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AI-DRIVEN INNOVATIONS IN HEALTHCARE AND PHARMACEUTICAL SCIENCES

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ABSTRACT

Artificial Intelligence (AI) is changing healthcare by making data management, diagnostics, treatment personalization, patient monitoring, and operations more effective. Technologies like machine learning, deep learning, natural language processing, and predictive analytics are helping with everything from drug discovery and hospital pharmacy to automated diagnostic tools such as MRI and CT imaging. For example, AI-assisted radiology is enhancing the accuracy of MRI and CT scan interpretations, reducing diagnostic errors, and speeding up turnaround times. Predictive analytics in patient monitoring systems can foresee potential health deteriorations, allowing proactive interventions. Still, using AI in healthcare comes with challenges, such as data privacy and security, ethical and legal issues, interoperability, and the difficulties of working with both humans and AI. Many healthcare professionals and members of the public are also hesitant to accept AI because of worries about safety, reliability, and access. This study reviews how AI is used in healthcare, its benefits, and the barriers to putting it into practice. It points out the importance of working across disciplines, continuing research and development, and improving AI education for healthcare workers to get the most out of AI in healthcare. The review also gives guidance for stakeholders as they adapt to the changing role of AI in healthcare.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Natural Language Processing, Healthcare.

INTRODUCTION:

Artificial intelligence (AI) is a revolutionary innovation that is transforming several industries, including banking, education, transportation, and more. Fundamentally, artificial intelligence (AI) is the creation of computer systems that will carry out activities that normally need human intelligence, including the ability to comprehend natural language, identify patterns, make decisions, and gain knowledge from experience [(1).] The field of artificial intelligence (AI) is concerned with intelligent machine learning, namely intelligent computer programs that produce outcomes like to the human attention process [(2)]. Typically, this process entails gathering data, creating effective mechanisms for using the data, displaying clear or self-corrections, modifications, and approximations [(3)]. AI is often used to analyze machine learning and mimic human cognitive skills [(3, 4)]. AI technology is used to obtain meaningful interpretation and to conduct studies that are more accurate [(4)]. AI technology has recently emerged as a key business component with practical uses in several technological and scientific domains. When considering the previous 25 years, pharmacies have done an excellent job of meeting the rising demand for prescription drugs despite decreased reimbursements, rising operating expenses, and a scarcity of pharmacists. Drug store has done an excellent job of utilizing enabling technology automation to enhance workflow effectiveness and reduce operating expenses while fostering efficiency, accuracy, and safety in all pharmacy settings. In addition to improving patient outcomes, automated dispensing frees up pharmacists' time to interact with more patients [(5).] Computers were likely first used in pharmacies in the 1980s, and since then, they have been used for a variety of purposes, including data collecting, retail pharmacy, there is no way to predict how much the pharmacy industry will change in the future given the rise of artificial intelligence. This includes management, clinical research, drug storage, pharmacy education, clinical pharmacy, and many other areas. Numerous expert systems have been created in the medical field to help doctors diagnose patients [(6)]. Furthermore, a number of studies have demonstrated that using AI in healthcare produces better outcomes than using current technology. These studies include developing medical devices that can assist in making decisions during treatments or for diagnosis; predicting the course of a disease using various medical and health care data; encrypting medical data; and using AI technology to analyze medical images in order to distinguish between different types of images and use them for treatments [(7,8,9,10,11,12)]. Additionally, there have been several attempts to create and market medical devices that use artificial intelligence. Leading international information technology (IT) firms like Samsung, Google, Apple, Microsoft, and Amazon, as well as a number of competitive start-ups, have shown notable

research accomplishments in the application of AI in healthcare, in addition to the leading medical device manufacturers like General Electric, Siemens, and Phillips. The firms are striving to develop business successes based on these research accomplishments. Furthermore, the industry's and the medical community's efforts are helping regulatory bodies successfully approve AI-based medical devices. AI-based medical devices were first authorized for use in the United States by the Food and Drug Administration (FDA) in 2017, and in Korea, since 2018, the usage of AI-based medical devices has been authorized by Food and Drug Safety. However, because AI-based medical technology differs greatly from traditional medical technology, there are still a lot of people who are worried about it. As a result, there are still not many real clinical treatment implementations that use AI [13, 14].

