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INTRODUCTION OF MODERN RESOURCE-SAVING TECHNOLOGIES AT PHARMACEUTICAL ENTERPRISES (LEAN MANUFACTURING APPROACHES)

Actuality. *Pharmaceutical companies are challenged to improve efficiency, reduce costs, and comply with strict regulatory requirements. Lean manufacturing approaches are considered an effective way to save resources, optimize processes, and improve quality continuously.*

Aim of the study is analyzes of the theoretical foundations of lean manufacturing for determining of the key stages of implementation at the pharmaceutical enterprises.

Material and methods. *The study was conducted in two stages: a review of domestic and foreign literature for 2000–2025 using Google Scholar, PubMed, Scopus, and Web of Science searches for relevant keywords; analytical summary of pharmaceutical manufacturing practices with a focus on production processes, quality control systems, loss reduction methods, and resource*

conservation strategies. At the second stage of the study, pharmaceutical production processes, quality control systems, loss reduction methods and resource-saving strategies were analyzed.

Research results. *A six-step implementation sequence has been identified: diagnosis and goal setting; mapping and analysis of losses; development and implementation of improvements; staff training and Kaizen culture development; monitoring and corrective actions; final assessment. It has been shown that integrating Lean with digital technologies enhances quality control and flexibility. According to the case studies reviewed, quality control reliability increased by more than 50%, inventory and defects were reduced by approximately 57%, throughput increased, and work in progress decreased. Three implementation scenarios (maximum, moderately optimal, "soft") are proposed, describing the limitations and risks for companies with varying degrees of readiness.*

Conclusion. *Lean manufacturing, enhanced by digital tools, reduces losses, inventory, and defects, speeds up processes, and improves the quality and productivity of pharmaceutical production. In the context of rising costs, stricter standards and environmental requirements, it is becoming a strategic factor of competitiveness, especially for developing countries. For the first time, a standard Lean manufacturing implementation plan has been proposed with three scenarios – "maximum", "moderate-optimal" and "soft", which allows flexible strategy selection depending on resources. The results can be applied to the implementation of Lean manufacturing in pharmaceutical enterprises, in particular The Republic Kazakhstan.*

Key words: *Lean Manufacturing, resource efficiency, pharmaceutical manufacturing, efficiency improvement, process optimisation.*

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УПРОВАДЖЕННЯ СУЧАСНИХ РЕСУРСОЗБЕРЕЖУВАЛЬНИХ ТЕХНОЛОГІЙ НА ФАРМАЦЕВТИЧНИХ ПІДПРИЄМСТВАХ (ПІДХОДИ ОЩАДЛИВОГО ВИРОБНИЦТВА)

Актуальність. *Фармацевтичні підприємства стикаються із завданнями підвищення ефективності, зниження витрат та дотримання суворих регуляторних вимог. Підходи ощадливого виробництва (Lean Manufacturing) розглядаються як дієвий інструмент ресурсозбереження, оптимізації потоків і безперервного поліпшення якості.*

Мета дослідження *– проаналізувати теоретичні основи ощадливих технологій для визначення ключових етапів їх упровадження на фармацевтичних підприємствах.*

Матеріал і методи. *Дослідження виконано у два етапи. На першому етапі проведено огляд літератури за 2000–2025 роки з пошуком у Google Scholar, PubMed, Scopus і Web of Science за релевантними ключовими словами: «ощадливе виробництво у фармацевтичній промисловості», «сталий розвиток у фармацевтичній промисловості», «ресурсозберігаючі технології у фармацевтичній промисловості», «підвищення ефективності фармацевтичного виробництва», «оптимізація фармацевтичних процесів» і «скорочення відходів фармацевтичного виробництва». На другому етапі дослідження було проаналізовано процеси фармацевтичного виробництва, системи контролю якості, методи зменшення втрат і стратегії ресурсозбереження.*

Результати дослідження. *Ідентифіковано послідовність із шести кроків упровадження, як-от: діагностика та постановка цілей; картування та аналіз втрат; розроблення та реалізація поліпшень; навчання персоналу та формування культури Kaizen; моніторинг і коригувальні дії; підсумкова оцінка. Показано, що інтеграція Lean Manufacturing із цифровими технологіями посилює контроль якості та гнучкість. За даними розглянутих кейс-стаді, надійність контролю якості збільшувалася більш ніж на 50%, запаси та дефекти скорочувалися приблизно на 57%, зростала пропускна здатність і знижувався рівень незавершеного виробництва. Запропоновано три сценарії впровадження (максимальний, помірно-оптимальний, «м'який») з описом обмежень і ризиків для підприємств з різним ступенем готовності.*

