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ROLE AND IMPACT OF ARTIFICIAL INTELLIGENCE IN DRUG MANAGEMENT AND PATIENT CARE: REVOLUTIONIZING PHARMACY PRACTICE

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ABSTRACT

AI technology is transforming pharmacy practice through improved efficiency, accuracy, and patient care. Tele pharmacy, drug discovery, personalized medicine, and medicine management, AR implementations of AI, will all ease and improve the way pharmacies and healthcare delivery fields work. Robotics and AI tools, which automate systems, predict predictive analytics, and support RPA, can aid in optimizing workflow, cost reduction, and clinical decision-making. In this spirit, quick and informed decision-making can be enhanced through the application of certain ML, DL, and NLP algorithms towards drug discovery, application withinpharmacovigilance, or prescription-creating care plans. Processes that AI undertakes to automatically perform will help to sexualize certain medication errors, optimize stock inventory management, and generally better manage the processes within the drug supply chain with resultant timely availability of medicines going to patients. AI can also be to use to provide AI-enabled virtual assistants and chatbots services to exhaust the counselling for patients and medication adherence. The pharmacist will now be relieved in terms of the administrative responsibilities through AI so that greater caregivers of patient care will be prescribed for. There might be challenges related to the shortage of under-staff, costs, and ethical issues, but AI will become a part of pharmacy practice in an efficient and data-driven manner.

I Introduction

Pharmacies might become health management hubs instead of just places to fill prescriptions if they are outfitted appropriately [1]. Data digitization in the pharmaceutical industry has increased exponentially in recent years [2]. To effectively handle complicated clinical concerns, intelligence retrieval solutions are progressively the processes of data collecting, analysis, and usage [3]. With automation playing a crucial role, artificial intelligence (AI) offers a more effective way to handle enormous volumes of data [4]. With its ability to save time and money and streamline a variety of pharmaceutical tasks [5]. this technology has advanced quickly in pharmacy practice over the years [6]. According to the McKinsey Global Institute [7]. the pharmaceutical industry's use of AI tools might contribute more than $100 billion to the US healthcare system each year. Artificial Intelligence (AI) tools [8]. are expected to alter several pharmacy practice areas, including patient care, prescription management, safety, and the drug supply chain.[9]

Data digitalization in the pharmaceutical industry has increased significantly in recent years. However [10], because AI can handle enormous amounts of data more automatically, the challenge of obtaining, analysing, and using such knowledge to address complex healthcare issues drives its adoption [11]. AI has the power to revolutionize a few pharmacy practice areas.involving patient care, prescription management, drug safety monitoring, and drug discovery in less time and with less effort [12]. Additionally, AI can significantly influence pharmacists' work and encourage them to focus more on patients rather than just writing prescriptions [13]. It can also help them make sure that patients get the most out of their drugs and stay healthy [14].

Over the last two decades, artificial intelligence has emerged as an indispensable component of multiple industries, making feasible applications in many areas of technological and research interest [15]. The pharmacy sector successfully fulfilled increased prescriptions over the past 25 years [16], even with challenges of a lack of pharmacists, increased operational expenses [17], and reduced reimbursement. Also, the pharmacy industry has been able to reduce costs and increase efficiency in the workflow via automation and modern technologies, while at the same time ensuring efficacy, safety, and accuracy in each pharmacy setting [18]. Automated dispensing systems enhance patient outcomes by enabling pharmacists to spend more time engaging with more patients [19].

Since the 1980s, computers have been utilized for various purposes, including data collection [20], retail pharmacy management, clinical research, drug storage, pharmacy education, clinical pharmacy, and more [21]. With the advent of artificial intelligence, predicting the future changes in the pharmacy industry has become challenging [22]. Numerous expert systems have been developed in the medical field to assist doctors in diagnosing patients [23]. Recently, several drugged-therapy-focused programs have been

introduced, guiding the selection of drug formularies, managing drug interactions, and monitoring drug therapy [24]. AI holds the potential to impact many aspects of pharmacy, and pharmacists should consider these opportunities, as they may eventually become integral to pharmacy practice [25].

Artificial intelligence and robotics are revolutionizing medicine and healthcare. by giving them in-depth and distinct patient data [26]. AI assists medical professionals in making better decisions [27]. This results in improved patient outcomes and more effective treatments. AI and robotics mechanize routine procedures [28], enhancing patient care and decreasing healthcare delivery costs. AI and supercomputing are assisting in accelerating drug design and discovery [29]. This might result in the creation of new and better treatments. Pharmacy robotic process automation (RPA) is another space where these technologies are creating a huge impact [30]. RPA software resolves tedious, repetitive, time-consuming, and highly structured tasks like data entry and back-office tasks [31].

II Basics of AI in Pharmacy

Definition and Types of AI

The simulation of human intelligence in computers that are designed to understand, learn, and make decisions is known as artificial intelligence (AI). AI makes it possible for computers and systems to carry out operations like reasoning, problem-solving, vision, language comprehension, and decision-making that normally call for human intelligence [32].

Classification of artificial intelligence

AI can be categorized using two different approaches (Table 1). [33]

A) Depended on caliber

b)Depended on the existence

Table 1: Classification of artificial intelligence

Classification	Types of AI
Depended on Caliber	Weak Artificial Intelligence
	Narrow Artificial Intelligence (ANI)
	Common Artificial Intelligence (AGI)
	Artificial Super Intelligence (ASI)
Depended on the existence	Type 1: Reactive Machines
	Type 2: Limited Memory System
	Type 3: Theory of Mind AI
	Type 4: Self-Aware AI

Depended on their caliber, AI system is classified as follow

Weak intelligence or Artificial narrow intelligence (ANI): Driving, face recognition, chess, and traffic signalling are some of the few tasks for which this system is constructed and trained. Some examples include Apple SIRI virtual personal assistance and social media tagging. [34]

Artificial General Intelligence (AGI) or Strong AI: It can also be called Human-Level AI. It has the ability to make human intelligence easier. For that reason, it can figure out problems in case of being faced with novel tasks. Everything humans can accomplish; AGI is able to do [35].

