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# ARTIFICIAL INTELLIGENCE IN PHARMACY: A CATALYST FOR CHANGE

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**ABSTRACT**

1. With applications divided into six stages—basic, intermediate, complex, localized, multidisciplinary, and pervasive—the integration of Artificial Intelligence is revolutionizing pharmaceutical practices in clinical, community, and hospital settings.
2. While advanced Artificial Intelligence concentrates on drug development and customized treatment, basic Artificial Intelligence automates repetitive processes like data entry, while intermediate Artificial Intelligence employs predictive analytics to enhance medication interaction screening and therapeutic outcomes.
3. While interdisciplinary Artificial Intelligence combines data from multiple sources to improve patient safety and care, localized Artificial Intelligence applications cater to particular operational demands, such as adherence tracking in community pharmacies.
4. Pervasive Artificial Intelligence refers to the complete integration of Artificial Intelligence into every aspect of pharmacy operations, promoting medication adherence, patient safety, and drug discovery while enabling smooth communication between technology and healthcare.
5. Pharmacists will need continual education and training to effectively utilize Artificial Intelligence's potential and improve patient care as it continues to lower costs and increase pharmacy practice efficiency.

**KEYWORDS:** AI, Cost-Effective, Adverse Drug Events, Catalyst, Patient Adherence.

## 2. BACKGROUND

Artificial Intelligence (AI) is a branch of research that deals with intelligent machine learning, mostly with intelligent computer programs that produce outcomes that resemble human attention.[1] In general, this process entails gathering information, creating effective methods for using that information, presenting precise or approximative conclusions, self-corrections, and changes.[2] Artificial Intelligence is typically used to analyze machine learning and mimic human cognitive skills.[2,3] Artificial Intelligence technology is used to obtain meaningful interpretation and to conduct studies that are more accurate.[3] From this angle, artificial intelligence technology combines computational intelligence with a variety of practical statistical models. Artificial Intelligence technology has recently grown to be a vital component of the industry with practical artificial applications in numerous technical and scientific domains. When looking back over the last 25 years, pharmacists have done a fantastic job of meeting the rising demand for prescription drugs, despite the shortage of pharmacists.[4] However, a lot of patients have trouble swallowing tablets and hard gelatin capsules, which makes it difficult for them to follow their prescriptions, leading to noncompliance and ineffective therapy. Therefore, it shows the goal of recent developments in innovative medication delivery systems is to improve patient compliance by creating a convenient dose form that will increase drug molecule safety and efficacy.

### 1.1Types of Artificial Intelligence in pharmacy

**1.1.1.** Caliber Basic artificial intelligence - Basic artificial intelligence, sometimes known as "caliber artificial intelligence," includes machine learning algorithms, rule-based systems, and basic automation tools. It is essential to improving decision-making, accuracy, and efficiency in several pharmacy areas.[5]

**For example**, artificial intelligence can streamline prescription processing by quickly verifying drug interactions and dosages, reducing the risk of human error. This enhances productivity by freeing pharmacists to focus on patient care and consultation. Additionally, artificial intelligence -driven inventory management systems can predict medication needs based on historical

data and trends, ensuring optimal stock levels and reducing waste.

**Merits**
**Task-Specific Efficiency**: It excels at performing repetitive tasks, automating processes, and analyzing data quickly and accurately.
**Less Complexity**: Easier to understand and manage compared to more sophisticated forms of AI, like deep learning systems.

**Demerits**
**Limited Scope**: Basic artificial intelligence can only function within the parameters it was designed for, lacking the ability to generalize or adapt to new tasks outside its specific domain.
**Lack of Creativity**: It cannot generate new ideas or innovate beyond the predefined rules.

**1.1.2.** Caliber Intermediate Artificial Intelligence - "Caliber Intermediate Artificial Intelligencev," or intermediate Artificial Intelligence in pharmacy, has many advantages for a variety of disciplines. Caliber Intermediate Artificial Intelligence integrates sophisticated data analysis and decision-making skills to improve pharmacy operations. artificial intelligence, for instance, can improve patient outcomes by using patient data to tailor treatment strategies and anticipate medication adherence.[14]
**For examples**, Machine Learning Models, Enhanced Automation.

**Merits**
**Improved Learning and Adaptability:** Unlike basic artificial intelligence, intermediate artificial intelligence can learn from new data, improving its performance and adapting to new situations**.**
**Cost-Effective Scaling:** With the ability to learn from data, it can handle increasing complexity without requiring constant reprogramming.

