

## Artificial Intelligence in Pharmaceutical Services and the Concept of Pharmaco-Intelligence

Nana Shashiashvili <sup>1,2</sup>

Doctor of Pharmaceutical Sciences, Associate Professor, <sup>1</sup>Georgian Technical University,  
Department of Pharmacy; <sup>2</sup>Tbilisi State Medical University, Department of Social and Clinical  
Pharmacy

### Abstract

Pharmaceutical intelligence, or the application of artificial intelligence (AI) in pharmacy systems, represents one of the most promising technological advancements, significantly transforming and optimizing pharmaceutical practices. AI technologies enhance the accuracy of medication distribution, inventory management, and patient safety. Among these benefits, AI's role in improving drug safety is particularly crucial, as it aids in analyzing interactions between medications taken by patients, thereby preventing adverse reactions. Furthermore, the use of AI supports the automation of medication distribution processes, leading to operational optimization and increased efficiency. AI also facilitates the analysis of "big data," enabling pharmacists to make more precise predictions and decisions, ultimately improving patient care and outcomes. While the integration of AI in healthcare presents challenges such as privacy concerns and high implementation costs, its potential in effectively managing complex situations and refining treatment processes far outweighs these obstacles. Research indicates that proper integration of AI into pharmacy systems will not only enhance operational processes but also improve patient safety and treatment results, requiring the assurance of trust and regulatory compliance.

**Keywords:** Artificial intelligence, Medicine, Pharmacointelligence, Pharmacy.

### Relevance and Importance of the Topic

The integration of computing technologies into the pharmacy sector began in the 1980s. Since then, computers have become essential tools for data collection, retail sales management, clinical research, medication storage, education, the development of clinical pharmacy, and many other areas. The development of artificial intelligence (AI) has ushered in a new era of transformation for pharmacy practice, with its future potential still uncertain. Existing experiences demonstrate that expert systems based on AI are successfully used in clinical medicine for diagnostic purposes, while newer programs

are focused specifically on managing drug therapies. These systems assist pharmacists in evaluating drug interactions, monitoring treatment, and selecting the appropriate medication formulations. Today, AI has numerous applications that can significantly enhance pharmaceutical practices. Pharmacists should explore these opportunities as pharmaco-intelligence is increasingly becoming an integral part of real-world practice.

According to the Oxford English Dictionary, artificial intelligence refers to the capability of computers and machines to exhibit or simulate intellectual behavior. It encompasses programs designed to perform tasks typically requiring human intelligence and extract conclusions from large data sets, often through machine learning techniques.

AI is commonly divided into two categories:

#### **Narrow AI**

Specifically created to perform specific tasks (such as facial recognition or language translation)

#### **General AI**

Theoretical concept that may, in the future, perform any intellectual task achievable by humans

Additionally, Natural Language Processing (NLP) allows systems to understand and respond to human language, while large language models (LLMs), like ChatGPT, are already used for text generation and analysis. While many modern digital systems claim to be "AI-based," some are merely rule-based algorithms and do not truly employ artificial intelligence. Such cases are often referred to as instances of "algorithmic misperception."

Artificial intelligence offers significant benefits to pharmaceutical practice at both clinical and administrative levels. AI can optimize drug release processes, improve therapy safety, reduce errors, enhance patient monitoring, and accelerate decision-making. Given these capabilities, it is essential for the pharmaceutical community to prepare for the effective integration of AI technologies across education, practice, and policy [1].

### **Research Objective**

1. To analyze the potential and challenges of integrating artificial intelligence (AI) into pharmacy practice, in order to determine its role in enhancing the safe and effective use of medications.
2. To investigate the principles of AI system integration, examining their impact on professional workflows, drug safety, and ethical considerations.
3. To develop general recommendations that will promote the effective and ethical application of AI technologies in pharmacy practice.

