AI In Pharmacy

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Abstract: Artificial Intelligence (AI) has become a popular remedy for issues involving numbers and data. AI has made significant contributions to the healthcare industry in a number of areas, including the management and storage of data and information about patient medical histories, medication stocks, sale records, and more; automated machinery; software and computer applications; and diagnostic tools like CT and MRI diagnostics. All of these have been developed to support and streamline healthcare procedures. Without a doubt, artificial intelligence (AI) has transformed healthcare to be more effective and efficient, and the pharmaceutical industry is not exempt. Artificial intelligence (AI) and novel robotic technologies have bright futures in pharmacy and medicine, with the potential to completely transform a number of facets of healthcare. PAT, CFD, and pharmaceutical automation in research and development are recent advancements in pharmacy AI. These approaches provide comprehensive details on methods that have been applied in healthcare previously, such as drug absorption and dissolution, inhaler designs, and disease-focused procedures. The seamless integration of robotics and AI technologies to assist patients and healthcare providers is the future of pharmacy and medicine. The primary subjects of this review are the following: AI milestones, classification, application, clinical trials, pharmacy, medicine accuracy, drug discovery and development, psychology, conceptual framework of AI in medicine, role of AI in healthcare, disease and diagnosis, current challenges and role of AI, advantages, disadvantages, limitations, and application of AI in pharmacy.

Keywords: Artificial Intelligence, Pharmacy, Medicine, Health Care, Applications of AI.

I. INTRODUCTION

Artificial intelligence (AI) is a branch of study that studies intelligent machine learning, primarily through intelligent computer programs that produce outcomes akin to those of human attention. (1) The first artificial intelligence framework, known as Logic Theorist, was developed in 1955 by Herbert artificial intelligence, blockchain, virtual reality, and augmented reality, among others, are offering A. Simon and Allen Newell. (2) Cyber tools, which encompass various technologies such as noteworthy advantages to patients and the pharmaceutical industry. These benefits include facilitating patient access to physicians and medications, as well as enhancing real-time diagnosis and treatment. (3) Alhas become a disruptive factor in several industries, changing how people live, work, and communicate. (4) AI has helpful in various studies. (5) AI based solution also used in radiation therapy targeting. (6) The availability of enough data for algorithm training and the incapacity of AI systems to handle data in their original format have historically been two of AIs main drawbacks. (7) The development of drugs and experimental pharmacology have undergone a radical change thanks to the quick development of artificial intelligence (AI). (8) The ultimate goal of health care AI is to enhance detection, prognostication, or prediction; specifying these objective aids in choosing the most effective intervention plan. (9) In clinical development, omics data, EHR, and biomarkers can be used with AI techniques like computer vision and NLP to identify and describe the most suitable subpopulation for a trial. By doing this, the population will become more enriched and less heterogeneous. (10) The developments in healthcare and biomedical research are increasingly shifting as the integration of AI and medicine gains momentum in different domains. (11) Big data and artificial intelligence combined, sometimes called the & quot; fourth industrial revolution& quot. (12) Research on artificial intelligence has potential for novel ways to assist nurses in making clinical decisions and in carrying out non-patient-related tasks, such as maintaining patient records and administrative duties. (13) Artificial intelligence (AI) as a cognitive aid may help lower this requirement and the related diagnostic mistakes. (14) AI is also used in the screening of diabetic retinopathy. (15) For the quantitative and categorical characterisation of pharmacological molecules, thousands of chemical fingerprints and quantitative structure–activity relationship (QSAR) descripor has been created. In recent decades, there has been a substantial progress in computational techniques, particularly in the field of artificial intelligence (AI), and parallel processing. This has enabled computer-based inference engines to draw ever-deeper conclusions. (16) Artificial intelligence (AI) systems have the potential to automate tasks, resulting in time savings and reduced resource
usage. (17) Concerns concerning potential benefits, ethical ramifications, and the requirement for proper training and supervision are also raised by AI in pharmacy. (18)

Fig.1: The Key Directions in Robotic Technologies applied in the Pharmaceutical and Medical Sector (19)