Висновок. *Ощадливе виробництво, доповнене цифровими інструментами, скорочує втрати, запаси й дефекти, прискорює процеси, підвищує якість і продуктивність фармацевтичного виробництва. В умовах зростання витрат, посилення стандартів і екологічних вимог бережливе виробництво стає стратегічним фактором конкурентоспроможності, особливо для країн, що розвиваються. Уперше був запропонований стандартний план упровадження ощадливого виробництва із трьома сценаріями – «максимальним», «помірно-оптимальним» і «м'яким», який дозволяє гнучко вибирати стратегію залежно від ресурсів. Отримані результати можуть бути застосовані для впровадження ощадливого виробництва на фармацевтичних підприємствах, зокрема Республіки Казахстан.*

Ключові слова: *ощадливе виробництво (Lean Manufacturing), ресурсоефективність, фармацевтичне виробництво, підвищення ефективності, оптимізація процесів.*

Introduction. Actuality. In Kazakhstan, providing the population with affordable medical and pharmaceutical services is one of the key areas of state policy, in accordance with the objectives of the National Medical Policy (Zhakipbekov et al., 2023). This policy, in turn, represents a complex and costly integrative system (Issatayeva et al., 2024). Human resource management plays an important role in the implementation of this policy (Datkhayev et al., 2016), in particular planning for seasonal spikes in demand for pharmaceutical personnel (Umurzakhova et al., 2017), developing communication skills through continuing professional education in pharmaceutical communication (Zhakipbekov et al., 2018), and creating pharmaceutical clusters (Serikbayeva et al., 2020).

The pharmaceutical market is one of the most profitable and rapidly growing sectors of the global economy and serves as a driving force for both economic and social development (Shertaeva et al., 2014). The development of the pharmaceutical industry is a key factor in the highly innovative prosperity of the national economy and an indicator of the well-being of the population (Li et al., 2021). To achieve an effective level of drug provision for consumers, it is necessary to develop the domestic pharmaceutical industry (Datkhayev et al., 2019), especially through the development and production of medicines based on local plant raw materials. At the current stage of development of the industry, such raw materials include medicinal plants growing in Kazakhstan, such as *Nicotiana tabacum* L. (Ashirov et al., 2020), *Echinops ritro* (Turgumbayeva et al., 2023), *Portulaca oleracea* L. (Tleubayeva et al., 2022), *Brassica napus* L. (Turgumbayeva et al., 2021), *Plantago major* L. (Turgumbayeva et al., 2022), representatives of the *Apiaceae* family (Kozhanova et al., 2025), *Ferula asafoetida* L. (Rakhymbayev et al., 2023; Mombekov et al., 2025) and others.

Given Kazakhstan's strong dependence on imported pharmaceuticals, expanding domestic production remains a strategic priority to ensure both economic independence and national security (Mazur et al., 2020). At the same time, modern pharmaceutical enterprises face the pressing challenges of improving efficiency, reducing costs, and complying with increasingly strict regulatory requirements. One of the most effective approaches to addressing these issues is the introduction of Lean manufacturing methods, which are based on waste elimination, workflow optimization, and continuous improvement (Womack et al., 2011).

In the context of global sustainability challenges and the demand for more efficient industrial processes, the pharmaceutical sector is increasingly turning to innovative management practices (Chomać-Pierzecka et al.,

2025). The integration of resource-saving technologies with lean manufacturing principles has become a key strategic direction for companies seeking to enhance competitiveness and align with international standards (Ghelani et al., 2021).

Under current economic conditions, improving the efficiency and sustainability of pharmaceutical enterprises is among the top priorities. Lean technologies provide unique opportunities to reduce costs, conserve resources, and improve product quality (Taher et al., 2024). This methodology has demonstrated high effectiveness in many international companies (Liker, 2005) and has also proven successful in the healthcare sector, further confirming its relevance for the pharmaceutical industry, including Kazakhstan.

Considering the above, the importance, stages of implementation and advantages of lean manufacturing in pharmaceutical enterprises are an urgent problem, especially for Kazakhstan. Thus, the introduction and adaptation of lean manufacturing technologies is timely and strategically important for the modernization of the industry.

The aim of the study is analyzes of the theoretical foundations of lean manufacturing for determining of the key stages of implementation at the pharmaceutical enterprises.

Materials and research methods. The study was conducted in two stages. At the first stage, a review of domestic and foreign literature on Lean manufacturing was conducted.