## Methods

The study was conducted based on the analysis of existing literature, utilizing the following methods:

- **Literature Review:** The research draws upon scientific and professional literature, reports, and statistics related to the implementation of AI systems in healthcare and pharmacy practices. The analysis includes evaluations of various authors, organizations, and studies concerning the development and use of AI technologies in the pharmacy sector.
- **Documentary Analysis:** Important documents and institutional policies regarding the use of AI systems in the pharmacy sector were examined, alongside a review of standards related to the implementation and regulation of these technologies.
- **Creative Analysis:** The primary trends in the use of AI technologies impacting various aspects of pharmacy practice, such as medication management, patient monitoring, and risk assessment, were identified and analyzed.

## Results

Healthcare systems are actively transitioning to a care model centered around the community and collaborative approaches, replacing the traditional hospital-based care. In this transitional phase, pharmacists can make significant contributions to improving patient safety and enhancing the effectiveness of pharmacotherapy, particularly during patient transitions from hospital to community settings. Today, community pharmacies widely use "robotic dispensing systems" that automate workflows for dispensing prescribed medications. These systems consist of three key components:

1. An automatic dispensing robot operated by pharmacy staff;
2. A robot specialized for dispensing powdered medications;
3. A barcode-based dispensing assistant system integrated with a personal digital assistant.

Artificial intelligence (AI) and machine learning (ML) technologies are increasingly being utilized in pharmaceutical practice to personalize services. For instance, ML algorithms effectively and quickly personalize email communication, improving interactions with patients. Chatbots are deployed to enhance service delivery efficiency by simulating interactions between patients and pharmacists. These systems can automatically respond to simple queries and complaints, while more complex issues are forwarded to human staff. A notable example is Walgreens' partnership with a telehealth company, which resulted in a video chat platform enabling patients to remotely connect with healthcare professionals. AI is also beneficial in inventory management, allowing pharmacists to predict future medication needs, ensuring timely stock replenishment, and sending personalized reminders to patients to refill prescriptions. One AI company developed a system for German online and catalog retail that accurately forecasts sales for the next 30 days with 95% precision. This implementation has significantly reduced supply chain delays, with products being delivered to customers in just one or

two days without being stored in inventory. At the University of California, San Francisco (UCSF) Medical Center, robotic technology is successfully used in medication preparation and dosage. According to UCSF, robots have already prepared 3.5 million doses of medication without errors. This robotic system surpasses human capabilities in both precise medication dosing and accurate drug delivery, preparing both oral and injectable medications, including chemotherapy drugs. The robots distribute medications into individually barcoded containers, each containing all the medications a patient requires for a 12-hour period.

