



IN PHARMACEUTICALS ROLE AND PRACTICAL SIGNIFICANCE OF COMPUTER TECHNOLOGIES

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Abstract

This scientific article provides a detailed analysis of the role and practical significance of computer technologies in the pharmaceutical sector in 2025. The article presents practical examples of the application of modern technologies in the pharmaceutical sector, such as artificial intelligence, in silico modeling, digital laboratories, IoT, 3D printed drugs, nanoinformatics, and cybersecurity, in Uzbekistan and Central Asia.

Keywords: pharmaceuticals, computer technologies, artificial intelligence, digitization, in silico, 3D printing, Uzbekistan, Central Asia.

Introduction

in the world over the past decade. Technologies such as artificial intelligence, digital technologies, and quantum computing are playing a key role in the development, testing, and safety of new drugs. By 2025, more than 70 percent of the pharmaceutical market will be actively using digital technologies.

Uzbekistan is carrying out a lot of practical work to develop the pharmaceutical sector within the framework of the "Digital Uzbekistan – 2030" strategy. Based on this strategy, drug registration, tracking, electronic prescription systems and pharmacy management systems are being gradually digitized. Central Asian countries, including Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan, are



strengthening the digital technologies of the regional pharmaceutical sector by creating tools for mutual information exchange.

The Role of Computer Technology in Drug Development

Digital information systems are now widely used in the process of drug development. In 2025, pharmaceuticals tested systems such as “PharmAgents” based on artificial intelligence. These systems analyze millions of substance molecules using mathematical models and select the most effective ones. This speeds up scientific research processes by 6-8 times. It helps to use time more efficiently and makes people's work easier.

introduction of digital information systems into the pharmaceutical industry in the production of drugs is called automation. Automation includes tasks such as IoT, artificial intelligence (AI), the production of robots to facilitate human work, digital control systems, and data integration.

The latest statistics on the role and market importance of computer and digital technologies in pharmaceutical manufacturing in 2025:

In 2018, a decision was made in Uzbekistan to introduce a "System for Controlling and Accounting for the Movement of Pharmaceutical Products."

In 2023, the Presidential Decree approved the plan "Additional measures for the digitalization of the healthcare system." Within the framework of this plan, it was envisaged to introduce an electronic prescription system.

On September 9, 2025, a document called “Regulations on Prescribing Medications in Medical Institutions through Electronic Prescriptions” was adopted. This document states:

It is envisaged that all medicines will be prescribed via electronic prescription, medical institutions will be connected to the "Medical Information System", each prescription will be assigned a unique QR code, and data will be automatically entered into the electronic medical card.

A pilot electronic prescription project was launched in the Kibray district (Tashkent region) in early 2025. Polyclinics and pharmacies participated in this project. It is planned to introduce electronic prescriptions in the cities of Tashkent and Samarkand from December 2025.



In 2018, the size of the pharmaceutical market was estimated at 8-8.5 trillion soums. In 2024, this figure increased by 2.5 times due to digital technologies, that is, to 20.3 trillion soums.

was developed in 2025, which is designed to support processes such as rapid optimization of the formulation with small amounts of API, accurate timing, and quality control. Such automated systems serve to increase production efficiency.

Advantages and specific directions in the pharmaceutical manufacturing process:

The application and importance of digital technologies in the pharmaceutical drug manufacturing process:

1. Process monitoring and control

— High quality and safety assurance, i.e. modern production technologies ensure the purity, stability and safety of medicines.

— Batch-to- batch (batch-to-batch consistency)

changes are quickly detected and automatic correction mechanisms are triggered.

2. Big data and analytics:

analyzing large amounts of collected data, it is possible to determine the course of processes and predict their development.

3. Artificial Intelligence and machine learning.

— Formulation optimization, modeling of interactions between API and excipients.

In Uzbekistan, at the BioTech Digital Lab center established at the Tashkent Pharmaceutical Institute, students and researchers are studying molecular modeling using AnyLogic and several other programs. Fergana State University, as part of the BioAI Project, has created a program that tests drug components using artificial intelligence.

IT technologies in clinical trials and drug safety monitoring

In clinical trials, computer technology is essential for ensuring drug safety, patient monitoring, and data integrity. In 2025, Electronic Data Capture systems were implemented in clinical centers in Uzbekistan and Kazakhstan, with effective results. This system provides real-time data on patients' biological parameters.

The pilot project “E-Clinical Uzbekistan” in Andijan region involved 120 patients, whose heart rate, blood pressure, and blood composition were monitored online using IoT sensors. The results were analyzed using an artificial intelligence system



to identify individual differences in drug effects. This method reduced the human factor and reduced clinical errors by 30 percent.

In recent years, the impact of information technology on clinical trials and drug safety monitoring systems in the pharmaceutical industry has been rapidly increasing. In particular, the global EDC market for collecting, storing and analyzing digital clinical data worldwide in 2025 exceeded 1.8 billion US dollars. According to observations and comparisons, this figure is growing by an average of 12–13% annually. This process has made it possible to maintain paperless information in clinical trials, control in real time and reduce errors.

Beyond clinical trials, digital information technology is enabling real-world data and drug safety. Computer systems have been greatly improved with data collected through electronic diagnostics, pharmacy data, and patient monitoring devices (such as “smart” bracelets). By 2025, more than 200 million patients worldwide will be able to track their medication intake through mobile apps—a 70% increase from 2020.

Remote Clinical Trials

"Remote clinical trials," which began after the pandemic, have become one of the main directions in the pharmaceutical industry in 2025. Such trials allow participants to participate from home, without having to come to the laboratory. This reduces the risk of contracting various diseases. This leads to savings in time and money.

