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Pharmacy Innovation: A Comprehensive Overview of AI Integration

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Abstract: *An answer to issues with numbers and data is artificial intelligence (AI). Numerous technological developments in almost every industry, including engineering, architecture, education, accounting, business, health, and more, have resulted from this discovery. AI has advanced significantly in the healthcare industry, having played important roles in the management and storage of data and information, including patient medical histories, medication inventories, sale records, and so forth; automated equipment and software and computer applications, including diagnostic tools like CT and MRI radiation technology and many more, have all been developed to support and streamline healthcare procedures. AI has unquestionably transformed healthcare, making it more effective and efficient, and the pharmaceutical industry is not an exception.In recent years, there has been a noticeable surge in interest in the application of AI technology for the analysis and interpretation of several significant pharmacy domains, such as drug development, dosage form design, polypharmacology, and hospital pharmacy. Given the increasing significance of AI, we sought to produce a thorough report that would aid all practicing pharmacists in understanding the most significant advancements made possible by the use of this subject.*

Keywords: Pharmacy, pharmacist, artificial intelligence

I. INTRODUCTION

The field of artificial intelligence (AI) is concerned with intelligent machine learning, namely intelligent computer programs that produce outcomes that are comparable to the human attention process [1]. In general, this process entails gathering data, creating effective methods for using the data, displaying precise or approximative results, self-corrections, and changes [2]. AI is typically used to analyse machine learning in order to mimic human cognitive functions [2][3]. AI technology is used to obtain meaningful interpretation and to conduct more accurate analyses [3]. According to this viewpoint, artificial intelligence (AI) technology combines a variety of practical statistical models with computational intelligence.

AI technology has become a highly important aspect of the industry in recent years, with numerous valuable applications in research and technological domains. Over the past 25 years, pharmacy has done a wonderful job of meeting the expanding need for prescriptions, even when there weren't enough pharmacists, expenses were rising, and reimbursements were falling. Pharmacy has also done a remarkable job of using enabling technology automation to make workflows more efficient and cut costs while also encouraging safety, accuracy, and efficiency in every pharmacy setting. Automated dispensing allows pharmacists more time to work with more patients and improve their health outcomes at the same time [4].

Since the 1980s, computers have likely been used for a variety of purposes, including data collection, retail pharmacy management, clinical research, drug storage, pharmacy education, clinical pharmacy, and much more. With the rise of artificial intelligence, it is impossible to predict how much the pharmacy industry will change in the future. Numerous expert systems have been created in the medical field to help doctors diagnose patients [5]. A number of drug therapy-focused programs have recently been reported [4]. They direct the selection of drug formularies, drug interactions, and drug therapy monitoring. AI has the potential to affect many facets of pharmacy, and pharmacists should think about these opportunities as they could eventually become

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This article's goal was to review AI-related subjects. These topics include the general overview and classification of artificial intelligence (AI), its applications in hospitals, the pharmaceutical industry, and retail pharmacies, as well as raising awareness of AI as a future component of pharmacy practice and encouraging pharmacists to embrace this advancement and make every effort to acquire the necessary skills so they can contribute to the much-anticipated development.

A General Overview of AI

"Robotics" and "automation" are frequently used interchangeably with "artificial intelligence" (AI), usually referred to as "machine intelligence." AI is the display of human-like behaviours or intelligence by any computer or machine, whereas robotics is just the construction of machines capable of performing challenging repetitive tasks[6]. Although they may be able to move or transport objects on their own with the use of a specially created program and surface sensors—a process known as automation—robots were not traditionally constructed to have these "intelligent capabilities." In essence, artificial intelligence (AI) is the branch of computer science that focuses on building intelligent machines that can carry out jobs that are typically performed by humans [7].

AI is widely used in the creation of digital computers or computer-controlled robots that can do cognitive and intellectual tasks that are similar to those of humans on their own. Learning, thinking, problem-solving, perception, and language are examples of these cognitive and intellectual processes. Because it is solely intended to carry out specific activities, such as internet search, voice and facial recognition, car control and driving, and so forth, the type of AI that is now in use is known as narrow AI or weak AI. The AI community's long-term objective is to create machines that can do better than humans on all cognitive activities on their own. General AI, often known as strong AI (ADI), is the type of AI that entails building machines that are capable of carrying out any cognitive function that humans do [8].