**Demerits**
**Data Dependency:** It relies heavily on the quality and quantity of data to perform well. Poor or biased data can lead to inaccurate or suboptimal results.
**Still Limited to Specific Tasks:** Although more capable than basic artificial intelligence, intermediate artificial intelligence remains task-specific and cannot perform tasks outside its trained scope.

**1.1.3.** Caliber Sophisticated Artificial Intelligence - These departments frequently use sophisticated techniques like deep learning, neural networks, and complicated data analytics. Caliber Sophisticated Artificial Intelligence provides real-time decision support and sophisticated predictive analytics that have revolutionary effects for the pharmacy industry. Artificial Intelligence is capable of, for instance, accurately predicting possible adverse drug reactions and recommending individualized treatment plans based on the analysis of intricate patient health records.[38] It can also integrate data from various sources, such as electronic health records and genetic information, to identify trends and optimize drug therapies. Additionally, artificial intelligence -driven systems can enhance drug discovery and development by analyzing vast amounts of research data, speeding up the identification of new medications.

**For examples,** Deep Learning Models, Predictive analytics and personalization, Natural language processing (NLP).

**Merits**
**Autonomous Learning**: Sophisticated artificial intelligence systems can learn continuously from large datasets, improving their accuracy and decision-making capabilities over time without human intervention.

**Human-Like Interaction**: Advanced artificial intelligence systems can engage in more natural interactions, understand emotions, and provide human-like decision-making, improving experiences in areas like healthcare, education, and customer service.

**Demerits**
**High Development Cost**: The complexity of developing, training, and deploying sophisticated artificial intelligence systems requires significant computational resources, time, and financial investment.

**Data and Resource Intensive**: These systems need vast amounts of high-quality data and powerful computational resources, which can be difficult to obtain or expensive to maintain.

**1.1.4.** Presence Localized Artificial Intelligence - refers to real-time interaction systems designed to operate in specific physical environments. This type of artificial intelligence has the potential to greatly enhance patient care, boost productivity, and simplify a number of processes in the pharmacy sector.[21]

**For example,** pharmacies can stock pertinent medications and provide targeted health programs by using artificial intelligence to analyze local health data and predict and address common health issues within a community. It can also ensure compliance with regional drug regulations and guidelines by automating documentation and reporting.

**Merits**
**High Customization**: Tailored to a specific environment, allowing for highly specialized performance and efficient task execution.
**Low Latency**: Operating in a local environment reduces the time it takes to respond to tasks or make decisions, improving the speed and reliability of services.

**Demerits**

**Limited Scope**: It is designed to work within a specific environment and may not perform well or be adaptable in different or broader contexts.

**Inflexibility:** Localized artificial intelligence systems may struggle to adapt to changes in the environment or new tasks outside their predefined operational scopes.

**1.1.5.** Presence Multidisciplinary Artificial Intelligence - The term "presence multidisciplinary Artificial Intelligence " describes artificial intelligence systems that incorporate knowledge from several departments or specialties in the pharmaceutical industry. These technologies improve several parts of pharmaceutical operations by combining domain expertise, data sources, and artificial intelligence techniques.[21,24] Caliber Multidisciplinary Artificial Intelligence offers substantial benefits in pharmacy by integrating expertise from various fields, enhancing both patient care and operational efficiency.

**For example**, artificial intelligence systems can combine insights from pharmacology, genomics, and patient health data to create highly personalized treatment plans and optimize medication regimens. This interdisciplinary approach enables pharmacies to better manage complex cases, such as those involving multi-drug therapies or rare conditions, Health System Integration, Multidisciplinary Use.

**Merits**

**Broader Problem-Solving Ability**: By combining insights from multiple fields, multidisciplinary artificial intelligence can tackle more complex problems that require diverse knowledge.

**Increased Flexibility:** It can operate in a wide variety of industries or sectors, from healthcare to engineering, making it versatile and adaptable.

**Demerits**

**High Complexity**: Developing and managing multidisciplinary artificial intelligence systems can be challenging due to the complexity of integrating diverse knowledge bases, tools, and datasets.

**Coordination Challenges**: Bringing together different disciplines may result in communication barriers or conflicts in methodology, making coordination difficult.