Artificial Super Intelligence (ASI): In all fields, from science to the arts, brainpower is more active than smart humans in fields such as drawing, mathematics, and space. It can vary from a computer that is just slightly smarter than a human to one that is trillions of times smarter [36].

an AI scientist classified the AI technology based on its presence and not yet present. They are as follows:

Type 1: A "reactive machine" is a type of artificial intelligence system according to that phrase. As a case in point, consider the Deep Blue, the IBM chess software that beat Garry Kasparov in the 1990s. It can recognize chess pieces and is able to predict moves but it lacks the recollection of previous games' moves. It was created for a very specific functionality and is therefore of no use in other contexts. One more example is Google's AlphaGo [37].

Type 2: This AI system with limited memory has been referred to as such in our study. To face the current and emerging challenges, this machine learning system may access the database of past experiences. The method of designing some of the decision-making processes in autonomous cars is through this approach alone. The future actions, such as driving by the car, are being described with the help of such observations that were already recorded. The observations are not permanent these are only the stored [38].

Type 3: These AI systems are referred to as "theory of mind" systems. This indicates that everyone has thoughts, intentions, and desires that influence their choices. AIs like this don't exist [39].

Type 4: We call these phenomena self-awareness. The AI programs possess consciousness and an identity. If a machine is self-aware, it acknowledges the scenario and borrows concepts from human beings' minds. This AI doesn't exist [40].

III Key AI Technologies in Pharmacy

1. An artificial intelligence subdiscipline named machine learning (ML) enables computers to learn from data and improve their accuracy over time without explicit programming. It is extremely helpful in pharmacy because it employs statistical techniques to identify trends in large datasets [41].

Applications in Pharmacy:

- **Drug Discovery & Development:** ML helps predict drug interactions, optimize chemical compounds, and speed up clinical trials [42].
- **Personalized Medicine:** ML analyses patient data to suggest tailored treatment plans based on genetics, lifestyle, and disease history [43].
- **Pharmacovigilance:** ML detects adverse drug reactions (ADRs) by analysing patient records, reports, and online reviews [44].
- **Supply Chain Management:**Supply Chain Management: Predictive analytics minimizes medication shortages and maximizes inventory levels [45].

2. Deep Learning (DL)

Artificial neural networks are used in Deep Learning (DL), a sophisticated type of machine learning. to process complex and large datasets. It mimics the human brain's ability to recognize patterns, making it particularly effective in image and speech recognition tasks [46].

Applications in Pharmacy:

- **Medical Imaging Analysis:** DL is used for identifying diseases in X-rays, MRIs, and CT scans, assisting in early diagnosis [47].
- **Drug Discovery & Molecular Modelling:** DL predicts drug-protein interactions, accelerating the identification of new drug candidates [48].
- **Automated Diagnosis:** AI-powered deep learning models assist in diagnosing conditions based on patient symptoms and clinical data [49].

3. Natural Language Processing (NLP)

NLP, short for natural language processingOne of the subfields of artificial intelligence, natural language processing (NLP), enables computers to understand, read, and generate human language. NLP plays a vital role in the pharmacy sector for extracting meaningful information from unstructured data sources.[50].

Applications in Pharmacy:

- **Electronic Health Records (EHR) Analysis:**Large amounts of patient records are processed by NLP to identify illness trends and enhance decision-making. [51].
- **Chatbots & Virtual Assistants:** AI-powered assistants provide drug information, dosage recommendations, and patient counselling [52].
- **Literature Review & Drug Information Extraction:** NLP scans scientific papers, clinical trial reports, and regulatory documents to extract key insights for research and development [53].
- **Voice Recognition for Prescriptions:** NLP converts spoken prescriptions into digital records, reducing human errors and improving efficiency [54].

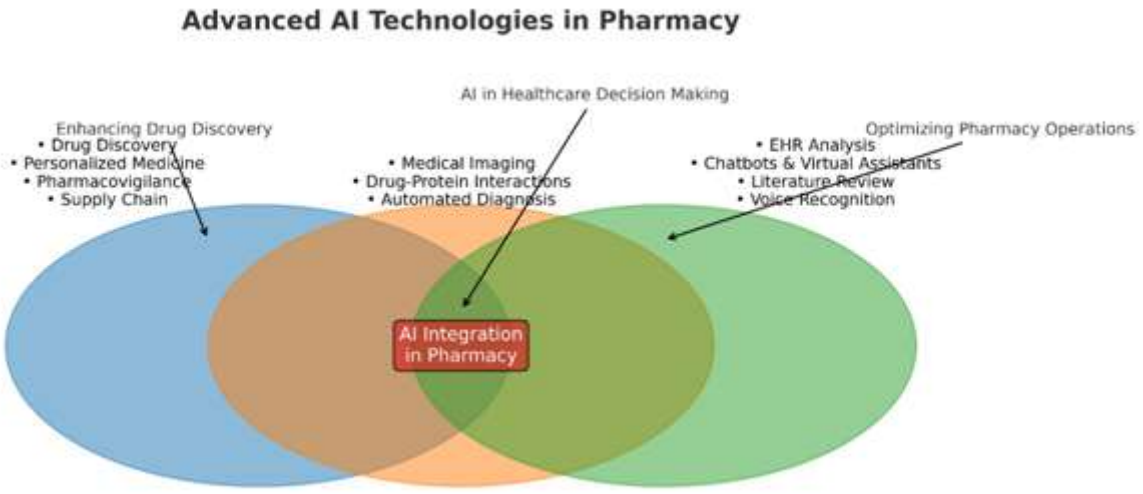

Figure 1 Advanced AI Technologies in Pharmacy

The Venn diagram (Figure 1) shows how Natural Language Processing (NLP), Deep Learning (DL), and Machine Learning (ML) are integrated in the pharmacy industry. A significant AI technology is represented by each circle, with overlapping regions indicating common uses like pharmacy automation, customized medicine, and drug discovery. The intersection in the middle shows how these technologies work together to improve patient care and pharmaceutical effectiveness. An organized viewpoint on AI-driven developments in the pharmaceutical industry is offered by this visual framework

IV AI Tools and Technologies Used in Pharmacy

The pharmaceutical business has developed several artificial intelligence solutions to meet its current needs. These tools have yielded positive outcomes. Here are a few AI solutions that have gained a lot of traction in the pharmaceutical sector. [55].