A comprehensive search was carried out in Google Scholar and PubMed using key terms such as *"Lean manufacturing in the pharmaceutical industry"*, *"Sustainability in the pharmaceutical industry"*, *"Resource-saving technologies in the pharmaceutical industry"*, *"Improving the efficiency of pharmaceutical manufacturing"*, *"Optimization of pharmaceutical processes"* and *"Reduction of pharmaceutical production waste"*.

The number of search results for each keyword is presented in table 1.

The selection criteria included domestic and foreign studies on the application of lean manufacturing principles in pharmaceutical production with an emphasis on process optimization and cost reduction. Additional relevant sources were identified through manual reference screening. The data collection period covered 2000–2025.

At the second stage of the study, pharmaceutical production processes, quality control systems, loss reduction methods and resource-saving strategies were analyzed.

Research results and their discussion. The term "lean manufacturing", or "Lean", refers to a philosophy of production management originally developed by Japanese engineer and Toyota executive Taiichi Ohno (Shook, 2008). It is often expressed by the phrase "produce more using less". Lean manufacturing focuses on improving the efficiency of production processes by identifying and eliminating waste-actions that slow down production and reduce productivity (Poppendieck et al., 2003). According to the Lean manufacturing methodology, there are usually seven types of waste: waiting, defects, unnecessary movements, excess inventory, overproduction, unnecessary transportation, and unnecessary processing (Kundu, 2015).

Lean manufacturing was not originally associated with healthcare and was developed to improve processes in Japanese manufacturing companies (Kaul et al., 2022). However, over time, the effectiveness of Lean manufacturing tools led to their widespread adoption in other professional fields, including healthcare (Tierney et al. 2022). The application of Lean manufacturing principles in hospital management began in the 1990s and is now rapidly gaining popularity around the world (Teich et al., 2013).

In pharmaceutical manufacturing, digital transformation has become a key factor in improving productivity and operational efficiency (Miozza et al., 2024). The integration of Lean principles with technologies such as Big Data, the Internet of Things (IoT), enterprise resource planning (ERP) systems, and artificial intelligence (AI) enables pharmaceutical companies to mon-

Table 1

The number of searches for each key word*

Key words	Number of Searches			
	Google Scholar	PubMed	Scopus	Web of Science
Lean manufacturing in the pharmaceutical industry	13 000	26	440	2
Sustainability in the pharmaceutical industry	19 100	3917	2063	26
Resource-saving technologies in the pharmaceutical industry	12 700	6	7	0
Improving the efficiency of pharmaceutical manufacturing	18 500	1354	186	0
Optimization of pharmaceutical production processes	17 900	9924	2311	11
Reduction of pharmaceutical production waste	18 600	1079	440	0

*Search date 07/29/2025.

itor product quality in real time and reduce production costs (Javaid et al., 2024). For example, modern ERP systems provide continuous monitoring of raw material flows, equipment wear and tear, and production cycle efficiency. These systems also facilitate the timely identification and elimination of delays in production processes (Powell et al., 2011).

Key Lean manufacturing tools in pharmaceutical manufacturing (Sieckmann et al., 2018):

1. The 5S system – a method of organizing the workplace aimed at improving efficiency through: Sorting – removing unnecessary items based on frequency of use and necessity; Rational placement – systematic arrangement of items for quick and easy access; Keeping clean – ensuring order and cleanliness in the workplace; Standardization – establishing uniform standards for consistent organization; Maintenance – regular compliance with established procedures.

2. Standardized work – a structured and visualized process for performing specific tasks, including standard cycle time, sequence of operations, and inventory levels required for each operation.

3. Breakthrough to Flow – a methodology aimed at balancing and improving production flow by establishing stable and synchronized production cycles.

4. Total Productive Maintenance (TPM) – a comprehensive approach to equipment maintenance that involves production personnel in regular inspections to ensure continuous operability. This reduces downtime due to breakdowns or scheduled maintenance and allows for maximum utilization of equipment throughout its life cycle, freeing up specialized technical personnel to perform critical tasks.

5. SMED (Single-Minute Exchange of Dies) is a system for reducing equipment changeover time. It distinguishes between: External operations (performed while the equipment is running, such as preparing tools or materials); Internal operations (requiring equipment shutdown).

The main goal is to convert internal operations into external ones through targeted technological and organizational improvements.

6. Pull Production System – a production flow management strategy that eliminates losses caused by overproduction or forced downtime. Each stage of production "pulls" only the amount of work that is necessary from the previous stage, ensuring a balanced process without shortages or surpluses (Emiliani, 2010).

According to the philosophy of lean manufacturing, all production activities can be divided into two groups (Womack et al., 1996): (1) operations and processes that add value to the final product; (2) operations and processes that do not add value for the consumer and should be reduced or eliminated.