ARTIFICIAL INTELLIGENCE (AI)s

Artificial intellect (AI) is the creation of computer systems that can do activities like learning, speech recognition, and problem solving that normally need human intellect.

Deep Learning (DL) Deep learning is a branch of machine learning in which large datasets are used to teach artificial neural networks—which are modelled after the human brain—to learn and make complicated choices on their own

Machine Learning (ML) Machine learning is a subfield of artificial intelligence through which computers may recognize patterns in data and perform better on tasks without the need for explicit programming **[73].**

IMPORTANCE OF AI IN HEALTHCARE

It is impossible to understate the importance of AI applications in healthcare. AI has the ability to completely change the way we manage the operational facets of healthcare delivery, diagnose illnesses, customize therapies for each patient, and track health status in real time. For example, Medical photos may be accurately analysed by AI-driven diagnostic technologies, which can frequently spot details that human eyes would miss. Patient outcomes are greatly impacted by the earlier and more precise diagnoses that result from this precision. Similar to this, AI systems may search through enormous databases for trends in treatment customisation and forecast which therapies will be most efficient for certain patient profiles, advancing the field of genuinely customized medicine.

AI applications also include patient monitoring, where wearable technology and remote monitoring platforms provide on-going patient health monitoring, facilitating prompt interventions and lowering readmission rates to hospitals. AI may improve hospital processes and appointment scheduling, among other aspects of healthcare delivery, increasing productivity and patient happiness [15]. AI is the creation of computer systems that are able to perform tasks that are frequently connected to human intelligence. ML algorithms, natural language processing, and robots are just a few of the ways artificial intelligence appears in the healthcare industry [17, 18]. Together, these technical features enable robots to analyze complex medical data, identify trends, and make defensible conclusions. AI essentially acts as a revolutionary addition to the skills of medical practitioners [18, 19, 20].

AI is an innovation in healthcare that has an impact on diagnosis, treatment planning, patient engagement, and administrative processes. The primary goals are to raise the standard of care, optimize healthcare delivery, and improve patient outcomes. AI is a versatile collection of tools rather than a panacea, offering a variety of applications that tackle different aspects of the healthcare setting [21, 22, 23].

As a result, several research are already being carried out on the application of AI-based technologies in healthcare (Table 1).

Table 1: Artificial intelligence uses of artificial intelligence in healthcare [16].

Technology	Application scheme	Application area
Machine learning	Make predictions and examine trends that affect treatment outcomes using the data. Reduce ambiguity in the medical treatment decision-making process by using self-learning.	Diagnostic medical image, Health IT
Predictive modelling	Use mathematical models to forecast treatment outcomes, such as identifying at-risk illnesses.	Medicine, Health IT
Robotics	Enhance the precision and accuracy of surgical procedures to deliver top-notch care.	Medical device, Health IT
Image processing	Process a lot of medical pictures quickly, then use the data to determine the kind of disease and whether a test is positive or negative.	Diagnostic medical image, Health IT
Digital secretary	Keep an eye on the patient's condition indicators and notify the nurse as needed to determine the best time to intervene.	Medical device, Health IT
Natural language processing	Create complex, unstructured text data, like medical records, readable and interpretable.	Medical device, Health IT
Big data analysis	Analyze vast volumes of data kept by healthcare organizations to provide patients and treatments with tailored suggestions.	Medicine, Health IT
Statistical analysis	Analyze vast volumes of patient health record data quickly to forecast the outcomes of patient treatments.	Medicine, Health IT
Voice recognition	Record the voice and language of the patient and save pertinent data in electronic health records.	Medical device, Health IT

1. Applications of AI in Healthcare

AI has completely changed how physicians' approach operating procedures, diagnosis, and therapy planning [19, 23]. Furthermore, there has been a recent surge in innovation in the healthcare industry. AI is quickly becoming a vital part of the healthcare sector because of its numerous applications, which greatly improve many aspects of the field [21,24]. The transition from personalized and diagnostic care to administrative processes, ethical concerns, patient engagement, and AI-powered remote monitoring is transforming healthcare delivery [19,21].