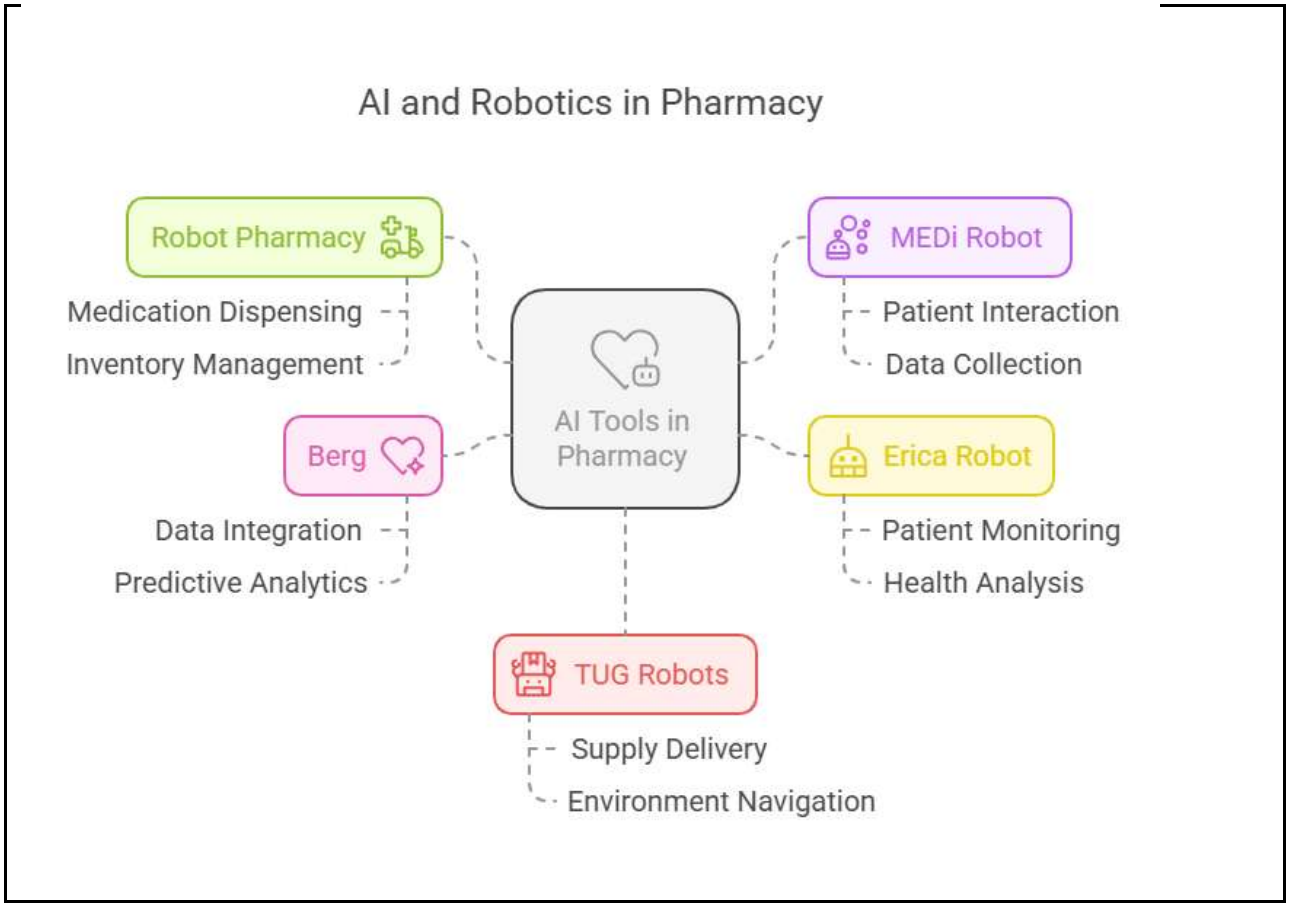

Figure 2 AI and Robotics in Pharmacy

This photo (Figure 2) visually depicts AI and robotics in pharmacy as a central node of "AI Tools in Pharmacy" that is connected to five significant AI-based tools or robotic systems. Robot Pharmacy is highlighted in medication dispensing and inventory management, while Berg is involved in data integration and predictive analytics. TUG Robots are tasked with supply delivery and environment navigation. MEDi Robot is

used for patient interaction and data acquisition, while Erica Robot is for monitoring patients and health analysis. Such AI technologies contribute to making pharmacy processes more efficient and automated

IBM Watson for oncology: AI and advanced analytical software are combined in IBM's Watson supercomputer, which is essentially a question-answering machine [56]. The purpose of Watson for Oncology is to help oncologists make better judgments on cancer therapy [57]. It works through the review of a patient's clinical records within a vast information database and then presenting treatment options on the basis of the acquired data [58]. Regardless of whether clinical notes or reports have been properly coded or not, Watson for Oncology is capable of analyzing meaning and context from any data [59]. Watson for Oncology might rapidly procure critical medical data and present them in plain English, which proves to be the very first stage of providing the correct [60].

treatment strategy for the patient. The most effective treatment plans that can be done on a patient are decided by merging data, clinical studies, external studies, and key characteristics from the patient's record [61]. With over 200 books, 12 million pages of text, over 290 medical journals, and literature and arguments chosen by MSK, Watson can draw on an enormous volume of material [62]. An Indian software engineer, 37, was recently diagnosed with a rare form of breast cancer that was rapidly growing to both of her breasts and threatening to remove both [63]. Bengaluru-based oncologist Dr. Somashekhar entered her medical records and genomic data into Watson, which produced workable treatment choices within [64].