II. Milestones in AI:

The term "artificial intelligence" was first used in print in 1956. Nonetheless, the idea of artificial intelligence has been used since 1950 in conjunction with symbolic approaches and problem-solving techniques. Five significant turning points in the field of AI applications are listed in Table 1. (20)

Table 1: Important milestones in the area of the AI uses. (20)

<table>
<thead>
<tr>
<th>YEARS</th>
<th>EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943</td>
<td>Walter Pitts and Warren McCulloch proved that logical operations like “and”, “or” or “not” can be done by neurons connected in a network.</td>
</tr>
<tr>
<td>1956</td>
<td>The term ‘artificial intelligence’ was first appeared.</td>
</tr>
<tr>
<td>1974</td>
<td>Initiation of “First AI Winter”.</td>
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<tr>
<td>1986</td>
<td>Georey Hinton promoted Back propagation algorithm design which is widely used in deep learning.</td>
</tr>
<tr>
<td>1997</td>
<td>Garry Kasparov (Russian grandmaster) was defeated by IBM Deep blue.</td>
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<tr>
<td>2013</td>
<td>Google carried out efficient research on pictures by utilizing the British technology.</td>
</tr>
<tr>
<td>2016</td>
<td>In this year, the Go Champion Lee Sedol was defeated by Google DeepMind, software AlphaGo.</td>
</tr>
</tbody>
</table>

AI classification AI can be classified in two different ways (1)

a) according to caliber
b) according to the presence

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.

According To Caliber
1. Artificial Narrow Intelligence (ANI), also known as Weak AI, is capable of performing a limited range of tasks, such as traffic signaling, chess practice, driving, and facial recognition.
2. Strong AI, often referred to as Artificial General Intelligence (AGI), is also referred to as human level AI. It is capable of all human functions. It can perform tasks that are foreign to humans and simplify human intellectual capacities.
3. Artificial Super Intelligence (ASI): It is far more active and intelligent than humans in areas such as mathematics, space, sketching, and other areas.

Based on Presence: (21)
i) Type 1: It is utilized for applications with a narrow scope that are unable to apply prior information because it does not have a memory system. People refer to it as a "reactive machine." Examples of this RAM include an IBM chess program that can analyze moves and recognize the chessboard's checkers.
ii) Type II: It can use past knowledge to solve a variety of issues, but its memory is limited. Certain recorded observations are utilized to record subsequent actions in the automated driving decision-making systems; these recordings are not stored indefinitely.

iii) Type 3: The "Hypothesis of Psyche" serves as its foundation. It suggests that people's unique viewpoints, sources of inspiration, and desires influence the decisions they make. AI does not exist in this system.

iv) Type 4: It is self-aware, having a feeling of self and consciousness of itself. This is just one more nonexistent AI system.

**AI in Pharmacy**

Artificial Intelligence is utilized in the pharmaceutical sector to create predictive models that forecast the efficacy of novel treatments and assist in identifying possible drug targets. Additionally, it's utilized to build virtual patient simulations that aid researchers in determining which course of action is appropriate for a given patient. Even novel medications are being developed using AI. In one recent instance, researchers employed AI to create a novel medication that targets a cancer-related protein. AI is undoubtedly significant to the pharmaceutical sector. It makes the process of creating new medications and treatments quicker and more effective than in the past. AI will undoubtedly become ever more significant in pharmacy as it develops. (22) Klopman conducted research on the structure activity relationship (SAR) of natural atoms. The structure assessment program is computerized and uses the KLN code, which is a straightforward coding system for atoms, to identify atom structures. From there, it further identifies, organizes, and disassembles biospheres, which are substructures that are actually measurably responsible for the natural action of the particles. The PCs in the computerized drugstore arrangement initially get electronic drug orders from the physicians and drug specialists at UCSF. Following this, mechanical technology selects, bundles, and administers pill amounts to each individual. Machines that accumulate the pieces onto a plastic ring with a barcode follow this. All of the medications that a patient needs to take within 12 hours are contained in the thin plastic ring. The computerized framework's ability to schedule sterile arrangements suggested for chemotherapy in addition to loading intravenous needles using the appropriate medications is an additional capability. (2) According to an estimate from IBM, as of 2011, the entire Healthcare domain included approximately 161 billion GB of data. The vast amount of data in this field makes artificial intelligence a valuable tool for data analysis and result presentation. This can aid in decision making, save human effort, time, and expense, and perhaps save lives. Epidemic outbreak prediction: by utilizing machine learning and artificial intelligence, one may examine the past of previous outbreaks, examine social media activity, and forecast the location and timing of outbreaks with a high degree of accuracy. (23)