AI has a wide range of applications in the medical field. Future healthcare delivery will be impacted by AI, which will transform diagnoses and treatment personalization while also enhancing administrative processes and ensuring ethical considerations. As AI integration advances, ongoing collaboration between engineers, healthcare professionals, and lawmakers will be essential to maximizing its potential while upholding moral standards and patient welfare [21, 23, 25].

3.1 Applications of AI Diagnostics and Disease Identification

Healthcare has been entirely transformed by the use of AI in diagnosis and illness detection, especially in medical imaging, where AI algorithms are incredibly effective. The rapid and precise interpretation of complex images, such as those from MRIs and X-rays, is a major advantage in time-sensitive situations since it expedites the diagnostic procedure [20,24].

AI is also quite good at analysing genetic data, which provides information on a patient's susceptibility to particular illnesses and ailments. AI systems can forecast the likelihood of genetic illnesses by examining genetic markers and variants, allowing for early detection or prophylactic interventions. Therapies based on a person's genetic composition. Similar to this, wearable device data is processed by AI applications in biometric data analysis to track vital signs and identify abnormalities that can indicate health problems, enabling early diagnosis and action. The majority of medical departments that employ pictures, including pathology, dermatology, cardiology, gastrointestinal, and ophthalmology, have used machine learning algorithms for medical image analysis in addition to radiology. Specifically, machine learning algorithms diagnose or categorize the severity of the disease using computed tomography (CT), magnetic resonance imaging, ultrasound, pathology picture, fundus image, and endoscope data [27,28,29,30,31,32,33,34].

Siemens Healthcare has created AI-based AI-Rad Companion Chest CT software to aid in chest CT diagnostics in the medical field [35] and GE Healthcare is also developing medical image analysis technologies based on artificial intelligence. Additionally, Philips Healthcare is attempting to market its IntelliSite Pathology Solution in the field of digital pathology diagnostics and has created IntelliSpace Discovery, an open platform for AI development and implementation [36] .The FDA has approved Arterys' Cardio AI, Liver AI, and Lung AI software for use in the creation of the Medical Imaging Cloud AI platform.28 In addition to the aforementioned instances, a number of businesses, such Zebra Medical Vison and Aidoc, are attempting to bring AI-based medical image analysis solutions to the market. The Ministry of Food and Drug Safety in Korea has approved several firms, including Vuno, Lunit, JLK Inspection, and Deepnoid, to commercialize AI-based medical image analysis solutions [37].

3.2 Role of AI in treatment Personalization

AI plays a revolutionary role in therapy personalization, facilitating the transition to precision medicine, in which patient-specific medicines are customized based on their unique traits. AI models examine enormous datasets, such as patient data, environmental variables, and genetic information. History, to forecast the best course of action for each patient. This method eliminates side effects, increases therapeutic efficacy, and lessens the trial-and-error process that is frequently involved in selecting the best drug or therapy.

AI in drug development speeds up the process of finding and testing novel medications by forecasting the interactions between various chemical compounds and biological targets. This shortens the time and expense involved in introducing novel therapies to the market by accelerating the drug discovery process and raising the possibility of finding promising therapeutic candidates [38] .

AI's disruptive influence in healthcare is particularly evident in therapy customization, where it plays a significant role in both the treatment landscape and pharmaceutical discovery and development [21].

Drug Discovery and Development

An important development for the pharmaceutical industry is the use of AI in drug research and development. AI is becoming a crucial partner in drug research, assisting in the identification of potential treatment possibilities [39,40,41] . Because of this innovative use of AI, drug development has gone through a paradigm change, moving from a labor-intensive and time-consuming approach to one that is more efficient and data-driven [21,42,43].