Robot pharmacy: Robotic technology used in UCS Medical Centre involves a lot of automation for the preparation and tracking of medications that would contribute to improving patient safety [65]. The technology has reportedly produced over 3,50,000 doses of medication without any error [66]. The robot works extremely larger and better in delivery accuracy of medications than even humans [67]. Robotic technology prepares injectable and oral medications, including lethal steroids in chemotherapy [68]. With UCSF nurses and pharmacists no longer having to spend their valuable time in such endeavours, direct patient care can therefore now be provided along with medical advice by doctors [69]. Automated systems for drugs have computers at UCS pharmacy. Doctors and pharmacists from UCS place electronic medicine orders directly into the automated system [70]. The robots choose, package, and distribute the individual medication doses. After that, they are assembled by the machines into a plastic ring that is marked with a barcode [71]. The drug contained in a thin plastic ring should be taken by the patient within 12 hours [72]. The automated system also could be applied for filling intravascular syringes of medications that were properly prepared and sterile for chemotherapy. It is expanding the horizons of automation [73].

MEDi robot:The acronym for Medicine and Engineering Designing Intelligence is MEDi [74]. Under the direction of Tanya Beran, a professor of Community Health Sciences at

the University of Calgary in Alberta, the pain management robot was created [75]. Working with youngsters who scream during medical procedures in hospitals gave her the idea [76]. The robot advises the kids what to expect during a medical procedure after first establishing a rapport with them [77]. It provides guidance on what to do, how to breathe, and coping mechanisms during the medical treatment [78].

Although the robot cannot think, plan, or reason, it can be programmed to seem to have artificial intelligence [79]. Aldebaran Robotics-produced MEDi comes equipped with facial recognition software, can communicate in 20 languages, and is highly situation-adaptive. In stores, the robot sells for $9000 but, upon addition of the applications necessary to help with medical procedures, it goes to $15,000 to $30,000[80]. Initially designed for pain management, the robot's uses have now expanded to cover physical rehabilitation, fundraising, and comfort between procedures [81].

Erica robot: Erica, a new robot care model, was developed in Japan by Osaka University professor Hiroshi Ishiguro and developed jointly with Kyoto University, the Advanced Telecommunications Research Institute International, and the Japan Science and Technology Agency. While Erica's voice is spoken in Japanese, her face retains European and Asian caractéristiques [83]. It is interested in human things: seeing cartoon movies, traveling in Southeast Asia, and looking for a partner for life who could interact with it [84]. Even though the robot cannot walk, it can read questions and respond to them through face expressions close to human ones [85]. Ishiguro says that Erica is the "most beautiful and intelligent" android because he included in it characteristics of the average 30 pretty women's face and the lowest morphological distance [86].

TUG robots: They are programmed to extemporaneously navigate the hospital environment for delivering supplies, food, medicines, specimens, and cumbersome items such as garbage and linens [87]. Configurable for carrying racks, bins, and carts, either fixed and secured or an exchange-based platform [88]. The exchange platform is used when transporting bulk materials that can be loaded into various racks, whereas the fixed carts are used to deliver lab specimens, sensitive materials, and medicines [90].

The TUG is a very adaptable and useful tool because it can deliver a variety of carts and racks [91]. When working, a user-friendly touchscreen enables users to identify the locations from which the TUG must pick up materials or supplies or make deliveries [92]. The TUG automatically determines the optimal route when there are multiple destinations. It has overlapping sensors to detect obstacles and provide 180° coverage during navigation. Low-lying obstacles can be detected by the "Light whisker" array of sonar and infrared sensors [93]. The advantages of utilizing TUG include increased productivity around-the-clock, enhanced patient satisfaction, worker safety, and patient safety [94].

Berg: One of the largest users of AI in its many operations is the Boston biotech company Berg. [95]. A drug discovery platform based on AI with a large patient

database is utilized to find and verify the various biomarkers that induce diseases, and therapies are selected based on the data collected [96]. The company's creed is to utilize AI to make a guess out of the process in drug discovery, which will accelerate the process of drug discovery and reduce expenditure [97].

Obtaining sequencing data from human tissue samples, identifying information about metabolites and protein formation, and testing the data using artificial intelligence algorithms are the steps Berg takes to accurately identify the true cause of disease [98].

Applications of AI in Pharmacy Practice

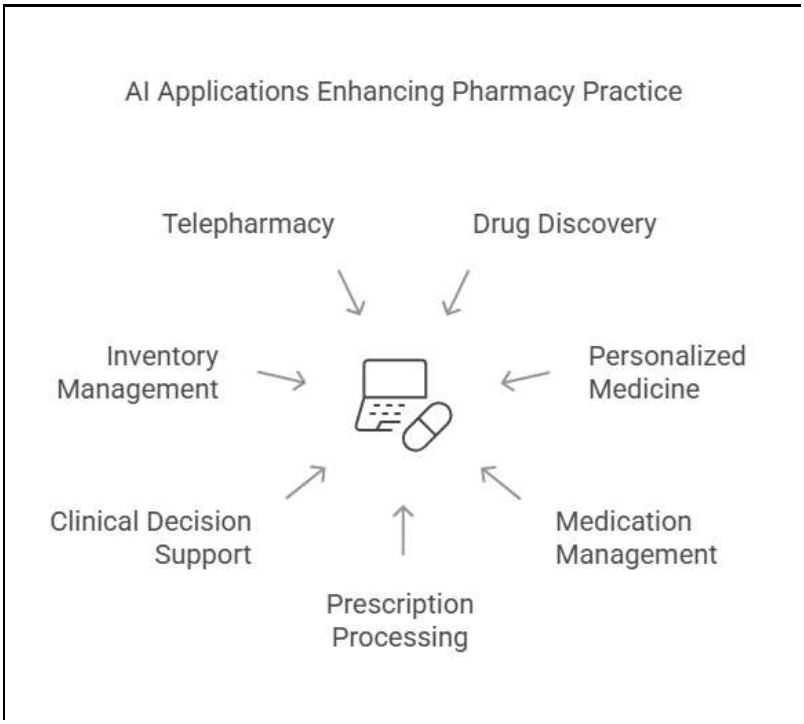

Figure 3 AI Applications in Enhancing Pharmacy Practice

The image (Figure 3) is an illustration of several uses of artificial intelligence (AI) as a way of advancing pharmacy practice. The focal visual point showing a computer and a pill like pixel art is a change that signifies AI's integration into the pharmaceutical operations. This central image is being connect with six AI application focused areas with arrows pointing towards the center, the concept of their interconnected AI-driven technology through these arrows.

