster clinical trials, enhanced patient monitoring, and personalized medicine. AI and telemedicine are two key technologies that are driving this digital transformation. The stethoscope was not immediately welcomed by the medical community after its invention. Similarly, despite the enormous potential that artificial intelligence has to completely transform the healthcare industry, it will take some time before it is acknowledged as a legitimate health tool. However, it is so potent that when it will finally take its rightful place in the healthcare industry, it will eventually replace the stethoscope as the icon of that industry.

REFERENCES

1. Shapiro SC. Artificial intelligence. Encyclopedia of Artificial intelligence, Vol. 1, 2nd Edn. New York; Wiley 1992.
2. Turing AM. Computing machinery and intelligence. Mined 1950; Vol.59: 433–60.
3. Deopujari, S., Algoman: Gearing up for the “Next Generation” and Era of Artificial Intelligence, One Step at a Time. The Indian Journal of Pediatrics, 2019; Vol. 86(12): 1079-1080.
4. Dasta, J.F., Application of artificial intelligence to pharmacy and medicine. Hosp Pharm, 1992; Vol. 27(4): 312-5, 319-22.
5. Telemedicine-Opportunities and developments in member states. 2nd ed. Geneva, Switzerland: WHO press; 2010.
6. A.N. Ramesh, C. Kambhampati, J.R. Monson, et al. Artificial intelligence in medicine Ann R Coll Surg Engl, 2004: Vol. 86: 334-338.
7. A.E.B. Greenhill A primer of AI in medicine Techn Gastrointest Endosc, 2020: Vol.22: 85-89.

8. Amisha, P. Malik, M. Pathania, et al. Overview of artificial intelligence in medicine J Family Med Prim Care, 2019: Vol.8: 2328-2331.
9. Tabbarah H., Abdulghafar A., The potential application of artificial intelligence in transport. IEE Proc.-Intell. Transport Syst, 2017; Vol. 153:183–198
10. Wright C., PreScouter, Artificial intelligence in medicine. Ann. R. Coll. Surg. Engl. 2018; Vol.86: 334–338
11. Greengard S., Datamation, Intelligent systems in manufacturing: current developments and future prospects. Integr. Manuf. Syst. 2019; Vol.11: 218–238
12. Ahmed H E., Generating focused molecule libraries for drug discovery with recurrent neural networks. ACS Cent. 2018, Vol. 4(4): 1-4.
13. Mulholland, M., et al., A comparison of classification in artificial intelligence, induction versus a selforganising neural network. Chemometrics and Intelligent Laboratory Systems, 1995; Vol. 30(1): 117-128.
14. Arend Hintze. Understanding the four types of AI. Cited 2022 13 June.
15. Klopman A. Artificial intelligence approach to structure activity studies. Computer automated structure evaluation of biological activity of organic molecules. J Am Chem Soc. 1984; Vol.106: 7315-21.
16. Silver D, Schrittwieser J, Simonyan K. Mastering the game of Go without human knowledge. Nature. 2017; Vol.550: 354–359.
17. Ozerov IV, Lezhnina KV, Izumchenko E et al. In silico Pathway Activation Network Decomposition Analysis (iPANDA) as a method for biomarker development. Nature Commun, 2016; Vol. 16: 253 - 258
18. Moosavi-Dezfooli S-M, Fawzi A, Fawzi O andFrossard P. Universal adversarial perturbations. IEEE Conference on Computer Vision and Pattern Recognition, Hawaii, 2017; Vol.6: 21–26.
19. Dimitrov D V. Medical internet of things and big data in healthcare. Healthc Inform Res. 2019; Vol.25: 3-10.
20. B. Lakshmi, S. Patel Digital Marketing in Pharmaceutical Industry–An Overview and Assessment. 2020; Vol. 8: 221 - 235
21. S. Anderson. The digitization of the Pharmaceutical Historian archive Pharm. Hist., 2018; Vol. 48: 2.
22. M.S. Rosenbaum, G.C. Ramírez, K. Edwards, J. Kim, J.M. Campbell, M.C. Bickle The digitization of health care retailing J. Res. Interact. Mark. 2017; Vol. 5: 53 - 58
23. L. Kumar, C. Panigrahi Communication with doctors: empowering Pharma field force with modern marketing techniques Asian J. Manag. Res., 2014; Vol.5 (2): 22 - 35
24. M.H. van Velthoven, C. Cordon, G. ChallagallaDigitization of healthcare organizations: the digital health landscape and information theoryInt. J. Med. Inform., 2019; Vol. 124: 49-57.
25. S. Chilukuri, R. Rosenberg, S. Van Kuiken A Digital Prescription for Pharma Companies McKinsey & Company. 2014; Vol. 13: 1-6.
26. J. Lee, I. Cameron, M. Hassall Improving process safety: what roles for Digitalization and Industry 4.0?Process. Saf. Environ. Prot., 2019; Vol. 132: 325-339
27. N. Ayati, P. Saiyarsarai, S. Nikfar Short and long term impacts of COVID-19 on the pharmaceutical sector DARU J. Pharmaceut. Sci., 2020; Vol. 28 (2): 799-805
28. NES Global Talent. How Artificial Intelligence is Beign used in the Pharmaceutical Industry. Available from:https://www.nesglobaltalent.com/media/press-releases/how-artificial-intelligence-being-used-pharmaceuticalindustry. [Last accessed on 2017 Jun24].
29. Eye for Pharma. Artificial Intelligence - A Brave New World for Pharma. Available from: http://www.social. eyeforpharma.com/clinical/artificial-intelligence-bravenew-world-pharma. [Last accessed on 2017 Jun 24].
30. Cherkasov A, Hilpert K, Jenssen H, Fjell CD, Waldbrook M, Mullaly Pharma Times - Vol. 51 - No. 01 - January 2019 15Sr. No. Company Name Pg. No.Advertisement Index SC, et al. Use of artificial intelligence in the design of small peptide antibiotics effective against a broad spectrum of highly antibiotic resistant superbugs. ACS Chem Biol. 2009; Vol.4:65-74.
31. Margaret Rouse. IBM Watson Supercomputer. Available from: http://www.hatis.techtarget.com/definition/IBMWatson-supercomputer.
32. Ramesh, A.N.; Kambhampati, C.; Monson, J.R.; Drew, P.J. Artificial intelligence in medicine. Ann. R. Coll. Surg. Engl. 2004; Vol. 86: 334.
33. Albu, A.; Ungureanu, L. Artificial neural network in medicine. Telemed. J. e-Health 2012; Vol.18: 446–45.
34. Troulis, M.; Everett, P.; Seldin, E.; Kikinis, R.; Kaban, L. Development of a three-dimensional treatment planning system based on computed