Treatment planning is one of the most revolutionary uses of AI in healthcare, and customization may be carried out even further by using AI to customize therapies according to the unique characteristics of each patient [21, 23].

The main structure of this AI R&D Strategic Plan is shown graphically in Figure 1, which has been modified in the 2019 edition of the Plan. The underlying, intersecting foundations that influence the evolution of all AI systems are shown across the bottom row of boxes; these foundations are explained

in the new Strategy 8 and Strategies 3–7. Many of the study fields required to enhance AI are included in the middle row of boxes, which is the next tier up. Strategies 1-2 list these R&D domains, which include use-inspired fundamental research.

3.3 Optimizing Clinical Processes

NLP and ML algorithms are used by mobile apps to create customized maps of patients' conditions, encourage users to feel symptoms, and provide easily comprehensible health information [44]. This proactive approach enhances the overall patient experience while enabling early intervention. Another important use case is the real-time monitoring of patient vital signs, where wireless sensors that provide data continually take the role of periodic human measurements. By ensuring timely reactions to

unanticipated changes in a patient's state, this enhances healthcare results [45].

3.4 Health support and medication assistance:

AI technology has been acknowledged in recent years as being effective in providing health support services, as well as for help with medicine. Molly[46], a virtual nurse created by a start-up, is given a kind face and a charming voice. Its goal is to support patients with their chronic ailments at doctor's appointments and assist them in directing their own treatment. An program called AI Cure [47] that runs on a smartphone's camera keeps track of patients and helps them manage their diseases. Patients taking part in clinical trials and those in serious drug circumstances can both benefit from this app.

3.5 Role of AI in Drug creation:

It takes more than ten years and billions of rupees to research or create drugs. The AI "Atomise" [48] Supercomputer-based technology is helpful for determining the treatments from the molecular structure database. It launched an online search for a safe and efficient Ebola virus treatment using already available medications. Two medications that caused an Ebola infection were discovered by the technology. n contrast to months or years of laborious analysis, this analysis was finished in a single day.

Big data was created by a Boston-based biopharma business for patient management. It saves information to determine why certain individuals manage to survive illnesses. They determined the distinction between disease-friendly and healthy meteorological conditions using AI technology and biological data from patients. It aids in the development of medications, medical treatments, and applications for problem-solving.

2. AI and development of pharmaceuticals:

Leading pharmaceutical firms are working with AI suppliers and utilizing AI technology in their production procedures for R&D and medication development in general discovery. According to reports, 72% of businesses think AI will be essential to their operations in the future, and over 62% of healthcare institutions are considering investing in AI soon.

Pharma News Intelligence [49] examines existing AI use cases, the most effective applications for the technology, and the future of AI in the industry to gain a deeper understanding of machine learning and artificial intelligence. According to the McKinsey Global Institute, the pharmaceutical sector's use of AI and machine learning might provide around $100 billion a year for the US healthcare system. Researchers claim that using these technologies enhances decision-making, maximizes innovation, boosts the effectiveness of clinical trials and research, and develops useful new tools for regulators, insurers, doctors, and consumers. Leading pharmaceutical firms have previously worked with or purchased AI technology, including Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers-Squibb, and Johnson & Johnson. In 2018, Novartis and Pfizer joined forces with the Massachusetts Institute of Technology (MIT) to revolutionize the medication design process and manufacturing with its Pharmaceutical Discovery and Synthesis Machine Learning Consortium[49].AI machine software called Reverse Engineering and Forward Simulation (REFS) is used by GNS healthcare [50]. REFS establishes the causal connections between different kinds of data that are typically unexpected when evaluating data directly. Millions of data points, including clinical, genetic, laboratory, imaging, medication, consumer, geographic, pharmacy, mobile, proteomic, and so forth, may be sent via REFS, according to GNS.