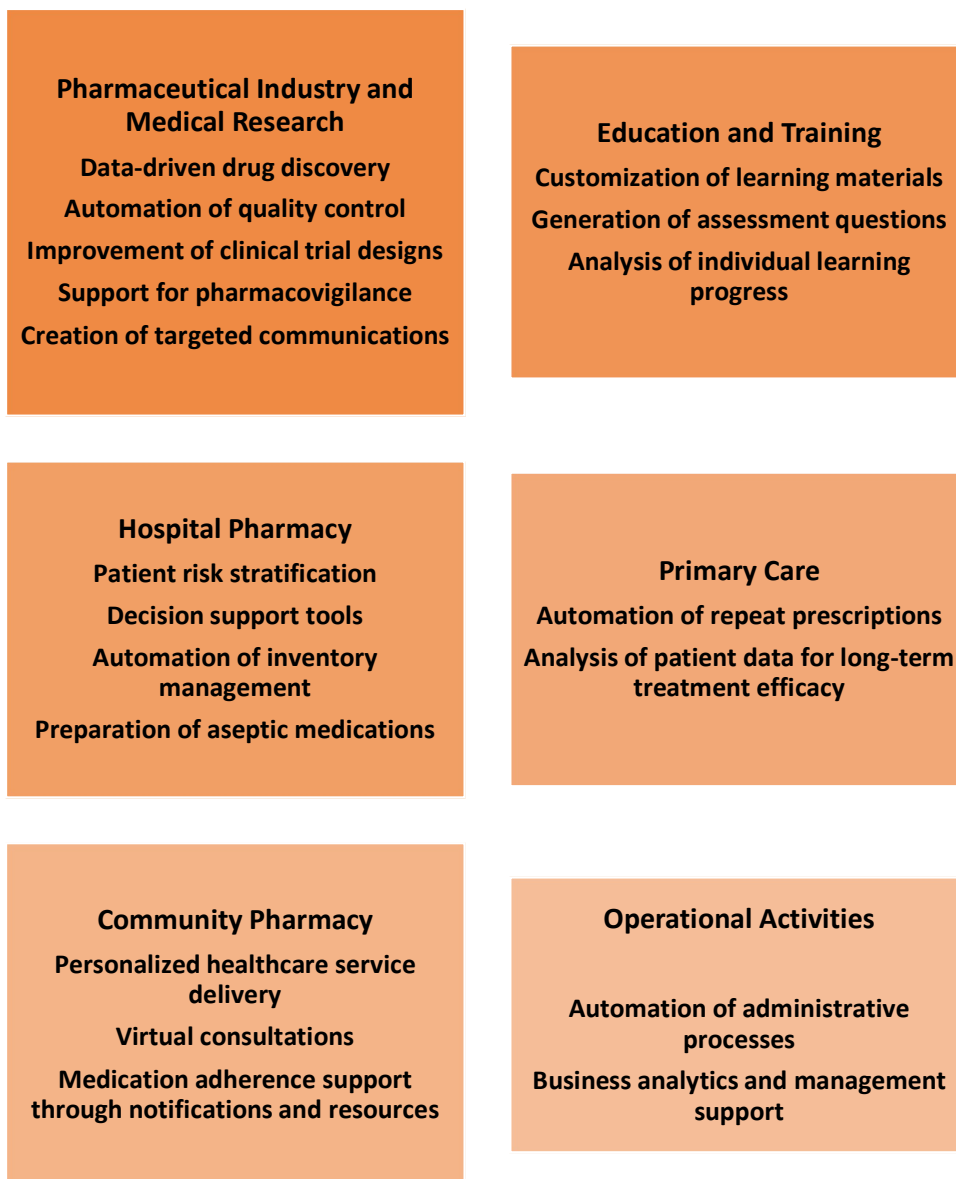
Thus, the concept of "Pharmaco-Intelligence" can be introduced — the integration of artificial intelligence, machine learning, and similar advanced technologies into pharmacy practice to enhance patient care and safety. Successful integration of these technologies requires their inclusion in pharmacy education programs. Pharmacists and all stakeholders must engage in continuous learning about technological innovations to ensure the profession is prepared for a rapidly evolving landscape [2].

**Pharmaco-intelligence represents the convergence of AI technologies and pharmaceutical expertise, providing a scientific foundation for optimizing drug therapy in alignment with evidence-based practice.** By harnessing large-scale healthcare data, machine learning algorithms, and clinical decision support tools, pharmaco-intelligence enables pharmacists and healthcare providers to make informed, timely, and patient-centered therapeutic decisions. This approach strengthens the evidence-based pharmacy model by incorporating real-time analytics, predictive modeling, and personalized risk assessments, which are essential in today's complex and fast-paced clinical environments. As a result, pharmaco-intelligence not only enhances medication safety and efficacy but also promotes more efficient use of healthcare resources, aligning innovation with the core values of scientific rigor and patient care [3].

Professional perspectives published in England, Scotland, and Wales have clearly shown that AI integration can significantly improve patient access to pharmaceutical services, enhance their satisfaction and experience, support clinical decision-making, and strengthen the safety and efficiency of the medication supply chain. Over the past five years, AI's capabilities have rapidly expanded in both clinical and operational fields, with a significant increase in related academic research, public discourse, and opinions. Today, AI is widely used in everyday life, from our smartphones to smart devices. Its application in medical imaging diagnosis is well-established, as evidenced by studies from the Royal College of Radiologists. However, it is important to note that the growing expectations for the technology are accompanied by concerns about potential risks. Therefore, pharmacists and their teams must develop an understanding of AI's capabilities and limitations to support its sensible integration into pharmacy practice. While there is occasional fear that AI may replace human workers, in reality, the technology has the potential to improve workflows and free up pharmacists' time for more patient-centered care. AI does not replace humans — it expands and enhances their abilities. According to a study by the Healthcare Foundation, there is some public skepticism: 53% of people believe AI will distance them from healthcare professionals, and 65% of NHS staff think that the patient connection will weaken. This suggests that the development and implementation of AI must remain human-centered and serve the goal of improving the quality of care.