![Image](image_url)

**Fig. 3: The Positive Impact of AI in the Field of Medicine. (24)**

**Artificial Intelligence in Clinical Trial Planning:**

Failure can be attributed to a variety of factors, including as inadequate technical planning and poor patient selection. The use of AI in clinical trials, which offers a wealth of digital data for access, can reduce these losses. The primary stage of clinical trials is the proper patient selection, which requires roughly one-third of the trial's total time. Proper patient selection can guarantee a success rate; if it is done incorrectly, the experiment will fail 86% of the time. AI may help in choosing patient data based on patient-specific gene-exposome profile analysis for stage II and III clinical trials of a particular disease, leading to early drug target expectations in a subset of patients. (25)

**Expected Change in Pharmacy Practice in the Age of Artificial Intelligence:**

The era of artificial intelligence (AI) is currently upon us. Even though clinical pharmacy practice took on a new function fifty years ago, will it still be sufficient fifty years from now? What medical needs will be most pressing at that time, and how can pharmacists play a significant role in meeting those needs? In the years to come, finding the answers to these questions will offer pharmacy practice improvement guidance and a new approach to meeting the demands of
the AI era in healthcare. It goes without saying that advancements in AI technology will impact pharmaceutical practices in the future. AI is expected to have a significant impact on pharmacists’ ability to dispense medication and provide drug information as it develops. According to predictions made by the World Economic Forum, a “robot pharmacist” will be accessible by 2025. Without a doubt, an AI-powered “robot pharmacist” can easily surpass a human in terms of accuracy and speed, particularly when it comes to dispensing medication products and information. The rate at which knowledge is expanding has been anticipated to double every 12 hours in the near future, from its current rate of doubling every 13 months. Given the speed at which knowledge is advancing, pharmacists will not only need to rely on artificial intelligence (AI) but also adapt to take on new, valuable roles in healthcare that will almost certainly be overseen by interdisciplinary teams. (26)

**Barriers to AI integration in pharmacy practice:**

Like any technology, artificial intelligence (AI) may run across a number of obstacles that prevent it from being widely used, working properly, and developing further. The absence of understanding and awareness of AI applications in pharmacy may impede the adoption of this technology. While AI has not yet attained perfect safety and privacy protection, patients’ security and privacy remain at risk because AI systems rely on the use of personal information to carry out necessary activities. Speaking about obstacles to the effective use of AI in pharmacy settings, one major one is the absence of AI infrastructure, which frequently makes resource-constrained circumstances worse. This can severely restrict the uptake of AI technologies. The advantages AI may have for pharmacy practice are limited by the absence of required hardware, software, and technological know-how. The ability of pharmacies to effectively use AI technology is hampered by the unfulfilled potential of AI technologies in the absence of a strong AI infrastructure. Inadequate education and training also hinder the use of AI, considering how complicated AI is and how important it is to have pharmacists who are knowledgeable and skilled enough to handle this new technology. (27)

**In Accuracy of Medicine:**

Artificial intelligence has a positive effect on genomics and genetic evolution. The Advanced Genomics Artificial Intelligence platform is effective at identifying patterns in genetic data and medical records that point to mutations and correlations that result in disease. This method gives medical practitioners knowledge about the cellular modifications brought about by genetic differences in DNA. (28)