1. Drug Discovery and Development

Artificial intelligence revolutionizes drug discovery by screening huge volumes of information in an attempt to identify leading drug candidates in a quicker and more efficient way, significantly curtailing the expenses and time frame of traditional drug development. Machine learning algorithms have the ability to engage with drug interaction prediction, toxicity level, and efficacy prediction, enabling researchers to concentrate on the most attractive compounds.AI-driven simulations help model how drugs interact with biological systems, reducing the reliance on expensive and time-consuming laboratory experiments. Additionally, AI

aids in drug repurposing, identifying new therapeutic uses for existing medications, and optimizing molecular structures for precision drug design. These advancements accelerate the introduction of innovative treatments to the market while improving safety and effectiveness [99].

2. Personalized Medicine and Pharmacogenomics

Artificial intelligence is the main party in personalized medicine as it weighs genetic, lifestyle, and environmental considerations into a drug therapy customized for individual patients. It employs machine learning algorithms that analyze genomic markers and predict how the patient might respond to a specific medication. This minimizes the chances of adverse drug reactions [100].AI-driven decision support tools assist healthcare providers in determining the optimal dosage and drug combinations based on a patient's metabolic profile. By continuously analysing real-time health data, AI can predict disease progression and recommend early interventions. In oncology, cardiology, and neurology, AI helps identify biomarkers that allow for targeted drug therapies, ensuring more precise and effective treatments [101].

3. Medication Management and Adherence

Ensuring that patients take their medications correctly is a major challenge in healthcare, and AI provides innovative solutions to improve medication adherence. AI-powered mobile apps send reminders, track medication intake, and provide real-time data to both patients and healthcare providers [102]. Smart pill dispensers use AI to release the correct dosage at the right time, preventing missed doses or overdosing. Wearable AI devices monitor physiological responses to medications, ensuring they are effective and detecting early signs of adverse reactions [103]. AI chatbots engage with patients, answering questions about drug use, potential side effects, and necessary precautions. By analysing patient behaviour, AI can also predict non-adherence risks and suggest personalized interventions to improve compliance [104].

4. Automated Prescription Processing

AI-driven automation enhances prescription processing by reducing human errors and increasing efficiency. Artificial intelligence (AI) systems may precisely transform handwritten or digital prescriptions into structured data by using optical character recognition (OCR) and natural language processing (NLP), which lowers transcription mistakes [105]. AI cross-checks prescriptions against a patient's medical history and allergy records to prevent potentially harmful drug interactions. Robotic dispensing systems, guided by AI, streamline the medication dispensing process, ensuring accuracy and faster service. AI also integrates seamlessly with electronic health records (EHR), ensuring that prescriptions align with a patient's medical background. Additionally, AI-driven automation simplifies prescription refills, alerting both patients and pharmacists when a refill is needed [106].

5. Clinical Decision Support Systems (CDSS)

Clinical Decision Support Systems (CDSS) intuitive. AI CDSS has

been designed to equip healthcare professionals to make evidence-based clinical decisions with regard to drug therapy. It will provide immediate alerts regarding dru g-drug interaction, contraindications, and allergies in order to reduce medication errors and enhance patients' safety. [108]. AI algorithms analyse patient histories, laboratory results, and clinical guidelines to recommend optimal drug therapies. Integrated with electronic health records, CDSS ensures that prescriptions are tailored to a patient's specific health conditions. AI can also predict disease progression, suggesting preventive treatments and alternative medications when necessary. By providing intelligent decision-making support, AI enhances the role of pharmacists and physicians in optimizing patient outcomes [109].

6. Inventory Management and Supply Chain Optimization

AI is revolutionizing inventory management by using predictive analytics to forecast medication demand, reducing both shortages and overstocking. AI-driven systems automate inventory tracking, ensuring that pharmacies maintain optimal stock levels while minimizing waste from expired medications. Machine learning models optimize drug distribution logistics, streamlining the supply chain and reducing costs [110]. AI also plays a crucial role in detecting counterfeit medications by analysing supply chain patterns and verifying drug authenticity. Additionally, AI-powered procurement systems automate order management, selecting the best suppliers and ensuring timely replenishment of critical drugs. These advancements improve efficiency, reduce costs, and enhance patient access to essential medications [111].

7. AI in Tele pharmacy and Remote Patient Monitoring

AI is driving significant advancements in tele pharmacy, enabling pharmacists to provide remote consultations and medication management services AI-enabled virtual assistants and chatbots are available for medication counselling 24/7, answering questions and addressing concerns from patients. Telehealth platforms integrated AI for video consultations, letting pharmacists help patients who might not easily attend consults in person. [112]. AI-powered remote monitoring devices monitor patient vitals and medication compliance in real-time and alert healthcare providers to impending health threats. Through the use of AI, telepharmacy facilitates timely and customized care to patients irrespective of geographical location. AI also facilitates education of patients via interactive health modules, enhancing medication literacy and health outcomes [113].

V Detailed Benefits of AI in Pharmacy

1. Enhanced Accuracy and Efficiency

2. Cost Reduction in Healthcare AI-powered solutions automate common pharmacy duties like stock management, medication distribution, and prescription processing.

Machine learning algorithms swiftly analyse enormous volumes of medical data, decreasing errors and boosting productivity.

By ensuring accurate dosing and packaging, robotic dispensing systems reduce the need for humans to perform repeated operations [114].