A research team from University College London Hospitals, led by Dr. Laura Shalkross, is developing an AI system named SamurAI, designed to monitor and optimize the use of antibiotics. This system relies on electronic health records, patients' historical data, and expert recommendations to identify patients in need of clinical review or dosage adjustments for antibiotics.

#### **Potential Applications of AI in Pharmaceutical Practice:**



AI Sciensus processes prescriptions from NHS hospitals through various channels, utilizing AI to scan and match prescriptions with patient records. This process reduces the need for human intervention, enhances accuracy, and strengthens patient safety. While AI is still in the early stages of adoption in pharmaceutical practice, the development of policies, education, and collaboration is crucial to maximize its potential for the benefit of both pharmacists and patients. Although many countries' pharmacy regulations have not yet addressed the effects of AI, this technology offers revolutionary opportunities in medication management, improving patient outcomes, and simplifying

pharmacy operations. As AI evolves, it brings both new opportunities and risks. Regulators and stakeholders must carefully assess the implications of this emerging technology.

Pharmacists have evolved from a traditional role focused solely on dispensing medications to becoming integral members of healthcare teams responsible for ensuring the safe and effective use of medications, optimizing patient outcomes, and enhancing the quality of care. They also provide vital education to patients on drug interactions and contraindications, essential for proper medication use. AI is rapidly transforming not only the pharmacy sector but also the entire healthcare industry. Its potential in pharmacy lies in improving medication management and personalized patient care. With the integration of AI-based technologies, pharmacists will be able to make more precise and effective decisions, enabling them to deliver more tailored care to patients [4].

AI is revolutionizing pharmacy practice by introducing advanced capabilities that enhance efficiency, accuracy, and patient care. Through the analysis of large datasets, prediction of trends, and the autonomous execution of complex processes, AI enables pharmacies to meet modern healthcare demands. This innovative technology is setting the stage for advancements in inventory management, automated dispensing, and decision support, ultimately driving the transformation of the pharmaceutical landscape.

**1. Inventory Management:** AI-driven solutions are radically transforming pharmacy inventory management by ensuring real-time stock adjustments to match demand, minimizing inefficiencies and waste.

•**Accurate Forecasting:**

- Machine learning algorithms analyze extensive data sets, including sales history, seasonal trends, and market fluctuations, to predict inventory needs with high accuracy. This precision prevents overstocking and expiration issues, ensuring medication availability.

•**Accurate Forecasting:**

- Machine learning algorithms analyze extensive data sets, including sales history, seasonal trends, and market fluctuations, to predict inventory needs with high accuracy. This precision prevents overstocking and expiration issues, ensuring medication availability.

•**Automation of Reordering:**

- AI integrates with supply chain systems to automate the reordering process, reducing manual intervention. By processing real-time inventory data, these systems identify low stock levels and place orders promptly to prevent shortages and improve operational efficiency.

**2. Automated Dispensing:** The integration of AI and robotics into medication dispensing is revolutionizing pharmacy workflows, ensuring maximum accuracy and efficiency.

#### •**Prescription Filling Accuracy:**

•AI-powered automated dispensing systems significantly increase accuracy when processing high volumes of prescriptions. These systems reduce human error, ensuring patients receive the correct medications and dosages.

#### •**Handling Increased Demand:**

•Hospitals and medical institutions benefit from AI-enhanced dispensing systems, effectively managing large volumes of prescriptions. These systems streamline workflows by reducing delays and ensuring timely medication delivery.

#### •**Freeing Pharmacists' Time:**

•With AI automating routine dispensing tasks, pharmacists can redirect their time to patient-focused activities such as consultations and medication reviews, ultimately improving the quality of service provided to patients.