**1.1.6.** Presence Pervasive Artificial Intelligence - Presence Pervasive Artificial Intelligence, describes artificial intelligence systems that are smoothly incorporated into routine situations and procedures. These systems frequently make use of ubiquitous computing technologies to offer ongoing, context-aware support. It has the potential to greatly improve a number of pharmacy-related departments by facilitating real-time decision-making, increasing productivity, and improving patient care.[38] This ongoing artificial intelligence presence frees up pharmacists to concentrate more on patient counseling and complex clinical decisions, which improves patient outcomes and optimizes resource management.

**For examples**, Healthcare Network Integration, Applications in Public Health.

**Merits**

**Increased Efficiency**: It automates everyday tasks and optimizes processes, saving time and energy for users, whether at home, in the workplace, or in public spaces.

**Enhanced Connectivity:** It connects multiple devices and systems to create smart ecosystems, making it easier for devices to communicate and work together autonomously.

**Demerits**

**Privacy Concerns**: Continuous data collection from various devices raises serious concerns about privacy and the potential misuse of personal information.

**Security Risks**: The interconnected nature of pervasive artificial intelligence increases vulnerability to cyber attacks and system failures, potentially compromising sensitive data or disrupting daily life.[39]

**Table 1: The table shows the classification factors with their descriptions and examples.[7,8]**

| Classification factor | Description | Examples |
|---|---|---|
| Caliber Artificial Intelligence | The level of complexity and sophistication of the artificial intelligence system. | Basic Artificial Intelligence:<br>Rule- based systems, Automated Dispensing.<br>Intermediate Artificial Intelligence:<br>Machine Learning Models, enhanced automation.<br>Sophisticated Artificial Intelligence:<br>Deep Learning Models, Predictive Analytics and Personalization, NLP. |
| Presence Artificial Intelligence | The extent and content of artificial intelligence application within clinical pharmacy. | Localized Artificial Intelligence:<br>Pharmacy Operation, Clinical Decision Support.<br>Multidisciplinary Artificial Intelligence: Health System Integration<br>Multidisciplinary Use.<br>Pervasive Artificial Intelligence:<br>Healthcare Network Integration, Application in Public Health. |

**1.2 Applications of Artificial Intelligence in various pharmacy fields**

**1.1.7 Caliber Basic Artificial Intelligence**

In Clinical pharmacy Drug Administration is routines and dosages for patient medications are tracked and managed by basic artificial intelligence systems. Assures patients follow their recommended regimens and lowers the chance of prescription errors.[23] It has verification of Drug Interactions artificial intelligence systems that are based on rules look for possible medication interactions. Prevents dangerous interactions, improving patient safety.[24] Support for Clinical Decision Making, makes suggestions in accordance with established clinical principles. Helps chemists make prompt, well-informed judgements.[26,27]

**1.1.7 Caliber Intermediate Artificial Intelligence**

In Clinical pharmacy, a Management of Medication Therapy (MTM) examines patient data to forecast adverse drug reactions, find possible drug interactions, and optimize prescription schedules. Decreased adverse medication events, better therapeutic outcomes, and increased patient safety.[28,29] In Community pharmacy, a customer service artificial intelligence chat bots help handle refill requests, respond to frequently asked customer questions, and provide advice on how to take medications. Increase consumer satisfaction, less work for pharmacy employees, and round-the-clock assistance.[3] In hospital pharmacy, a Clinical Decision Support offer evidence-based suggestions for the administration, dosage and use of medication. Increased patient safety, better clinical judgement, and adherence to protocols. In Research and development has a Drug discovery, Artificial Intelligence examine huge data sets to find possible medication candidates and gauge their safety and effectiveness.[6] It includes quicker medication discovery, lower research expenses, and better success rates. In the field of regulatory affairs, monitoring compliance with legal requirements by examining data and identifying instances of non-compliance. It includes a lower chance of fines from regulations, better compliance, and greater reputation. Health Informatics Electronic Health Records (EHR), use natural language processing and predictive analytics to improve EHR systems. It includes better patient insights, higher-quality data, and improved clinical workflows. Supply Chain Management Demand fore casting, make use of past data and trends to forecast demand for pharmaceuticals and medical supplies. It includes cost savings, an optimized supply chain, and decreased waste.[30] By implementing intermediate artificial intelligence, these departments can increase patient outcomes, improve operational efficiency, and gain a competitive advantage in the pharmaceutical industry.