By ensuring pharmacies keep the proper quantity of pharmaceuticals on hand, AI improves inventory control and lowers waste and overstocking. Prescription verification and processing automation lowers labour and administrative costs. Remote consultations are made possible by AI-assisted tele pharmacy services, which reduce hospital visits and related expenses [115].

3. Improved Patient Safety and Outcomes

Using patient history, genetic testing, and medical records, the AI personalizes treatment plans in ways that provide medication efficacy. AI chatbots and virtual assistants accomplish 24 hours a day/7 day a week medication influencing to better aid patients and keep them adherent. AI helps identify possible side effects or adverse reactions before starting a treatment. [116].

4. Reduction of Medication Errors

AI detects potential drug interactions, contraindications, and incorrect dosages before medication is dispensed. Automated medication dispensing machines ensure accurate drug selection and administration.AI enhances electronic prescribing (e-prescriptions) by flagging potential issues, ensuring prescription accuracy [117].

5. Simplifying Administrative Work

AI systems perform routine tasks such as billing, insurance claims processing, and patient record keeping. Natural language processing (NLP) in AI supports rapid and precise data entry with less administrative burden.AI assists in regulatory compliance through proper documentation and observance of pharmacy laws [118].

Table 2: Detailed Benefits of AI in Pharmacy

Benefit	Description
Accuracy & Efficiency	AI automates stock management, prescription processing, and medication distribution, reducing errors and boosting productivity.
Cost Reduction	AI optimizes inventory, reduces labor costs, and enables remote consultations, lowering healthcare expenses.
Patient Safety	AI personalizes treatment, offers 24/7 medication guidance, and detects side effects before prescribing.
Medication Error Reduction	AI identifies drug interactions, ensures accurate dispensing, and improves e-prescriptions.
Administrative Efficiency	AI automates billing, insurance claims, and record management, ensuring compliance.

This table highlights the key benefits of AI in healthcare and pharmacy, showcasing its role in improving efficiency, reducing costs,

enhancing patient safety, minimizing medication errors, and streamlining administrative processes.

VI Challenges and Limitations of AI in Pharmacy

The application of AI in pharmacy has a number of obstacles and restrictions, despite its revolutionary potential. These include challenges with data security and privacy, difficulty integrating with current healthcare systems, ethical and legal considerations, and employee reluctance to change. Resolving these issues is essential to the ethical and successful integration of AI in pharmacological treatment [119].

Legal and Moral Concerns

Legal and Moral Concerns in AI-Powered Pharmacy

Societal and Legal Implications Behind AI Operated Pharmacies

Pharmacy relies on ethical and legal concerns, which are to be properly addressed while deliberating adoption of AI into pharmacy to ensure accountability, openness, and fairness.Bias within artificial intelligence concerns the fact that AI solutions can affect certain groups disproportionately because they are designed with biased or incomplete training datasets. The use of AI systems can lead to disparity in healthcare results, wrong prescriptions of medications, and different care of patients. Biases would result in effects like these [120].

Another problem is the lack of transparency and explainability of decision-making with AI. Most AI models, particularly "black box" ones, do not produce understanding for regulators and pharmacists regarding the recommendations made. Accountability concerns arise because lack of transparency makes it difficult to verify AI-informed decisions in medicine and patient care [121].

One of the most contentious areas is the legal liability in AI-related decisions. When AI system is wrong with drug suggestion that causes an adverse event, it becomes very hard to pinpoint the responsible parties. The pharmacists, healthcare providers, or the developers of the AI themselves may be liable under these laws, but as the laws exist today, there are no clear rules on the issue of accountability. There is venture for a regulatory body to set some clear mandates on the questions of legal liability in the AI-powered pharmacy practice [122].

Moreover, ethical dilemmas are inherent in AI drug research. Although AI accelerates the process of drug discovery, there are moral issues to get through the priority of profits over patient welfare. Moreover, not all the patients will be able to use AI-assisted personalized medicine, which will raise the question of equity in health care. An equitable provision of access to such advanced AI therapies becomes critical for maintaining ethical integrity in pharmaceuticalresearch [123].

2. Data Privacy and Security Issues

Artificial intelligence in pharmacy, in instances such as this, has its fit under the umbrella of legislation and regulations provided by the GDPR in Europe and by the HIPAA in America, both of which are in essence the following basic data protection regulations. Compliance is the central issue, as violation of that security might pose the original danger of infringing upon

someone's privacy and inciting a variety of legal actions. [124].

Cybersecurity risks are in high demand, for AI-based medical solutions are the main goal of cybercriminals. Attacks of the sort that include ransomware and data leaks impose great risks for the patient safety and the sanctity of his/her personal information. Cybersecurity safeguards that are not sufficient can result in serious threats which will cause the loss of the patients' medical histories and prescription of the medications in a secure manner. This is why it is a must to install robust security measures [125].

Additionally, the ethical use of patient data is at the forefront of the problem of phosphate. AI can only function with vast, often patient-voted data. That means that companies' overreliance on ambiguity when they talk about patient data for commercial AI-based drug research does not only violate the basic standards of data privacy but also opens the road to privacy violations, data exploitation, and unregulated data ownership and management [126].

Also, besides that, data reliability, and correctness hold the key to pharmacy's AI software effectiveness. AI models require clear, non-biased, and recent data in order to give a correct prediction and a recommendation. Outdated, wrong patient records, or ones that are not at all complete can lead to the scenario where AI-guided drug recommendations can turn out to be always the wrong ones. As a result, an incorrect treatment or side effects may occur. Phasing data without any alteration is the principal position which AI can take in the pharmaceutical industry to operate properly and securely [126].

3. Integration with Existing Healthcare Systems

One of the main obstacles that AI has to face in the pharmacy is the process of fitting it into the healthcare systems that were already built. A big hassle, all the nurses are facing is the lack of suitable legacy systems in the institution. The reason for this is because many healthcare providers still use outdated electronic health records (EHRs) and pharmacy management software; such software does not even support AI features. Furthermore, the lack of compatibility in healthcare data standards complicates interoperability and thus limits AI usage [127].