**3. Enhanced Decision Support:** AI is becoming an indispensable tool in clinical decision-making, assisting pharmacists in navigating complex patient care scenarios with greater accuracy and confidence [4,5,6].

#### **Patient Data Analysis:**

AI systems process large amounts of patient information, including medical histories, allergies, and current medications, to identify drug-drug interactions and recommend dosage adjustments. This real-time analysis enhances medication safety and reduces the risk of adverse effects.

AI holds immense potential in revolutionizing pharmacy practice worldwide. This research examines pharmacists' perceptions of AI's role in pharmacy practice, their willingness to adopt it, and the barriers to its implementation in public pharmacies in Ethiopia.

A cross-sectional study conducted by community pharmacists in Ethiopia aimed to examine their perceptions and readiness to integrate artificial intelligence (AI) into pharmacy practice. Data collection was achieved through a self-administered questionnaire, and statistical analysis included independent samples t-tests, one-way ANOVA, and post-hoc analyses. Linear regression analysis was performed to investigate the associations between pharmacists' perceptions and their willingness to use AI, in relation to factors such as education level, professional experience, exposure to AI technologies, and knowledge of AI. A statistically significant result was considered at  $p < 0.05$ . Of the 241 pharmacists surveyed, 225 (93.3%) completed the study. The findings revealed that almost two-thirds (67.1% and 66.2%) of pharmacists working in community pharmacies expressed interest in using AI applications, particularly in the group with high perceptions and willingness to adopt AI. Notably, pharmacists with a bachelor's degree or higher, those using scientific drug information resources, and those with more perceived knowledge of AI were more inclined to utilize the technology. Major barriers identified included lack of internet access (89.3%), insufficient software and hardware for AI applications (88.2%), and limited training opportunities (80.9%). However, pharmacists also noted that improved internet access (93.3%), clear policies and frameworks (91.6%), and accessible research and educational



resources (89.3%) were key factors for successful AI integration. Despite pharmacists' positive perceptions and readiness, the adoption of AI in public pharmacies may be hindered by resource constraints, inadequate training, and infrastructure issues. Therefore, supportive policies, institutional frameworks, enhanced training, and practical support during the implementation process are essential for successful AI adoption [7].

**Pharmaco-intelligence**, as an AI-driven approach within pharmaceutical services, not only strengthens evidence-based pharmacy but also provides valuable tools for **pharmacoeconomic analysis** and the **economic evaluation of the pharmacist's role**. By generating real-time data on medication use, clinical outcomes, and resource utilization, pharmaco-intelligence enables more precise assessments of the cost-effectiveness and impact of pharmacists' interventions. This is particularly important when applying various types of pharmacoeconomic analyses—such as cost-effectiveness, cost-utility, and cost-benefit evaluations—to demonstrate the clinical and economic value of pharmacy services. Ultimately, integrating pharmaco-intelligence supports a more data-informed and outcome-oriented framework, where the pharmacist's contribution to patient care can be quantified, justified, and continuously optimized [8].

Considering experiences from various countries, the role of AI in pharmacies remains highly significant. Its application shows promise in medication management, inventory optimization, and improving patient safety. AI systems analyze medical and pharmaceutical data, promoting efficiency, accuracy, error detection, and the prevention of medication-related harm. Looking ahead, AI could have an even greater impact as its use expands in community pharmacies. AI may assist pharmacists in addressing drug interactions and potential side effects. Algorithms processing large patient datasets could help manage treatment processes more effectively, ultimately improving patient health outcomes. Training and resources must be prioritized to elevate pharmacists' qualifications, laying the foundation for broader AI use in pharmacies, which will ultimately enhance healthcare outcomes [9,10,11].