**1.1.7 Caliber sophisticated Artificial Intelligence**

In Clinical pharmacy, customized health care, customize drug schedules for each patient by analyzing genetic, environmental, and lifestyle variables. It includes better patient outcomes, decreased side effects, and increased therapy efficacy. In Community pharmacy, advanced customer interaction uses machine learning and Natural Language Processing (NLP) to respond to consumer inquiries with greater accuracy and context awareness. It includes better patient education, more individualized care, and increased customer satisfaction. In Hospital pharmacy, systems for Clinical Decision Support (CDSS) Offer evidence-based suggestions in real time for intricate clinical situations. It includes better clinical judgement, less variation in patient treatment, and better patient outcomes. In drug development and discovery, make use of artificial intelligence to forecast compound activity, find new medicinal targets, and improve medication formulations.[19] It includes lower research and development (R&D) expenses, quicker medication discovery, and increased success rates. In the field of regulatory affair, compliant with regulations with intelligence use artificial intelligence to assure compliance by continuously monitoring and analyzing changes to regulations. It includes lowered non-compliance risk, proactive regulatory change adaptation, and improved operational effectiveness. In health informatics has EHR Systems with Advanced use artificial intelligence integration to improve EHR features like real-time clinical insights, automated charting, and predictive analytics. It includes enhanced patient insights, more accurate data output, and more efficient healthcare workflows. Management of the Supply Chain, a predictive Upkeep use artificial intelligence to forecast and stop supply chain equipment breakdowns. Enhanced dependability, decreased downtime, and increased operational efficiency. In pharmacovigilance, identification of adverse event applies artificial intelligence, to patient data analysis to identify possible adverse medication reactions early in good time. It includes increased patient safety, quicker detection of safety problems, and better public health results.[31] The pharmacy industry can achieve major improvements in productivity, patient safety, and overall healthcare outcomes by implementing advanced artificial intelligence in these departments.

**Table 2: The table Shows the Caliber Artificial Intelligence technologies, their organization, functions, and cost considerations.**

| Caliber | Artificial Intelligence Technology | Organization | Function | Cost Considerations |
|---|---|---|---|---|
| Basic Artificial Intelligence | Rule-based Systems | Hospitals, Clinics, Pharmacies | Drug-drug interaction checking, alerts | Initial setup cost, maintenance, staff training |
| Basic Artificial Intelligence | Expert Systems | Pharmaceutical Companies | Drug formulation, clinical trials | Development cost, integration with existing systems, ongoing updates |
| Basic Artificial Intelligence | Natural Language Processing (NLP) | Healthcare Providers, EHR Vendors | EHR data extraction, patient interaction | Software licensing, training, customization for specific use cases |
| Intermediate Artificial Intelligence | Machine Learning (ML) | Hospitals, Research Labs | Predictive modeling, patient outcome prediction | Data acquisition, computational resources, model training, expert personnel |
| Intermediate Artificial Intelligence | Natural Language Processing (NLP) | Hospitals, EHR Vendors, Pharmacies | Advanced EHR data analysis, clinical documentation | Licensing fees, customization, integration with existing systems |
| Intermediate Artificial Intelligence | Decision Support Systems (DSS) | Healthcare Providers, Insurance Companies | Complex treatment planning, risk assessment | Implementation cost, regular updates, regulatory compliance |
| Intermediate Artificial Intelligence | Reinforcement Learning | Pharmaceutical Companies, Research Institutions | Drug discovery, clinical trial optimization | High computational costs, long training times, data quality |
| Sophisticated Artificial Intelligence | Natural Language Understanding (NLU) | Advanced Healthcare Systems, Artificial Intelligence Labs | Understanding and generating human language | High development cost, integration complexity, ongoing refinement |
| Sophisticated Artificial Intelligence | Generative Adversarial Networks (GANs) | Research Institutions, Drug Discovery Firms | Creating synthetic data, drug discovery | High computational resources, specialized hardware, expert personnel |
| Sophisticated Artificial Intelligence | Advanced Robotics | Hospitals, Surgical Centers | Robotic surgery, rehabilitation therapy | High initial cost, maintenance, specialized training |