The most significant limitation in the intelligence of artificial indeed is the requirement for high costs to install it. One common hurdle that silicon birth models face is the cost of infrastructure upgrade, integration, software upgrade, and staff training which are needed to implement AI. Big chains like CVS have no additional difficulties regarding the financial aspect in introducing AI, as compared to small pharmacies that experience financial constraints which may hinder widespread AI uptake [128].

Being a change factor in the workflow, new technologies, such as AI, require employees to undergo training sessions so that they learn how to use them. In particular, turning to machine learning may lead to the required workforce to embrace a different corporate culture, abandon old strategies, and employ automated workflow systems. At first, the changes can cause slow

productivity, but in time, they will improve efficiency. Smooth AI integration may not be instant but will need adaptation in healthcare setups; the introduction of the technology among them could require more time and training [127].

Another factor that comes into play are the regulations that do not let AI from being implemented easily. AI-based decisions must cohere with the existing laws of the pharmacy, which in fact, healthcare is not fully capable of yet. Besides, the regulatory approval processes for AI-based and prescription automation are still getting there, which naturally creates the unbearable lack of compliance and the speed down of the adoption. The toughest part of this process will be the ability to overcome these challenges and replace them with a successful and coherent assimilation of the AI pharmacy [129].

4. Resistance to Change and Workforce Implications

AI in pharmacy brought many professionals who were largely concerned about the human resource to automation, and the rest of the health tech. Pharmacists think that automation and AI applied to prescriptions risk taking away their jobs. However, the use of AI, which is actually intended to complement a pharmacist rather than to replace a pharmacist, is being faced with resistance [130].

Being literate in AI and being properly trained can be a very good starting point for the professionals to overcome the resistance. Pharmacists and other health professionals need to build competencies in AI literacy, algorithms, and telemedicine in order to operate and innovate with AI-driven systems. On the contrary, not having sufficiently trained staff can definitely cause a delay in integrating AI in the pharmacy [130].

Moreover, the unease of healthcare providers with AI-generated recommendations is also an important factor contributing to healthcare workers' scepticism. Certain pharmacists might not fully trust AI-driven recommendations, given the fact that the system's decision-making process is not transparent, thus they would be reluctant to rely only on AI. AI systems, particularly when they are without human control, might expose the practice to hazards should visualization of AI-generated errors is jeopardized [131].

Moreover, the ethical component in AI-based decision-making is a stressful issue in pharmacy practice. Pharmacists need to manage the AI-guided medication selection carefully and not forget to use good clinical judgment. AI should be viewed as an additional source for drug assessment aside from a skilled pharmacist. It is the guaranteed transparency, proper training, and the usage of a team approach that is crucial for AMR to drive pharmacy practice satisfaction and trust [132].

VII Future Perspectives of AI in Pharmacy

Artificial Intelligence (AI) is transforming pharmacy by improving drug discovery, personalizing medicine, and enhancing operational efficiency in pharmaceutical care. This shift is redefining pharmacist roles and raising new regulatory challenges. Below is an in-depth exploration of key areas where AI is shaping the future of pharmacy [133].

1. Emerging Trends in AI for Pharmacy

The pharmacyindustry has eye-catching AIapplications that are fast-changing and exerting influence in various areas. Predicting drug behavior in the human body is a fast and talent-filled job by computers. Not only can they spot molecules when they are not fitting in but they also suggest combinations that will work better. Although this solution saves time, patients may suffer potentially serious side effects if the suggested therapy is not tailored to their unique features. The products that software and ML companies like have been built of are definitely the result of in-depth analysis and creative work of professional pharmaceutical engineers and physicians [134].

Are AIs making the drug research process faster? Yes, the research of new medications is growing faster than ever before, and AI technology has become an essential tool in this process. Latent semantic indexing attributes the object of the conversation to the products' quality, which is not the case here. Taking this further, the use of digital platforms in the pharmaceutical industry is not limited only to the needs of customers, companies and their ancillary services but also plays a crucial role in the realization of sales. Do you envision intelligent machines to already be helping the pharmacy to reduce counterfeit drugs? Nowadays, AMRs (Autonomous Mobile Robots) are already connected to SAP, a digital platform that sends them places depending on which areas they are short of products. Your AI will have a much easier time if you know which one of the 7 sizes the package has [135].

So, AI robots also help keep the patients on a regimen? The healthcare systems are striving to deliver the best possible treatment, thus minimizing human error by allowing the use of robots. However, with the help of AI, we are creating an entirely new way of interacting with the machines that we can soon call Robotic Process Automation. Nevertheless, in the near future, he will be the only way to be able to receive almost personalized advice when nobody else can [136].

2. Potential Impact on Pharmacist Roles

The penetration of AI into pharmacy is changing the role of pharmacists, and the ones that adapt to carry out new roles beyond the traditional dispensing operations [137]. AI cannot just dispense automatically with accurate prescriptions, the pharmacists will have more time to focus on patient-centred care, in which they will monitor medical therapy and give medical consultations [138]. AI-based decision support systems can not only facilitate the pharmacist's work of finding drug interaction, but also, can provide the best treatment plan, and predict undesired drug effects, which will, in turn, positively affect the health and the safety of the patient. Implementing AI is also the one to blame for the development of tele pharmacy, a technology that enables pharmacists to perform online consultations, remotely supervise medication adherence, as well as provide services with digital medicines [139]. But to put these advances into practice pharmacists need to train for AI literacy, data analytics, and digital health technologies. Moreover, in a world where

AI has great influence in the process of prescribing and dispensing, pharmacists are bound to observe the moral and legal responsibilities of healthcare and the proper use of AI in clinical practice [140].