Simply expressed, artificial intelligence (AI) is the capacity of computers and machines to think, act, behave, and perform tasks similar to those of humans. Apple's Siri (in the iPhone) [9], Amazon's Alexa [10], and the self-driving cars made by Google, Mercedes, BMW, and Tesla, to mention a few [11], are well-known instances of AI-controlled systems. Knowledge engineering, the foundation of artificial intelligence, involves building robots with access to a wealth of facts and information about the human environment so they may imitate human behaviour. Another kind of artificial intelligence is machine learning, which uses statistical models and algorithms to increase the precision of software programs' outcome predictions without the need for explicit programming. It was founded on the notion that data can teach machines.It was founded on the notion that machines are capable of learning from data, recognizing issues, and coming to choices with little assistance or involvement from humans. Self-driving Google cars, fraud detection, and online recommendation systems like those on Netflix and Amazon are examples of machine learning applications [12]. Another facet of AI is machine perception, which entails creating and constructing devices that can infer information about the various facets of the world from sensory inputs. The ability of machines to comprehend visual inputs, including gestures, objects, and facial information, is known as computer vision [13].

There have been many myths, criticisms, and scepticisms about AI, most of them have to do with safety and the potential risks that could be exacerbated by the development of robots that are as intelligent as humans. It might become a national political issue, according to Forbes' five forecasts for AI in 2019[14]. In addition to worries that AIs could be used as weapons of mass destruction and conflict, some people have voiced worries that the development of AI systems that are more intelligent than humans—through general AI—could be much more deadly and spell the end of humanity.They contend that humans may eventually come to be dominated by these extremely intelligent robots and that we may not be able to predict the behaviour of AI systems that are smarter than we are. If the "goals" of these computers can be manipulated to match our own, scientists think that the majority of the safety concerns regarding future super-intelligent AI systems may be addressed [14].

AI Classification:

AI can be classified into two different groups [15][16].

a) according to Caliber

b) according to the presence

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Classification of AI:

Based on the Caliber:

- Weak intelligence
- Artificial narrow intelligence
- Artificial general intelligence
- Artificial super intelligence

Based on presence:

- Type 1 reactive machine
- Type 2 limited memory system
- Type 3 is based on the theory of mind
- Type 4 self-awareness

Artificial intelligence systems are classified based on their Caliber as follows:

Artificial narrow intelligence (ANI) or weak intelligence: This system is made and trained to do specific tasks, like traffic signals, chess play, driving, and facial recognition. For instance, social media tagging and Apple's Siri virtual personal assistant.

Strong AI, often known as artificial general intelligence (AGI): Another name for it is human-level AI. It can make human intelligence simpler. As a result, it can solve problems when presented with new tasks. AGI is capable of everything that humans can do.

In every discipline from science to the arts, artificial super intelligence (ASI): refers to brainpower that is more active than intelligent humans in areas like painting, mathematics, and space. It varies from a computer that is only marginally more intelligent than a human to one that is trillions of times more intelligent.

AI scientist Arend Hintze [17] categorized AI technology into two categories: those that are currently in use and those that are not:

Artificial intelligence systems are classified based on their presence as follows:

Type 1: Reactive machines are the name given to this kind of AI system. For instance, Garry Kasparov, the chess champion, was impacted by the IBM chess software Deep Blue in the 1990s. It lacks the memory to draw on prior experiences, yet it is able to recognize checkers on the chessboard and make predictions. It was created with certain uses in mind and is useless in other contexts. AlphaGo from Google is another example.

Type 2: Limited memory systems are the name given to this kind of AI system. For current and upcoming issues, this system can draw on prior experiences. This approach alone is used to construct part of the decision-making processes in autonomous cars. The recorded observations are utilized to record the actions happening in the future, such as changing the lanes by car. The observations are not permanently stored in the memory.

Type 3: The term "theory of mind" refers to this kind of AI system. It implies that every individual has thoughts, goals, and wants that influence their choices. This AI doesn't exist.

Type 4: These are referred to as self-aware. The AI systems are sentient and have a feeling of self. If the machine is self-aware, it recognizes the situation and applies the concepts found in other people's minds. This AI doesn't exist.