#### 1.1.7. Presence Localized Artificial Intelligence

In Clinical pharmacy, real-time patient monitoring track medication adherence and patient vital signs using sensors and Internet of Things devices linked to artificial intelligence systems. It includes prompt interventions, immediate identification of changes in health, and individualized patient care. In Community pharmacy, automation of medication dispensing procedures using robotics and Artificial Intelligence. It includes decreased dispensing errors, increased productivity, and enhanced inventory control.[32] In Hospital pharmacy, efficiency of operations makes use of artificial intelligence to forecast resource requirements, monitor medicine usage trends, and streamline processes. Improved worker productivity, lower expenses, and streamlined operations.[33] In research and development, laboratories automation testing, analysis and data interpretation by integrating artificial intelligence into laboratory apparatus and procedures. It includes shorter research deadlines, more precise data, and lower experimental variability. In regulatory affairs, compliance monitoring employs artificial intelligence to keep an eye on pharmaceutical operations' compliance with rules and guidelines. It includes lowered risks associated with noncompliance, prompt notifications of regulatory changes, and proactive process modifications. In medical data management, integration of data in real time to enable real-time data transmission and analysis by integrating them with electronic health records (EHR).[24] It includes better decision assistance, better care coordination, and thorough patient records. In supply chain management, supply chain transparency to track shipments, manage supplier relationships, and give real-time visibility into supply chain processes. It includes improved supply chain interruption response times, proactive risk management, and more transparency.[34] Existence by facilitating real-time decision-making, enhancing operational procedures, and providing individualized care experiences, localized Artificial Intelligence benefits the pharmacy industry. It is a major step forward in applying artificial intelligence technology to pharmacy environments' unique requirements and improving patient and healthcare provider outcomes.

#### 1.1.8. Presence Multidisciplinary Artificial Intelligence

In Clinical pharmacy, precision health care to the analysis of clinical, environmental, and genetic data to

customize drug regimens for specific patients. It includes fewer side effects, improved medication schedules, and increased therapeutic efficacy.[32] In Community pharmacy, comprehensive patient management to oversee drug adherence initiatives, give health counselling, and provide tailored drug advice. It includes better drug adherence, more patient participation, and greater health literacy.[35] In Hospital pharmacy, it has automation in pharmacy put into practice automated and artificial intelligence -driven robots and systems for sterile compounding, inventory control, and medicine dispensing. It includes improved pharmaceutical safety, less human error, and increased efficiency.[36] In development and research, drug development and discovery apply artificial intelligence to large-scale dataset analysis, drug interaction prediction, formulation optimization, and discovery of novel therapeutic targets. It includes shortened timeframes for drug discovery, lower R&D expenses, and higher clinical trial success rates. In the field of regulatory affairs, adherence to regulations manage documents, automate compliance reporting, and make sure regulations are followed by using artificial intelligence. It includes a proactive regulatory approach, streamlined audit procedures, and decreased compliance risks. In health informatics, integrated data analytics to enhance population health management, facilitate clinical decision-making, and analyze extensive patient data.[38] It includes greater care coordination, enhanced data-driven insights, and enhanced patient outcomes. In management of the supply chain transparency in the supply chain to track shipments, monitor supply chain activities in real time, and guarantee regulatory compliance. Proactive risk management, improved transparency, and expedited procurement procedures are the advantages.[37] Existence In pharmacy, multidisciplinary Artificial Intelligence combines a range of skills and tools to tackle complicated problems, boost productivity, and provide more individualized patient care. It encourages innovation in healthcare delivery, improves decision-making skills, and promotes departmental teamwork.