Integrating AI into pharmacy practice offers potential benefits, such as ensuring safe and effective medication use, improving operational efficiency, and achieving better patient outcomes. However, this process involves certain challenges that require attention from professional, ethical, legal, and technical perspectives. A global approach is necessary to ensure that AI use not only simplifies processes but also maintains safety and quality standards. The following recommendations outline key strategies and directions for effectively integrating AI into pharmacy practice globally:





Implementing these recommendations will help advance pharmacy practice, where AI becomes a valuable tool for ensuring safe and effective medication use, improving operational efficiency, and achieving better health outcomes for patients.

## Conclusion

The integration of artificial intelligence (AI) into pharmacy practice presents both innovative opportunities and certain challenges. AI technologies have the potential to streamline pharmaceutical

processes, enhance operational efficiency, and contribute to better patient care. However, the adoption and effective implementation of these technologies continue to face significant barriers, including high costs, regulatory concerns, and issues related to trust.

Despite these challenges, the potential of AI systems to improve data analysis and forecasting greatly enhances the effectiveness of its applications. The use of "big data" through AI can support pharmacists in making more informed decisions, particularly in improving medication safety. However, for full integration of these technologies, increased investment in financial resources and training will be required.

It is crucial that issues related to trust, confidentiality, and security remain central to the attention of all stakeholders during both the adoption and usage phases of AI. In conclusion, while AI has the potential to transform pharmacy practice, realizing its full benefits will necessitate further regulatory development, comprehensive training, and the incorporation of technological advancements, all of which will optimize its potential and improve patient outcomes.

#### REFERENCES:

1. Raza MA, Aziz S, Noreen M, Saeed A, Anjum I, Ahmed M, Raza SM. Artificial Intelligence (AI) in Pharmacy: An Overview of Innovations. *Innov Pharm*. 2022 Dec 12;13(2):10.24926/iip.v13i2.4839. doi: 10.24926/iip.v13i2.4839. PMID: 36654703; PMCID: PMC9836757.
2. Chalasani SH, Syed J, Ramesh M, Patil V, Pramod Kumar TM. Artificial intelligence in the field of pharmacy practice: A literature review. *Explor Res Clin Soc Pharm*. 2023 Oct 21; 12:100346. doi: 10.1016/j.rcsop.2023.100346. PMID: 37885437; PMCID: PMC10598710.
3. Shashiashvili, N. Evidence-Based Pharmacy: A Scientific Approach to Safe and Effective Medication. *Georgian Scientists*. Vol.7 Issue 2, 2025. p. 27-38. <https://doi.org/10.52340/gS.2025.07.02.03>
4. Singh, N.; Kumar, S.; Prabhu, K.; Shukla, A.; Yadav, A. A review on: Artificial intelligence in pharma. *Int. J. Pharm. Sci. Rev. Res*. 2024, 84, 6.
5. Stasevych, M.; Zvarych, V. Innovative robotic technologies and artificial intelligence in pharmacy and medicine: Paving the way for the future of health care—A review. *Big Data Cogn. Comput*. 2023, 7, 147.
6. Allam, H. (2025). Prescribing the Future: The Role of Artificial Intelligence in Pharmacy. *Information*, 16(2), 131. <https://doi.org/10.3390/info16020131>
7. Ashenafi Kibret Sendekie, Liknaw Workie Limenh, Biruk Beletew Abate, Gashaw Sisay Chanie, Abebe Tarekegn Kassaw, Fasil Bayafers Tamene, Kalab Yigermal Gete, Ephrem Mebratu Dagnew,
8. Shashiashvili, N. (2024). Types of Pharmacoeconomic Analysis and Economic Evaluation of the Pharmacist's Role. *Journal Economics* 106(11-12):34-37. DOI: [10.36962/ECS106/11-12/2024-34](https://doi.org/10.36962/ECS106/11-12/2024-34)
9. Artificial intelligence in community pharmacy practice: Pharmacists' perceptions, willingness to utilize, and barriers to implementation, *Exploratory Research in Clinical and Social Pharmacy*, Volume 16, 2024, 100542, ISSN 2667-2766, <https://doi.org/10.1016/j.rcsop.2024.100542>.
10. Raza, M.A.; Aziz, S.; Noreen, M.; Saeed, A.; Anjum, I.; Ahmed, M.; Raza, S.M. Artificial intelligence (AI) in pharmacy: An overview of innovations. *Innov. Pharm*. 2022, 13.