AI and pharmaceutical development:[18][19][20][21][22][23][24]

Leading pharmaceutical firms are working with AI suppliers and utilizing AI technology in their production procedures for R&D and general drug 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 [25] explores existing AI use cases, the greatest applications for the technology, and the future of AI and machine learning to gain a better understanding of the industry's AI prospects. According to the McKinsey Global Institute, the pharmaceutical industry's use of AI and machine learning might produce up to $100 billion a year for the

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US healthcare system. According to researchers, the use of these technologies improves decision-making, optimizes innovation, improves the efficiency of research/clinical trials, and creates beneficial new tools for physicians, consumers, insurers, and regulators. Top pharmaceutical companies, including Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers Squibb, and Johnson & Johnson, have already collaborated with or acquired AI technologies. In 2018, the Massachusetts Institute of Technology (MIT) partnered with Novartis and Pfizer to transform the process of drug design and manufacturing with its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium[25].

Every day, research is done to discover novel active ingredients for diseases and ailments that are currently incurable, improve the safety profile of medications that are already on the market, fight drug resistance, and reduce therapeutic failure. As a result, the quantity and diversity of biomedical data sets used in medication design and discovery are growing. The development of AI in the pharmaceutical sector was aided by this and numerous other factors. Some businesses now provide software that is highly relevant to data processing, drug creation, and treatment outcome prediction.

AI machine software called Reverse Engineering and Forward Simulation (REFS) is used by GNS healthcare [26]. The cause-and-effect correlations between different forms of data that are typically unknown through direct data review are determined using REFS. Millions of data points, including clinical, genetic, laboratory, imaging, medication, consumer, geographic, pharmacy, mobile, proteomic, and more, can be transferred 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 [27]. AtomNet predicts how tiny molecules will attach to proteins by using a statistical method to extract information from thousands of protein structures and millions of experimental affinity measurements.Pharmaceutical chemists 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 show channels for carbon, oxygen, nitrogen, and other atom types.

Insilico Medicine [28][29] revealed Pharm AI, a business AI project. According to Insilico Medicine, they used reinforcement learning algorithms and Generative Adversarial Networks (GAN). The GAN is a form of generative model that can produce samples and also learn from training examples. They consist of the discriminator, the generator, and two neural networks. "Adversarial" describes the connection between the discriminator and the generator. After learning how to create new samples, the generator delivers them to the discriminator, which determines whether they are real or fake. Real samples are those that are part of the data set, whereas "fake" samples are those that the generator creates.As the discriminator improves at the identification process, the generator starts to produce samples that resemble the genuine ones through ongoing training. According to Insilico Medicine, Pharm AI may create novel molecular structures and identify the biological cause of an illness by using GAN and reinforcement learning.

AI in pharmacy practice at community and hospital pharmacies:

Emails can be tailored using machine learning models faster and more accurately than a human could. Service delivery can be made more efficient with the usage of chatbots [30]. Chatbots can simulate conversations between customers and customer service representatives. Customer complaints and inquiries can be automatically resolved by chatbots, while more complex concerns are forwarded to real employees. This idea can 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[31] to establish a way for people to communicate with medical professionals via video chat. Inventory management is another area where AI might be helpful. Imagine, as a retail pharmacist, being able to anticipate your customers' needs for the near future, stock them, and use customized software to send them emails reminding them of their medication requirements. It is possible to forecast a patient's future medication purchases using AI-powered data analytics. AI-powered drug purchase prediction will assist the pharmacist in making informed stock procurement choices.

While several inventory management applications and software, such as McKesson's, Liberty, Winpharm, PrimeRx, and WinRx, are currently in use for retail pharmacy stock management, not all of them make use of artificial

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intelligence or machine learning. For instance, the German online and catalog retailer Otto Group [32] used software created by Blue Yonder, an AI startup. With 90% accuracy, this software 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 purchased goods was shortened from a week or longer to two days.

The University of California San Francisco (UCSF) Medical Centre uses robotic technology to prepare and track pharmaceuticals with the goal of improving patient safety. They claim that the system has successfully prepared 3,50,000 doses of medication. The robot has demonstrated superiority over humans in terms of size and precise medication delivery. One of the robotic technology's capabilities is the ability to prepare injectable and oral medications, including deadly chemotherapy agents. The UCSF nurses and pharmacists now have more latitude to apply their skills by concentrating on providing direct patient care and collaborating with the doctors.Medication orders are first electronically received by the computers in the pharmacy's automated system from UCSF's doctors and pharmacists. The robotics then selects, packages, and dispenses specific amounts of tablets. The doses are then assembled by machines into a plastic ring with a barcode. All of the prescription drugs that a patient must take within 12 hours are contained in the thin plastic ring. The automated system's capacity to fill intravascular syringes with the appropriate drugs and make sterile preparations intended for chemotherapy is an addition to its capabilities [33].