**AI in Drug Discovery and Development:**

A drug's research or approval process takes about 14 years to reach the point of approval (R&D), at an estimated cost of $3 billion. Due to the improved use of resources available for the synthesis of the therapeutic molecules, AI has many advantages over traditional methods of discovering and creating drugs. These advantages include speeding up the process and lowering expensive, time-consuming protocols. (29) The field of experimental pharmacology and drug discovery has undergone a revolution thanks to the quick development of artificial intelligence (AI). (8) Better decisions in drug design, chemical synthesis, and biological test analysis have been predicted as a result of the creative partnership between mind and machine. The process of creating an AI model for drug discovery generally consists of four steps: (1) defining the problem, which must be specific or general; (2) selecting an appropriate AI algorithm and initializing hyperparameters to provide an appropriate AI architecture; (3) preparing input data that is satisfactory in terms of quantity, quality, representation, and fitting proportion; and (4) selecting training algorithms, optimization strategies, evaluation mechanisms, and metrics for the model. (30)

**Fig. 4: Process of Computer- Aided Drug Design (31)**

**AI and Connected Devices in Drug Development:**

The use of AI and ML in drug development is a cutting-edge topic that is expanding quickly. The application of AI/ML approaches has lately extended to the optimization of patient selection and monitoring during clinical trials, in addition to their usage in protein structure prediction, target identification, and drug development. The use of AI/ML approaches in clinical pharmacology and research is growing as a result of advancements in connected technology and
software that produce large amounts of data (big data). The term "digital clinical trial" was coined to describe the concept of monitoring patients in real-life settings, including those who are involved in clinical trials, thanks to these gadgets. (32)

AI in Psychology:
In the past, the discipline of "psychology" has made major contributions to the use of AI. Using the ideas of a neutral network, Rosenblatt created the first computer capable of self-learning in 1957, contributing to the definition of the pattern of artificial intelligence in humans. The neuropsychologist Donald O. Hebb's work, whose theories explain how neurons learn by fortifying their connections with one another. He laid the groundwork for the study of neural nets in artificial intelligence in 1949. Later, in 1986, David Rumelhart and associates investigated neural-net models of memory, which had a major impact on the advancement of machine learning. (29)

Conceptual Framework of AI in Medicine
The phrase "clinical innovation" refers to a range of tools that assist health professionals in improving patient and societal well-being by facilitating early diagnosis, reducing complications, improving care, making less intrusive decisions, and reducing hospital stays. Before the smartphone era, clinical innovations were primarily recognized as exemplary clinical gadgets (such as prosthetics, stents, and inserts). However, with the advent of smartphones, wearables, sensors, and communication frameworks, medicine has undergone a transformation as computerized reasoning (AI)-powered instruments (like applications) can now be housed in tiny sizes. Artificial Intelligence (AI) is an emerging field in computational science that has revolutionized medical technology. It is typically recognized as a branch that can tackle complex problems with various applications in domains with a lot of data but little theory. The Food and Drug Administration (FDA) has approved a few AI-based computations over the past ten years, so they may be utilized. (33)

Role of AI In Health Care:
In the hypothetical scenario, a significant decrease in the number of patients who visited emergency rooms and were readmitted to hospitals was achieved through the deployment of artificial intelligence (AI) programs that do data analysis on patient information in real time. In the not-too-distant future, a growing number of artificial intelligence (AI) apps that support or enhance diagnostic, therapeutic, and surgical procedures may lead some individuals to believe that doctors won't be required. The growing number of AI apps may lend credence to this line of reasoning. (34) AI is able to derive a meaningful association that can be applied to illness reduction, diagnosis, and therapy. Almost every branch of medical study has the potential to benefit from the application of a broad variety of more contemporary computational understanding techniques to address the complex clinical challenges, a large amount of knowledge must be gathered, assessed, and applied. The development of medical AI has helped doctors solve difficult clinical problems. (21) Artificial intelligence (AI) can offer suitable medicinal therapy, doses, and combination drugs because of its ability to comprehend enormous volumes of patient data and clinical recommendations. An AI-driven application called IBM Watson for Oncology, for instance, helps clinicians identify possible cancer drug treatments based on the unique characteristics of each patient. Watson recommends treatments that might be most successful for specific cancer types by examining a patient's medical history along with a wealth of clinical trial data and medical literature. (35)
Recent Trends:

1. Pharmaceutical automation in research and development: AI is a relatively new concept. Although lab automation systems have existed since the 1990s, it has only become widely used in the last few years, primarily in large-scale biorepositories, programmed clinical and analytical evaluation, combinatorial chemistry, high-throughput screening, and diagnostics. A fully automated library is now a reality thanks to developments in robotics and other technology.

2. Process analytical technology, or PAT: This is yet another innovative trend. This is crucial in supporting pharmaceutical businesses’ efforts to improve their manufacturing processes through innovation and a continuous improvement mindset. Patients save money as a result of increased product yields, better utilization, and decreased waste.

3. The utilization of computational fluid dynamics as a design tool enables product designers to quickly and economically assess various concepts. (37)

Disease Diagnosis and Treatment:

- **Updating medical records:**
  It might be difficult to keep up with patients' medical records. By using the AI system, data collection, storage, normalization, and tracking are made simpler.

- **Creating a treatment plan:**
  AI technology makes it feasible to create treatment programs that are both effective and efficient. An artificial intelligence (AI) system is required to take control of the situation when a patient develops a severe condition and choosing an appropriate treatment plan becomes challenging.

- **Aiding with repetitive jobs:**
  Artificial intelligence (AI) technology also helps with certain repetitive chores, such as analyzing radiology, X-ray imaging, ECHO, ECG, and other tests to identify and detect diseases or problems.

- **Health support and medication aid:**
  In recent times, it has been acknowledged that the application of AI technology is effective in providing medication assistance as well as health support services. (1)

- **AI in Radiation Therapy:**
  A relatively new technology that is very helpful in radiation treatment planning is automated treatment planning. With automated treatment planning, the quality, consistency, and error rate of the plan are effectively improved. (38)

- **AI in Cancer:**
  Due to its broad application, AI has become more significant in the fields of cancer diagnosis and treatment. In gastrointestinal cancer, colorectal cancer (CRC) screening technology is utilized to assess the cancerousness in patients, and visual nocturnal imaging plays a critical role in predicting the advancement of gastric cancer by detecting Helicobacter pylori infection. (38)

![Fig. 6: AI in Acquiring and Analyzing Data of a Patient in Personalizing the Treatment (38)](image)

Anti-Cancer Drug Discovery Based on AI:

Organizations are increasingly establishing "best practice" recommendations for creating and implementing patient-beneficial AI technologies. To promote and harmonize ML-based treatments, new checklists have been created. AI technologies need to be trusted by clinicians and patients alike in order to be deployed successfully in clinics. For human-computer cooperation, human-computer interfaces need to be properly designed and tested. Precision oncology is new to artificial intelligence. The number of proof-of-concept trials has increased recently, offering hope for the development
of precision oncology. Although this preliminary study creates realistic expectations, significant advancements in our understanding of the limitations that have already been identified are necessary. Throughout the world, patients could profit from precision oncology as a result of AI in the years to come. (39)

**AI in Other Chronic Diseases:**

Based on programming skills, several computerized therapies are offered. The behavioral and cognitive approach— which uses joysticks or multiple-choice questions—is the main focus of the therapy. Advanced artificial intelligence methods that operate at the molecular level, including digital biomarker generation, genomics, epigenetic modifications, and molecular phenotyping, can also be applied to the treatment of many medical disorders. Patients can now control their diabetes using more advanced methods, such as web-based apps for smartphones and tablets. (38)