3. Regulatory Considerations and Policy Development

The exponential rise of AI in pharmacies raised some important regulatory and policy questions that cannot be ignored for fear that its safe, ethical, and effective use is stymied [141]. The FDA and EMA have issued guidelines for the application of AI in drug discovery and approval, so that the drugs produced with AI can ensure a superb safety and efficacy ranking. But the considerations of massive patient data driving AI open avenues for privacy infringement, not to mention the resolve of compliance with laws such as GDPR and HIPAA [142]. Moreover, algorithms have to be both transparent and explainable so that regulators can assess whether these systems are interprable and accountable—such as making the right drug recommendations and patient care for regulative actions to be taken. Furthermore, the issue of responsibility and the ethical spectrum brings on even more problems when AI is a major player in pharmacy, which is the reason why there should be transparent policies regulating this area in the case of AI-based medication errors or adverse drug reactions [143]. In addition, all developing countries should put effort in place towards a single AI blueprint that will guide all state hospitals and ensure there is a single technology brand in use that fulfils all ethical and security requirements. Addressing these challenges is fundamental for stopping the result of AI technology growth to be the loss of patient safety, trust as well as regulation compliance [144].

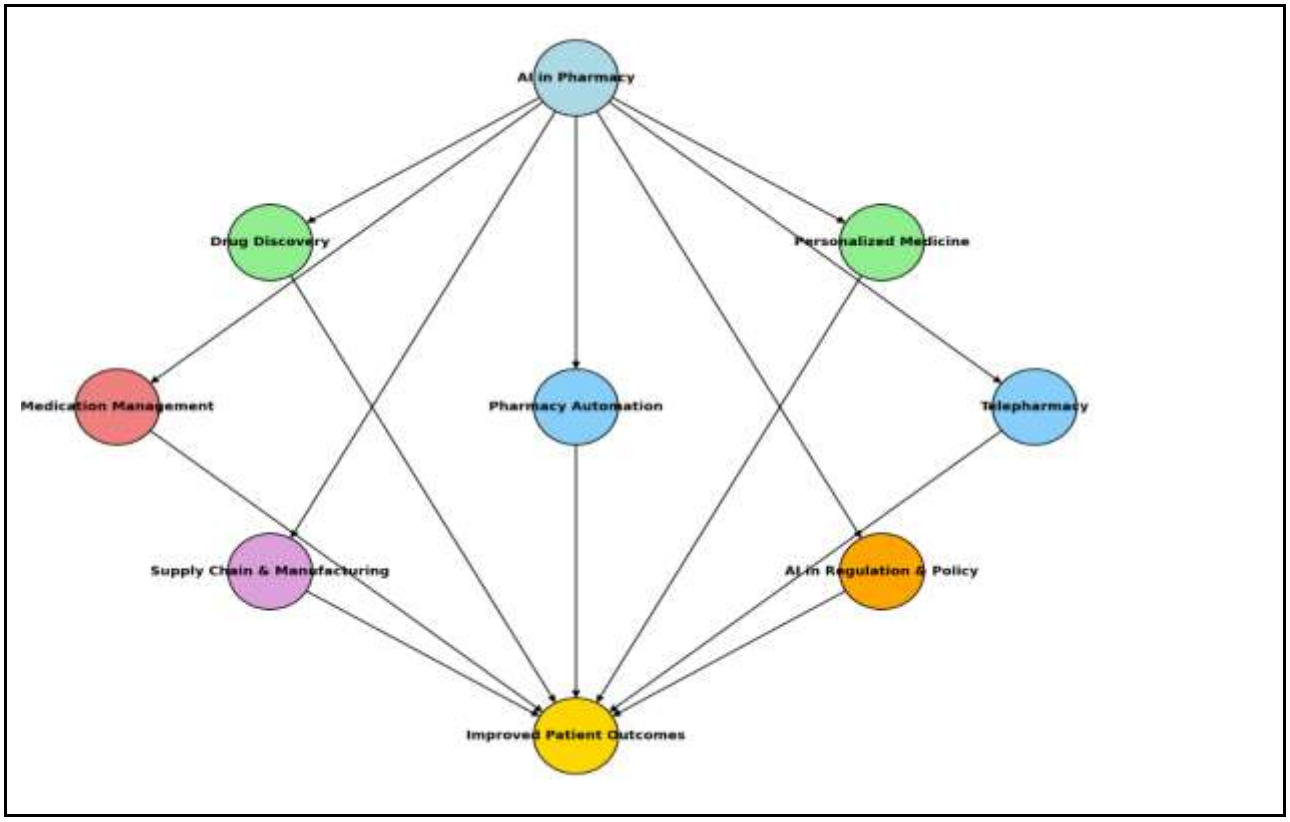

Figure 4 AI Revolution

This flowchart (Figure 4) demonstrates how artificial intelligence (AI) is revolutionizing the pharmacy industry by emphasizing important uses such supply chain optimization, automation, tele-pharmacy, customized care, drug discovery, and regulatory compliance. Improvements in AI-driven innovations lead to better treatment outcomes and more efficient pharmaceutical operations by improving efficiency, precision, and patient-centred care.

VIII Conclusion

The application of artificial intelligence (AI) will have a complete, deep impact on pharmaceutical operations in terms of simplifying it, speeding up the offer of drugs, and improving patient care. AI-based automation and decision-support systems significantly contribute to the repackaging of pharmacists from it functions into patient care-related roles like medication therapy management and tele pharmacy services. Through optimization of supply chain management and minimizing prescription management errors, AI yields improved healthcare outcomes. Furthermore, AI-powered predictive analytics help in monitoring the safety of medicines so that their use would result in minimal side effects. These technologies will not only make operations more efficient but will also allow pharmacists to play a larger role concerning patient health.

However, the integration of AI into pharmacy would certainly raise issues and concerns, both consequential and serious, in terms of the regulatory and ethical hurdles to be overcome for safe and effective

application. Regulators like the FDA and EMA are quickly working on some of the principles which the regulations would set for the application of AI in drug discovery and approval, principles which must be beyond transparency and accountability: data privacy issues, compliance with directives such as GDPR and HIPAA, and interpretability requirements necessary for AI systems should all be addressed. For that reason, AI training and digital literacy for pharmacists become a very important consideration for the potential adjustment within the ethical-legal framework of the practice. A robust policy would thus have to propose and create a global AI framework to protect patient safety and give the public confidence that the adoption of AI would have a bright and sustainable impact on pharmacy.

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