Applications of AI:

AI in targeted genomic therapies and diagnosis

AI is used in hospital-based health care systems in a number of ways, including choosing appropriate or accessible administration routes or treatment strategies, as well as structuring dosage forms for specific patients [34][35].

Medical record maintenance: Keeping track of patients' medical information is a challenging undertaking. The AI system's implementation facilitates data gathering, storage, normalization, and tracing. The Google Deep Mind health project[36], which was created by Google, helps to quickly uncover medical records. Therefore, this project is beneficial for providing faster and better healthcare. In order to improve eye care, our effort helps the Moorfields Eye Hospital NHS.

Designing treatment plans: AI technology makes it feasible to create efficient treatment programs. An AI system is required to manage the scenario when a patient develops a severe condition and choosing an appropriate treatment strategy becomes challenging. The treatment plan that this technology suggests is designed taking into account all of the prior data and reports, clinical competence, etc. The software as a service, IBM Watson for Oncology [37], is a cognitive computing decision support system that compares patient data to thousands of past cases and insights gained from working with physicians at Memorial Sloan Kettering Cancer Centre for thousands of hours. It then presents treatment options to assist oncology clinicians in making well-informed decisions.Memorial Sloan Kettering's collection of literature, which includes more than 300 medical periodicals and 200 textbooks totalling about 15 million pages of text, supports these therapeutic options [37].

Assisting with repetitive work: AI technology also helps with some repetitive tasks, such as analysing radiography, X-ray imaging, ECHO, ECG, and other data to identify and detect illnesses or abnormalities. An IBM algorithm called Medical Sieve [38]is a "cognitive assistant" with strong analytical and reasoning skills. By merging deep learning with medical data, a medical start-up is required to enhance the patient's condition. For every bodily part, there is a specific computer software that is used in a particular ailment. Nearly all imaging analyses, including X-ray, CT, ECHO, ECG, and others, may be performed using deep learning.

Health support and medication assistance: AI technology has been acknowledged as effective in recent years for both health support services and pharmaceutical assistance. Molly [39], a virtual nurse created by a start-up, is given a friendly face and a charming voice. Its goal is to support patients with their chronic ailments during doctor's appointments and assist people in directing their own treatment. A smartphone webcam app called Ai Cure [40] keeps track of patients and helps them manage their diseases. Patients who take part in clinical trials and those with serious drug issues can both benefit from this app.

Medical accuracy: AI has a positive effect on genetic development and genomics. An AI system called Deep Genomics [41] can be used to find mutations and connections to diseases by looking for patterns in genomic data and medical

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records. This technique tells physicians what happens inside a cell when genetic variation changes the DNA. Craig Venter, the creator of the human genome project, has developed an algorithm that uses a patient's DNA to provide information about their physical attributes [42]. In its early stages, "Human Longevity" AI technology can pinpoint the precise location of vascular disorders and cancer.

Drug development: It takes over ten years and billions of rupees to develop or create medications. An AI tool called "Atomwise" [43] that makes use of supercomputers is helpful in determining the treatments from the molecular structure database. It launched an online search for a safe and efficient Ebola virus treatment using currently available medications. Two medications that caused Ebola infections were detected by the technology. In contrast to months or years of laborious analysis, this analysis was finished in a single day.A Boston-based biopharma company created big data for patient management. It stores information to determine why certain patients manage to survive illnesses. They distinguished between healthy and disease-friendly meteorological conditions using biological data from patients and artificial intelligence technology. It aids in the development of medications, medical treatments, and applications for problem-solving.

AI benefits people in the healthcare system: in 2016, one of the top 10 potential technologies was the "open AI ecosystem" [44]. Data from social awareness algorithms can be gathered and compared for usefulness. A great deal of data is kept in the healthcare system, including treatment records and patient medical histories from infancy to that age. Ecosystems can analyse this vast amount of data and provide recommendations regarding the patient's behaviours and way of life.

Analysis of the healthcare system: Data retrieval is made simple in the healthcare system if all of the data is computerized. 97% of bills in the Netherlands are kept in digital format [45], and they include hospital names, doctor names, and treatment information. As a result, these are easily retrievable. A local business called Zorgprisma Publiek uses IBM Watson cloud technology to analyse the bills. If something goes wrong, it identifies it right away and acts appropriately. As a result, it enhances and prevents hospitalization for patients.