**Current Pharmaceutical Challenges and the Role of AI:**

Because of their many benefits, small molecules are the subject of ongoing research in the pharmaceutical business to improve goods and consumer satisfaction. While the preparation of synthetic derivatives is inexpensive, the chemical synthesis process is straightforward. There are thus a lot of stable and effective small-molecule-loaded formulations available in the pharmacy industry. Generic molecules compete with many novel small molecules, with the exception of treating uncommon disorders. Complex data and clinical trials are necessary before these molecules may be introduced to the market. These procedures put more financial pressure on businesses to innovate more. AI offers enormous potential for improving medicine delivery and discovery, but it also has significant drawbacks that eventually necessitate human intervention or the need for experts to understand the intricate outcomes. The datasets provide the majority of the AI predictions; but, because of the gray area in the results, human interpretation is necessary to arrive at the right conclusion. When processing data for predictions and evaluating hypotheses, AI may encounter problems with algorithmic bias. Furthermore, finding inactive molecules as a result of docking simulations is a regular occurrence. Therefore, in order to effectively make decisions and do cross-verifications in order to rule out system bias issues, a careful review of these factors still requires human input. In terms of artificial intelligence, the approach that is being used makes use of machine learning or any of its subsets, including natural language processing and deep learning. Both supervised and unsupervised learning are possible, and the kind of algorithm used is crucial factor. (40)

**How AI is Changing the Pharmaceutical Industry?**

Among the world's most regulated industries is the pharmaceutical one. This is mostly due to the fact that pharmaceutical businesses' products have the potential to significantly affect public health. As a result, in the past, the industry has made many decisions about which pharmaceuticals to develop and release onto the market primarily based on human judgment and experience. But with the rise of artificial intelligence (AI), the pharmaceutical sector is starting to realize that AI can help with some of the repetitive chores associated with developing and promoting new drugs. AI can be used, for instance, to design clinical trials or analyze data to find novel drug targets.

**Advantages of AI Technology**

The potential advantages of AI technology are as follows. (20,37,41)

1. AI helps to improve precision and reduce errors while increasing accuracy.
2. The mining industry demonstrates the value of AI. The field of fuel exploration also makes use of it.
3. To lessen the demand for human labor, sophisticated companies are now utilizing AI systems like "avatars," or representations of digital assistants.
4. In general, doctors can use AI programs to evaluate patients' conditions and examine side effects and other health hazards related to medication.
5. The pharmaceutical business may now use artificial intelligence to solve issues that were previously intractable with straightforward data analysis.
6. AI provides insightful data that can significantly enhance clinical trial results.
7. Deep learning and natural language processing are two AI techniques that are revolutionizing drug development by comprehending and analyzing enormous amounts of bioscience data.
8. AI uses massive amounts of data to handle high volumes of automation.
9. To forecast manufacturing costs and choose the best course of combination therapy.
10. The prediction of physicochemical features and combination therapy is aided by AI-based technologies.
11. AI systems are also discovered to be able to identify RNA and DNA mutations. (20,37,41)

**Disadvantages of AI Technology (20,37,41).**

1. AI's debut results in significant financial spending.
2. Complex machine design, upkeep, and repair are incredibly economical.
3. Experience can lead to improvements in human resources.
4. On the other hand, AI-powered robots are incapable of learning from experience.
5. Artificial intelligence (AI) machines lack both emotional intelligence and sensitivity.
6. The extensive application of AI technology across all industries could result in widespread joblessness.
7. It is successful at infecting the next generation.
8. It can be altered to primarily cause massive destruction.
9. Data issues and privacy concerns were these technologies' main causes for concern.
10. Personnel training and ethical concerns make implementation challenging.
11. System malfunctions are serious setbacks that result in cybersecurity issues and a loss of management control.
12. AI system implementation in the pharmacy field due to the lack of IT infrastructure. (20,37,41)

Limitations (43,23)

Streamlining Electronic Records: Since they are scattered over several databases and unkempt, they must first be cleaned up.

Transparency: Given the complexity of artificial intelligence-based systems, people need transparency in the medical care they receive. However, this is a challenging task.

Data Governance: Legally and confidentially accessible medical information is available. It is imperative to secure popular endorsement. Pharma businesses have a reputation for being conservative and reluctant to change. To provide the greatest care possible, we must eradicate the stigma. (43,23).