tomographic data. Int. J. Oral Maxillofac. Surg. 2002; Vol.31: 349–357.
35. Arimura, H.; Soufi, M.; Kamezawa, H.; Ninomiya, K.; Yamada, M. Radiomics with artificial intelligence for precision medicine in radiation therapy. J. Radiat. Res. 2019; Vol.60: 150–157.
36. J.K. Ruffle, A.D. Farmer, Q. Aziz Artificial intelligence-assisted gastroenterology—promises and pitfalls Am J Gastroenterol, 2019; Vol.114: 422-428
37. F. Pace, M. Buscema, P. Dominici, et al. Artificial neural networks are able to recognize gastro-oesophageal reflux disease patients solely on the basis of clinical dataEur J Gastroenterol Hepatol, 2005; Vol.17: 605-610
38. F. Sato, Y. Shimada, F.M. Selaru, et al. Prediction of survival in patients with esophageal carcinoma using artificial neural networks Cancer, 2005; Vol.103: 1596-1605
39. J.C. Peng, Z.H. Ran, J. Shen Seasonal variation in onset and relapse of IBD and a model to predict the frequency of onset, relapse, and severity of IBD based on artificial neural network Int J Colorectal Dis, 2015; Vol..30: 1267-1273
40. D.E. Fleck, N. Ernest, C.M. Adler, et al.Prediction of lithium response in first-episode mania using the LITHium Intelligent Agent (LITHIA): pilot data and proof-of-concept Bipolar Disord, 2017; Vol.19: 259-272
41. S.A. Hoogenboom, U. Bagci, M.B. Wallace AI in gastroenterology. The current state of play and the potential. How will it affect our practice and when? Tech Innov Gastrointest Endosc, 2020; Vol..22: 42-47
42. J. Zhou, L. Wu, X. Wan, et al. A novel artificial intelligence system for the assessment of bowel preparation (with video) Gastrointest Endosc, 91 (2020), pp. 428-435
43. C. Hassan, M.B. Wallace, P. Sharma, et al. New artificial intelligence system: first validation study versus experienced endoscopists for colorectal polyp detection Gut, 2020; Vol.69: 799-800
44. Carreras, J.; Hamoudi, R. Artificial Neural Network Analysis of Gene Expression Data Predicted Non-Hodgkin Lymphoma Subtypes with High Accuracy. Mach. Learn. Knowl. Extr. 2021; Vol.3: 720–739.
45. Schmidt-Erfurth, U.; Sadeghipour, A.; Gerendas, B.S.; Waldstein, S.M.; Bogunovi´c, H. Artificial intelligence in retina. Prog. Retin. Eye Res. 2018; Vol.67: 1–29.
46. Deep Mind's health team. [cited 2022 13 June]; Available from: https://www.deepmind.com/blog/deepminds-healthteam-joins-google-health.
47. Madhav, N.; Oppenheim, B.; Gallivan, M.; Mulembakani, P.; Rubin, E.; Wolfe, N. Pandemics: Risks, Impacts, and Mitigation. Disease Control Priorities: Improving Health and Reducing Poverty, 3rd ed.; The International Bank for Reconstruction and Development/The World Bank: Washington, DC, USA, 2017; Vol. 9: 315–345.
48. Steele, L.; Orefuwa, E.; Bino, S.; Singer, S.R.; Lutwama, J.; Dickmann, P. Earlier Outbreak Detection—A Generic Model and Novel Methodology to Guide Earlier Detection Supported by Data from Low- and Mid-Income Countries. Front. Public Health 2020; Vol.8: 452.
49. Gopinath, N. Artificial intelligence: Potential tool to subside SARS-CoV-2 pandemic. Process Biochem. 2021; Vol.110: 94–99.
50. Pandian, P.S. An Overview of Telemedicine Technologies for Healthcare Applications. Int. J. Biomed. Clin. Eng. 2016; Vol.5: 29–52
51. Deldar K, Bahaadinbeigy K, Tara SM. Teleconsultation and clinical decision making: A systematic review. Acta Inform Med. 2016; Vol.24: 286–92.