Discussion:

Analysing the connections between patient outcomes and prevention or treatment methods is the main goal of AI applications in the health sector. AI systems have been created and used in a variety of fields, including drug development [1], personalized medicine [46], diagnosis procedures, treatment protocol development [47], patient monitoring and care [48], and more. Here are some ways pharmacies can use the ongoing technological expansion to influence value-based outcomes as the importance of patient care continues to rise.

Pharmacies can transform from being only places to fill prescriptions into health management centres since they are the most accessible and reasonably priced healthcare stakeholders. Advice, direction, and a wider range of services (such as vaccinations, screenings, MTM, and disease state management) can all be provided more individually with the aid of technology. 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 [49].

AI has the potential to save human effort, time, and money by evaluating data and delivering findings that improve decision-making, ultimately saving lives. The general evolution of computers, which led to faster data collection and more powerful data processing; the expansion of the availability of health-related data from personal and healthcare-related devices and records; and the creation of pharmacogenomics and gene databases are examples of medical and technological advancements that have aided the development of AI in the healthcare industry. growth and industry adoption of natural language processing, electronic health records, and other computer innovations that have made it possible for machines to mimic human functions [50].

AI from tech firms like Microsoft is making inroads into the healthcare sector by helping physicians choose the best cancer treatment amid the plethora of available options. AI is assisting doctors in identifying and selecting the appropriate medications for the correct patients by gathering information from multiple databases about the ailment [51][52]. By identifying the appropriate patients from several data sources, AI is assisting researchers in the pharmaceutical industry in making decisions about new therapies for various ailments and existing medications. It is also speeding up the clinical trial process [1][53][54]. Pharma is even attempting to use AI learning based on a history

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of prior outbreaks and other media sources to forecast with some degree of accuracy when and where epidemic outbreaks might occur.

AI is being utilized in hospitals to lower readmission rates and prevent medical errors. In addition to many other clinical applications, AI will eventually identify and prevent complications for high-risk patients by analysing patient data from medical and medication errors, readmission root causes, and other internal and external databases. It will also provide diagnostic support and guidance for future care. AI will also be helpful in workflow efficiency and optimization, assisting in the removal of redundant or needless processes that result in cost redundancy [55][56].

We already have an early version of AI in use in pharmacies today. It's known as our pharmacy management system, and it contains information about drug usage, patient utilization, and the possibility of drug-related issues being detected through clinical decision support screening. A technology-based information expert system is being introduced as the next generation of pharmacy technology. It uses patient data collected from the pharmacy system and other external data systems to identify drug-related issues in real time. This would relieve the pharmacist of some of the burden of finding major drug-related issues, which is consistent with workflow robots [57][58].

Implications for the profession of pharmacy:

AI has the power to significantly impact pharmacists and cause them to refocus their attention from distributing prescription drugs to offering a wider range of patient care services. AI can be used by the pharmacist to help patients stay healthier and get the most out of their medications. Most significantly, AI gives pharmacies the chance to work together more while treating the same patient across numerous organizations. AI may be a helpful tool for patients in addition to the potentially better healthcare services provided by their professionals. It can maximize the value of wearable data, provide advice on everyday lifestyle, integrate diet and exercise, support treatment compliance and adherence, and advise patients on how and where to get the most cost-effective healthcare and how to communicate with healthcare professionals.

II. CONCLUSION

Combining artificial intelligence with human resources and knowledge is known as artificial intelligence (AI). Even those who view AI as an enemy may come to view it as a necessary evil as research into the technology advances and more intriguing uses are developed. Consequently, it is highly advised that pharmacists obtain the necessary hard skills to support AI augmentation. All areas of pharmacy practice require exposure to and education regarding AI. During their PharmD studies, pharmacy students should be exposed to the foundations of AI and data science through a health informatics program.

Additionally, pharmacists must be permitted to learn about AI through continuous education. Pharmacists who want a more practical approach to AI development, governance, and application should have access to data science courses or pharmacy residencies that concentrate on AI themes. The pharmacy education system needs to stay flexible as new technologies develop quickly in order to guarantee that our profession is prepared to manage these changes in patient care.

List of abbreviations:

MRI Magnetic resonance imaging
CT Computerized tomography
ECHO Echocardiogram
ECGElectrocardiogram
DNA Deoxyribonucleic acid
NHS National health services
GSK GlaxoSmithKline
GNS Gene network sciences
MTM Medication therapy management

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