Application (31,41,43)

AI in diagnosis: Misdiagnosed illnesses result in up to 80,000 reported deaths annually. Deadly mistakes have been caused by a large number of cases and insufficient medical histories. AI is not affected by these factors. Artificial intelligence (AI) can forecast and diagnose sickness more quickly than medical practitioners.

Digital Consultation: The idea behind digital consultation is to cut down on patients' hospital stays for minor ailments that they may manage on their own in the comfort of their own homes with a doctor's guidance.

Research and Development: Research and development can benefit greatly from the use of software-based technologies such as artificial intelligence. Computational approaches are being used to speed the creation of new drugs.

Traditionally, doctors were responsible for writing prescriptions, a task that might occasionally lead to prescription errors. Artificial intelligence (AI) has developed knowledge bots based on AI to reduce medication errors and their harmful repercussions.

Expert systems can serve as effective decision-making instruments in the pharmaceutical product development process. The kind and quantity of excipients used in the formulation of tablets and capsules can be selected using these expert systems.

Drug synergism and antagonistic relationships: Understanding and assessing these relationships is essential to therapeutic interventions as it can help reduce dosage and prevent the harmful consequences of taking drugs in combination.

Clinical diagnosis and treatment: A number of diseases' clinical diagnosis and treatment are impacted by AI-based systems. AI interventions enhanced clinical diagnosis for conditions such diabetes nephropathy, pancreatic cancer, heart disease, stroke, and bladder cancer. Artificial intelligence (AI) is seen as a possible technique in dermatology for discovering and diagnosing skin lesions. (31,41,43)

AI for Next Generation of Precision Oncology

Medication used in precision oncology targets genetic alterations in a patient's tumor. Clinical oncology has used molecular profiling more frequently in recent years, and a number of medications that target specific molecules have received approval to enhance patient outcomes. Large and diverse data sets can be analyzed using AI and ML to find trends that are important for medicine. Thus, machine learning (ML) has the potential to enhance patient care. Researchers in computer vision and digital pathology have demonstrated how machine learning models can enhance diagnostic methods while requiring less human intervention. By supporting generalist pathologists in clinical workflows, pathologists can expedite clinical diagnosis. AI-driven cancer patient decision support systems are also developing. By combining tumor growth kinetics, genetic profile, and pharmacological features into machine learning (ML) models, the most successful treatment options for treating cancer patients may be identified. Access to population-scale data sets with clinical and molecular annotations is necessary for this. (49)

The Application of Artificial Intelligence to the Fields of Forensic Medicine and Toxicology:

The next Industrial Revolution will begin with artificial intelligence (AI) being the dominant technology. Artificial intelligence is going to change business in every way. Forensic medicine and toxicology are key fields in crime investigation, and they have a lot of space to expand and advance with the aid of artificial intelligence. Various procedures, including the analysis of toxins, the extraction of various samples of medicolegal significance from body cavities, the identification of pathological changes in different body organs, the identification of different body stains, the identification of a weapon used in a crime, the calculation of time since death, and so forth, are the areas of forensic medicine in which AI will be crucial in framing the different perspectives of medicolegal significance. AI may also be included into testing and analysis protocols already in place, which will improve the overall accuracy and efficiency of
the process. In the future, artificial intelligence might have a big impact on toxicology and forensic medicine practices. (44)

Conclusion

Artificial Intelligence (AI) combines artificial intelligence with human expertise and resources. In all areas of pharmacy practice, exposure to and education regarding AI are crucial. During their PharmD program, pharmacy students ought to be exposed to the principles of AI and data science via a health informatics curriculum. AI and robotics in healthcare seem to have a bright and transformational future. These technologies have the potential to completely transform a number of facets of health care, including patient care, diagnosis, treatment, and drug development and production. AI is gradually becoming a very important component of the medical services sector and the pharmaceutical industry. Furthermore, it is imperative to emphasize the benefits and value addition provided by AI systems in pharmacy, as they allay worries and demonstrate the possibility of improved patient care and results.

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