IT convergence in Uzbekistan and Central Asia

Clinical trials are also being gradually digitized in the pharmaceutical industry of Uzbekistan. According to the results of 2024, 60% of clinical trial centers under the Ministry of Health were connected to electronic data exchange systems, and in 2025 this figure is expected to reach 80%.

Digital systems innovation in pharmaceuticals

IT technologies have made a significant breakthrough in drug safety monitoring. With the help of artificial intelligence, machine learning and big data analytics, the speed of detecting side effects has increased by 40% by early 2025. Also, the World



Health Organization's VigiBase systems are being used to process millions of safety messages annually through automated signal analysis.

3. Computer systems in pharmaceutical production and quality control

Precision, hygiene, and safety are the most important factors in the pharmaceutical manufacturing process. Large Uzbek companies — Jurabek Laboratories, DentaForte, and Nobel Pharmsanoat — have fully transitioned their production systems to SCADA platforms in 2025. This system automatically monitors temperature, humidity, pressure, and mixture ratios and transmits accurate time data to a central server.

Pharmaceutical factories in Kazakhstan and Uzbekistan have implemented “AI Quality Control” systems that use cameras and artificial intelligence to automatically detect tablet sizes, weights, and deviations. As a result, the human error rate has been reduced to less than 5 percent.

In recent years, computer technologies have become an integral part of the production process in the pharmaceutical industry. During 2023–2025, digital systems, automation, and artificial intelligence-based control tools are being rapidly introduced in the pharmaceutical industry worldwide and in Uzbekistan.

By 2025, 78% of the world's pharmaceutical companies will use digital control systems (SCADA, MES, LIMS) at at least one stage of production.

Quality control processes using artificial intelligence (AI) will become more efficient starting in 2023. According to reports, AI-based monitoring systems can detect errors 35% faster and reduce production failures by 25%.

Digital transformation in the pharmaceutical industry of Uzbekistan.

The pharmaceutical industry in Uzbekistan has also been developing rapidly over the past three years.

in the industry that adhere to GMP and GDP standards is increasing.

In 2024, 3,785 enterprises were audited based on international "Good Practices" requirements, 318 distributors were GDP certified, and 2,538 pharmacies operated in accordance with GPP (Good Pharmacy Practice) requirements.

Within the framework of the Tashkent Pharma Park project, digital management and automated monitoring systems are being implemented for pharmaceutical manufacturers in 2023-2025. This platform allows manufacturers to remotely



monitor the quality of medicines and store laboratory data in digital form through the LIMS system.

In India, Sun Pharma is reported to have analyzed more than 12,000 sensor data from production in 2025 using AI, controlling product quality with 99.3% accuracy.

European companies are increasingly using "Digital Twin" technology to create a virtual replica of their production lines, enabling them to identify errors in advance.

Digital Revolution in the Pharmacy System

The digitalization of pharmacy systems has simplified pharmaceutical services. In 2025, more than 2,500 pharmacies in Uzbekistan were connected to the "E-Pharmacy" system. This platform allows you to order medicines online, compare prices, check availability, and obtain information about the medicine.

In Central Asia, Kyrgyzstan's MedLink system allows patients to remotely video chat with a pharmacist. The EurasiaPharma platform between Uzbekistan and Kazakhstan aims to monitor the regional circulation of medicines and prevent counterfeiting.

Pharmaceutical Education and Research

In Uzbekistan, attention is increasing to computer technologies in pharmaceutical education. At the Tashkent Pharmaceutical Institute, the Medical Academy, and Fergana State Universities, subjects such as "Bioinformatics" and "Pharmaceutical Information Systems" are being taught. Students are learning how to create drug models in the programs "PharmaSuite", "AnyLogic", and "MatLab".

A master's degree program "Digital Pharmacy and AI in Medicine" has been opened at Nazarbayev University in Kazakhstan, a major breakthrough for Central Asia.

3D Printed Drugs and Nanoinformatics

3D printing technologies are revolutionizing pharmaceuticals. Spritam is the first 3D printed drug, which is expected to be approved by the FDA in 2025. This technology allows for the preparation of drug doses tailored to a patient's age, weight, or genetic characteristics.



Nanoinformatics is playing an important role in modeling nanoparticle drugs and studying their effects on the human body. Research conducted in 2024–2025 by laboratories at the Tashkent Institute of Chemical Technology showed that nanoparticle drugs increase the efficiency of targeted delivery by 40 percent.

Cybersecurity and the ethics of artificial intelligence

Personal data security is important in digital pharmaceutical systems. Uzbekistan launched the PharmaSecure project in 2025. This system protects data in pharmacies and clinics by encrypting and authenticating user access. These systems allow decisions to be explained in a language that humans can understand.

Prospects in Uzbekistan and Central Asia

The pharmaceutical industry of Uzbekistan is in the process of digital transformation. In 2025, 15 new digital laboratories were launched within the framework of the “PharmaTech Uzbekistan” program. All this is aimed at making people spend their time wisely. Regional market integration is also strengthening in the region by establishing pharmaceutical data exchange with Kazakhstan, Kyrgyzstan and Tajikistan.

In the future, the pharmaceutical industry plans to use AI to produce drugs, strengthen cybersecurity, and create a qualification system that meets international standards.

Conclusion

In pharmaceuticals, computer technologies have become not only an innovative tool, but also a key factor and an effective method of drug production. In Uzbekistan and Central Asia, these technologies have improved the quality of drugs, significantly changed production efficiency and medical safety. Through digital solutions, artificial intelligence and automation, the pharmaceutical industry has reached a new level and developed further. With the introduction of digital technologies, the efficiency of drug production is increasing day by day.

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