In the field of drug design, Atomwise created AtomNet, the first deep learning neural network for structure-based drug design and discovery [51]. The AtomNet predicts how tiny compounds will bind to proteins by using a statistical method to gather data from thousands of protein structures and millions of experimental affinity measurements. Pharmacists can now complete key drug discovery and design tasks like hit discovery, lead optimization, and toxicity prediction with high precision and accuracy in weeks rather than years thanks to AtomNet technology, which displays 3-dimensional images of the protein and ligand pair that display channels for carbon, oxygen, nitrogen, and other atom types[51] .

Insilico Medicine [52, 53] revealed Pharm AI, a business AI project. According to Insilico Medicine, they used reinforcement learning algorithms and Generative Adversarial Networks (GAN). One kind of generative model that can both create samples and learn from training examples is the GAN.

They consist of the discriminator, the generator, and two neural networks. "Adversarial" describes the interaction between the discriminator and the generator. The discriminator identifies the sample as either genuine or fake after the generator attempts to make and learns to create new samples. genuine samples are those that are part of the data set, while "fake" samples are those produced by the generator. The generator starts producing samples through on-going training.

3. AI in pharmacy practice in hospital and community pharmacies:

Emails can be tailored using machine learning models more quickly and accurately than a human could service delivery may be made more efficient with the usage of chatbots [54]. Chatbots may simulate human interactions between clients and sales representatives. Customer complaints and inquiries can be automatically resolved by chatbots, while more complex concerns are forwarded to real employees. This idea may be used in a retail pharmacy. It is possible to program the chatbots to simulate interactions between patients and pharmacists

Medline, a telehealth company, partnered with Walgreen [55] to establish a way for people to communicate with medical experts via video chat. Additionally, AI can be helpful for managing inventories. As a retail pharmacist, picture being able to anticipate your customers' needs for the near future, stock them, and send them emails reminding them of their medication requirements utilizing customized software.

It is possible to forecast a patient's future medicine purchases using AI-powered data analytics. AI-powered medicine purchase prediction will assist the pharmacist in making informed stock procurement choices.

However, there are now applications and inventory management software used for stock management in retail pharmacies, such as Mckessons, Liberty, Winpharm, PrimeRx, and not all of them make use of AI or machine learning, WinRx. For instance, Blue Yonder, an AI business, created software for the German online and catalog retailer Otto Group [56]. With 90% accuracy, this program can forecast what Otto will sell in the next 30 days. Because the product could now be sent straight from the supplier to the customer without going via the warehouse, the delivery timetable for bought goods was shortened from a week or longer to two days.

The University of California San Francisco (UCSF) Medical Center employs robotic technology to prepare and track pharmaceuticals with the goal of improving patient safety. They claim that the system has accurately prepared 3,50,000 doses of medicine. The robot has shown itself to be far superior than humans in terms of size and medicine delivery accuracy. The production of injectable and oral medications, including hazardous chemotherapy agents, is one of the capabilities of robotic technology. The UCSF nurses and pharmacists now have more latitude to use their knowledge by concentrating on providing direct patient care and collaborating with the doctors. The computers of the pharmacy's automated system initially receive [57].

DISCUSSION:

Analyzing the connections between patient outcomes and preventative or treatment strategies is the main goal of AI applications in the health sector. AI applications have been created and utilized in a variety of procedures, including patient monitoring and care [58], medication development [62], customized medicine [59], diagnosis procedures, and treatment protocol creation [60]. Here are some ways pharmacists may use the ongoing technological expansion to influence value-based outcomes as the standard of patient care continues to rise. Pharmacies may develop into health management centers rather than just places to buy prescriptions since they are the most accessible and reasonably priced healthcare stakeholders. Technology can support the provision of more individualized healthcare services, such as counselling, advising, and a wider range of treatments (such as screenings, MTM, disease condition management, and vaccinations). Wearable technology and health trackers will be able to collect data in real time, allowing pharmacies to evaluate the quality of improvement and follow up with at-risk patients on their diseases [62].