### 1.1.9. Presence Pervasive Artificial Intelligence

In Clinical pharmacy, ongoing evaluation and guidance use wearable technology and artificial intelligence - powered sensors to continuously monitor patient vitals, medication compliance, and health trends. It includes preemptive interventions, tailored therapy modifications, and early identification of changes in health.[32] In Community pharmacy, personalized customer interaction uses chat bots and smartphone apps driven by artificial intelligence to offer individualized drug recommendations, refill alerts, and health education. It includes better drug adherence, happier customers, and more pharmacy loyalty.[35] In Hospital pharmacy integrated clinical decision support to clinical processes and electronic health records (EHR) to offer real-time decision support for patient care and medication management. It includes better medication reconciliation, decreased adverse events, and improved clinical outcome.[38] In research and development, drug discovery driven by artificial intelligence make use of artificial intelligence algorithms to evaluate big datasets, forecast medication interactions, and pinpoint possible treatment targets. It includes a quicker drug discovery process, lower expenses, and higher clinical trial success rates. In regulatory affairs, automated compliance monitoring to detect possible hazards, automate compliance reporting, and keep an eye on adherence to regulatory standards. It includes less regulatory risks, lower compliance costs, and improved audit readiness.[32] In health informatics, real-time data integration and analysis with electronic health record (EHR) systems is to enhance care coordination, facilitate clinical decision-making, and analyze patient data. It includes better treatment plans, increased patient safety, and better healthcare results. In management of the supply chain visibility in real time to track shipments in real time, keep an eye on supplier performance, and make sure regulations are followed. Proactive risk management, improved transparency, and expedited procurement procedures are the advantages. Existence through the integration of intelligent capabilities into routine activities and settings, pervasive artificial intelligence revolutionizes pharmaceutical operations. It helps pharmacists to provide more effective, individualized care, enhance patient outcomes, and quickly adjust to the ever-changing needs of the healthcare system.

**Table 3: The table shows the Presence Artificial Intelligence technologies, their organization, functions, and cost considerations.[47,48]**

| Presence | Artificial Intelligence Technology | Organization | Function | Cost Considerations |
|---|---|---|---|---|
| Localized Artificial Intelligence | Chat bots | Pharmacies, Customer Service | Patient education, medication reminders | Development and deployment costs, server costs, privacy considerations |
| Localized Artificial Intelligence | Rule-based Systems | Hospitals, Clinics, Pharmacies | Drug-drug interaction checking, alerts | Initial setup cost, maintenance, staff training |
| Localized Artificial Intelligence | Image Recognition Systems | Hospitals, Radiology Departments | Medical imaging analysis, diagnostics | High initial cost, specialized hardware, ongoing maintenance |
| Multidisciplinary | Machine Learning (ML) | Hospitals, Research | Predictive | Data acquisition, |

| | | | | |
|---|---|---|---|---|
| Artificial Intelligence | | Labs | modeling, patient outcome prediction | computational resources, model training, expert personnel |
| Multidisciplinary Artificial Intelligence | Natural Language Processing (NLP) | Hospitals, EHR Vendors, Pharmacies | Advanced EHR data analysis, clinical documentation | Licensing fees, customization, integration with existing systems |
| Multidisciplinary Artificial Intelligence | Decision Support Systems (DSS) | Healthcare Providers, Insurance Companies | Complex treatment planning, risk assessment | Implementation cost, regular updates, regulatory compliance |
| Pervasive Artificial Intelligence | Advanced Deep Learning Models | Research Hospitals, Specialized Clinics | Personalized medicine, advanced diagnostics | High computational cost, continuous data feeding, expert personnel |
| Pervasive Artificial Intelligence | Natural Language Understanding (NLU) | Advanced Healthcare Systems, artificial intelligence Labs | Understanding and generating human language | High development cost, integration complexity, ongoing refinement |
| Pervasive Artificial Intelligence | Generative Adversarial Networks (GANs) | Research Institutions, Drug Discovery Firms | Creating synthetic data, drug discovery | High computational resources, specialized hardware, expert personnel |

### 1.2. Future of Artificial Intelligence

Self-driving cars are already powered by artificial intelligence thanks to the efforts of companies like Google and Uber. Artificial Intelligence's ability to assist drivers with disabilities and reduce accident rates will have a significant impact on the automated transportation industry. More advanced artificial intelligence systems may eventually replace people and assist in dangerous factory occupations. Artificial Intelligence systems can forecast climate change by utilizing environmental technologies and data sciences. Artificial Intelligence systems will conduct about 80% of customer support operations in an efficient and timely manner. Artificial intelligence systems' symptom-identification and medical data processing capabilities will simplify personalized health management.[29] By interacting with a robotic system, cyborg technology can assist patients in using artificial prosthesis for a better quality of life. Artificial Intelligence in space technology is able to analyze orbital trajectories during successful launches and recommend course of action based on its findings. In the drug industry, Artificial Intelligence is the wave of the future, yet the technology is here already. Above all, Artificial intelligence has the potential to save lives by reducing expenses and developing novel, efficient treatment procedures. Regarding the selection of individuals for clinical trials, the program will assist businesses in identifying issues with medications far sooner in terms of their safety and efficacy.[28] Therefore, adopting artificial intelligence and machine learning solutions will benefit the pharmacy sector greatly. It can be effectively applied to build a robust and long-lasting pipeline of novel medications. We would be able to develop medications more quickly and more cheaply if we could harness the power of contemporary supercomputers and machine learning is adopted.[39]