11. Oswalt, R.; Candidate, P. The Role of Artificial Intelligence in Pharmacy Practice. 2023. Available online: <https://www.pharmacytimes.com/view/the-role-of-artificial-intelligence-in-pharmacy-practice> (accessed on 6 January 2025).
12. Chin, M.; Afsar-Manesh, N.; Bierman, A.; Chang, C.; Colón-Rodríguez, C.; Dullabh, P.; Duran, D.; Fair, M.; Hernandez-Boussard, T.; Hightower, M. Guiding Principles to Address the Impact of Algorithm Bias on Racial and Ethnic Disparities in Health and Health Care. *JAMA Netw Open* 2023, 6, e2345050.

## ხელოვნური ინტელექტი სააფთიაქო სერვისებში და ფარმაცოინტელექტის კონცეფცია

ნანა შაშიაშვილი<sup>1,2</sup>

ფარმაცევტულ მეცნიერებათა დოქტორი, ასოცირებული პროფესორი <sup>1</sup>საქართველოს  
ტექნიკური უნივერსიტეტი, ფარმაციის დეპარტამენტი, <sup>2</sup>თბილისის სახელმწიფო  
სამედიცინო უნივერსიტეტი, სოციალური და კლინიკური ფარმაციის დეპარტამენტი

### აბსტრაქტი

ფარმაცოინტელექტის, ანუ ხელოვნური ინტელექტის (AI) გამოყენება სააფთიაქო სისტემებში წარმოადგენს ერთ-ერთ ყველაზე პერსპექტიულ ტექნოლოგიურ ინოვაციას, რომელიც მნიშვნელოვნად ცვლის ფარმაცევტულ პრაქტიკას და ახდენს მის ოპტიმიზაციას. AI ტექნოლოგიები შესაძლებლობას იძლევა გაუმჯობესდეს მედიკამენტების განაწილების სიზუსტე, ინვენტარის მართვა და პაციენტთა უსაფრთხოება. ამ მხრივ, განსაკუთრებით მნიშვნელოვანია AI-ის პოტენციური მედიკამენტების უსაფრთხოების მიმართულებით. ხელოვნური ინტელექტი გამოიყენება პაციენტების მიერ მიღებული მედიკამენტების ანალიზში, რაც ხელს უწყობს გვერდითი მოვლენების თავიდან აცილებას. მნიშვნელოვანია AI-ს როლი წამლის განაწილების პროცესების ავტომატიზაციაში, რაც ზრდის ოპტიმიზაციას და ოპერაციულ ეფექტურობას. ამავდროულად, ხელს უწყობს "დიდი მონაცემების" ანალიზს და საშუალებას იძლევა უფრო ზუსტი პროგნოზები და გადაწყვეტილებები იქნეს მიღებული ფარმაცევტების მიერ, რაც, საბოლოო ჯამში, გააუმჯობესებს პაციენტთა მკურნალობის შედეგებს. მიუხედავად აღნიშნულისა, ხელოვნური ინტელექტის დანერგვა ჯანდაცვის სფეროში ისეთ მნიშვნელოვან გამოწვევებს უკავშირდება, როგორიცაა კონფიდენციალურობის საკითხები და მაღალი ხარჯები. კვლევები აჩვენებს, რომ ხელოვნური ინტელექტის სწორი ინტეგრაცია სააფთიაქო სისტემებში მნიშვნელოვნად გააუმჯობესებს როგორც ოპერაციულ პროცესებს, ასევე პაციენტთა უსაფრთხოებასა და მკურნალობის შედეგებს. ამ პროგრესის რეალიზებისთვის აუცილებელია რეგულაციებთან შესაბამისობის უზრუნველყოფა და საზოგადოებრივი ნდობის გაძლიერება.

**საკვანძო სიტყვები:** აფთიაქი, ფარმაცოინტელექტი, წამალი, ხელოვნური ინტელექტი.