AI has the potential to save human effort, time, and money by evaluating data and delivering findings that improve decision-making, ultimately saving lives. Medical as well as the general progress of computers, which has led to quicker data collecting and more potent data processing, is one technical improvement that has aided in the development of AI in healthcare. As pharmacogenomics and gene databases are developed, and health-related data from personal and healthcare-related devices and records becomes more widely available, Growth and industry acceptance of natural language processing, electronic health records, and other computer innovations that allow machines to mimic human functions [63]. AI from tech firms like Microsoft is entering the physician field by helping medical professionals choose the best course of action from the wide range of available possibilities. for cancer. AI is assisting doctors in identifying and selecting the appropriate medications for the correct individuals by gathering information from several databases on the ailment [64, 65]. In the pharmaceutical industry, artificial intelligence is collaborating with researchers to assist in the decision-making processes for both new and existing medications, diseases, as well as identifying the appropriate individuals from multiple databases to speed up the clinical trials procedure [2, 66, 67]. Pharmacy is even attempting to use AI learning based on a history of prior outbreaks and other media to forecast with some degree of accuracy when and where pandemic outbreaks could occur sources. AI is being utilized in hospitals to lower readmission rates and avoid medical mistakes. By examining patient data from pharmaceutical and medical mistakes, the underlying causes of readmissions, with other internal and external databases, artificial intelligence (AI) will eventually detect and stop problems in high-risk patients, as well as offer diagnostic support, direction for future treatment, and many other therapeutic uses. AI can help with process efficiency and optimization, reducing cost duplication from pointless or duplicate procedures [68,69].

We are currently using an early version of AI in use in pharmacies today. It's known as the pharmacy management system, and it includes information on medication and patient usage in along with perhaps identifying issues relating to drugs using clinical decision support screening. A technology-based information expert system which employs patient data gathered from the pharmacy system and other external data systems to promptly identify drug-related issues is the next generation of pharmacy technology. This would relieve the pharmacist of some of the workload associated with recognizing significant drug-related issues, in line with workflow robots [70, 71].

Data Extraction and Synthesis

The type of AI utilized, the healthcare domain targeted, the outcomes measured, and the major findings were among the data that was gathered from the chosen research. To arrange and condense the data into major topics, including AI applications in diagnosis, treatment, and operational efficiency, as well as obstacles to AI adoption, a thematic synthesis technique was utilized. Ultimately, the information was arranged according to major themes or goals and presented as narrative or thematic summaries; Figure 02 shows the outcomes.

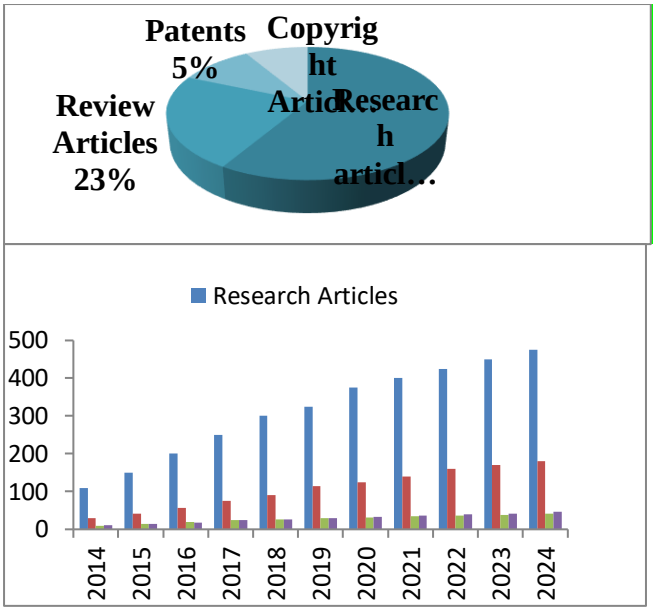

Fig. 3. Thematic summary and statistical overview of AI's Impact on healthcare [73].

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