### 1.3. Outcome of Artificial Intelligence

The artificial intelligence has the potential to revolutionize pharmacy practice by enhancing decision-making through improved drug interaction predictions and personalized medication regimens, while also increasing operational efficiency through task automation. To fully capitalize on these advancements, pharmacy education must evolve to include artificial intelligence and data science principles in the curriculum, and continuous education is crucial for keeping pharmacists updated with emerging technologies. Access to specialized training, such as artificial intelligence -focused courses and residencies, is necessary for practical experience. Additionally, the pharmacy education system must be flexible to adapt to rapid technological changes, and collaborative efforts between academic institutions and industry can enhance the relevance and application of artificial intelligence training.[40] Fostering a culture of innovation and continuous learning will further support the effective integration of artificial intelligence into pharmacy practice.

### 1.4. Impact of Artificial Intelligence in pharmacy

The integration of artificial intelligence into pharmacy practice represents a transformative shift in the field, necessitating an evolution in both educational strategies and professional skills. As highlighted in the conclusion, the convergence of artificial intelligence with human expertise is not merely a theoretical concept but a practical reality with far-reaching implications. The field of artificial intelligence is still in its formative stages, yet it promises to revolutionize various aspects of healthcare, including pharmacy practice.[49] This discussion aims to expand on the conclusion by exploring the implications of artificial intelligence for pharmacists, the need for educational reforms, and potential strategies for ensuring that pharmacists are well-prepared to harness artificial intelligence technologies effectively.

### 1.5. Implications for Pharmacy Practice

Artificial intelligence has the potential to significantly enhance pharmacy practice through improved data

analysis, decision-making, and patient care. For example, artificial intelligence algorithms can assist in predicting drug interactions, personalizing medication regimens, and optimizing therapeutic outcomes based on large datasets. As artificial intelligence systems become more sophisticated, they will increasingly support pharmacists in managing complex cases, ensuring patient safety, and enhancing the overall efficiency of pharmacy services. However, to fully leverage these advancements, pharmacists must be equipped with both the technical skills and the conceptual understanding of artificial intelligence technologies.[50]

### 1.6. Educational Reforms

The current educational framework for pharmacy students and professionals must evolve to incorporate artificial intelligence and data science principles. It is essential that pharmacy curricula include components of health informatics that cover the fundamentals of artificial intelligence, data management, and analytical techniques.[47] By integrating these elements into the PharmD program, future pharmacists will be better prepared to navigate the complexities of artificial intelligence applications in healthcare.

Moreover, continuous education and professional development are critical. As artificial intelligence technologies advance rapidly, ongoing training and certification in artificial intelligence related subjects will be necessary for pharmacists to stay current with emerging tools and methodologies. Institutions should offer specialized courses, workshops, and residency programs focused on artificial intelligence and data science to provide pharmacists with hands-on experience and in-depth knowledge.

### 1.7 Strategies for Implementation

To ensure that pharmacists are adequately prepared for the integration of artificial intelligence into their practice, several strategies can be considered. First, the pharmacy education system must be adaptable and responsive to technological advancements. This flexibility will allow educational programs to incorporate new artificial intelligence tools and methodologies as they emerge.

Second, collaboration between academic institutions, healthcare organizations, and technology developers can facilitate the creation of relevant educational content and practical training opportunities. Such partnerships can help bridge the gap between theoretical knowledge and practical application, ensuring that pharmacists gain experience with real-world artificial intelligence systems.[55]

Finally, fostering a culture of innovation and continuous learning within the pharmacy profession will be essential. Encouraging pharmacists to field engage with emerging technologies, participate in research, and contribute to the development of artificial intelligence solutions can drive the advancement of the and improve patient care outcomes.

### 1.8 CONCLUSION

1. Artificial Intelligence holds great promise for improving patient care and streamlining pharmacy operations.

2. To fully realize this potential, pharmacists must be given the skills and information they need through Artificial Intelligence -focused education and continual professional development.
3. Pharmacists will need to be prepared for leadership in a healthcare environment that is becoming more and more Artificial Intelligence -driven by proactively modifying professional and educational frameworks.

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