A production management system based on Lean manufacturing principles includes the following key aspects (Schumacher et al., 2022):

1. Strategic aspect – enterprise development strategies are based on Lean ideology with continuous improvement of the "lean manufacturing" strategy.

2. Intellectual aspect – emphasis on teamwork, innovation, and rationalization proposals.

3. Production aspect – reduction of both direct and indirect production costs, optimization of business processes, and effective exchange of information between all departments and employees.

4. Resource aspect – effective management of all types of enterprise resources with an emphasis on the value created for the customer and end user.

Currently, the pharmaceutical industry faces serious global challenges (Madalaimuthu, 2025), including resource depletion, rising production costs (Akomea-Frimpong et al., 2025), negative environmental impact, and stricter quality standards (Rajpuriya, 2025). These factors have significantly increased the need to implement effective management systems aimed at optimizing production processes and reducing costs (Somani, 2025).

Lean manufacturing technologies have become a viable solution for overcoming these challenges, enabling pharmaceutical companies to ensure both operational stability and efficiency.

In addition, growing global demand for pharmaceutical products-especially in the context of pandemics and international crises-requires manufacturers to produce high-quality and environmentally safe products in an accelerated timeframe (de Margerie et al., 2021). In this context, the critical importance of implementing innovative management strategies, including Lean manufacturing principles, in pharmaceutical companies is particularly emphasized. The development of digitalization and Industry 4.0 technologies also enhances lean management capabilities by enabling real-time monitoring, data-driven decision-making, and production flexibility, which further improves production efficiency (Tripathi et al., 2022).

The implementation of Lean manufacturing technologies in the pharmaceutical industry not only improves internal processes, but also strengthens the competitiveness of the enterprise in the market and ensures compliance with international standards (Khalid, 2025). For developing countries such as Kazakhstan, these measures are particularly significant as they contribute to the achievement of sustainable economic growth and

integration into the international market. The results of the implementation confirm significant advantages: an increase in the reliability of quality control by more than 50%, a reduction in inventories and defects by almost 57%, an increase in throughput and a decrease in work-in-progress (Tetteh-Caesar et al., 2024).

Resource conservation objectives are achieved by reducing material and energy costs (Sivachenko et al., 2018), efficient use of raw materials and packaging (Mosconi et al., 2024), and the application of energy-saving technologies and methods (Pimenov et al., 2022). Additional priorities include minimizing waste, recycling or disposing of unnecessary materials, and effectively managing production assets to avoid excessive costs (Poppendieck M., 2003).

Lean manufacturing technology aims to eliminate "waste" in production, such as excessive use of raw materials, inefficient processes, or downtime (Suwanda, 2023). In the pharmaceutical sector, the implementation of Lean includes process automation, robotics, and the use of information technology (ElLithy et al., 2023), which ensure more efficient resource management and product quality control. This helps to reduce costs and speed up processes without compromising quality (Emiliani, 2010).

In the second stage of the study, we identified the key steps necessary for the implementation of Lean technologies in pharmaceutical enterprises. These stages include the following:

1. Assessment of the current state and setting goals

The first stage of Lean manufacturing implementation involves a comprehensive assessment of the current state of all operational processes at a pharmaceutical company. During this stage, existing operations are analyzed to identify weaknesses, excessive costs, and sources of loss. This assessment helps determine which processes need improvement and which need to be completely redesigned.

The main objectives of Lean manufacturing implementation are then clearly formulated. As a rule, these include increasing production efficiency, reducing costs, improving product quality, and shortening the production cycle time. At this stage, a specialized Lean manufacturing implementation team is formed, responsible for managing and implementing the subsequent phases (Radnor, 2010).

2. Identification and analysis of losses in the production process

Lean technology focuses on identifying and eliminating "losses" in the production process. In pharmaceutical manufacturing, typical types of losses may include: Waiting – periods when employees or equipment are idle due to delays or inefficient processes; Defects – products that do not meet quality standards and require rework or disposal; Unnecessary movement – excessive or inefficient movement of personnel or equipment that does not add value to the process; Excess inventory – surplus raw materials or finished products that require additional resources for storage and management; Overproduction – producing more than is required or earlier than necessary; Unnecessary transportation – unnecessary movement of materials or products within the enterprise; Unnecessary processing – performing more operations or achieving greater precision than is necessary to ensure product quality.

After identifying these types of losses, an action plan is developed to eliminate or minimize them (Burmenko, 2019).

3. Development and implementation of improvements

At this stage, specific changes aimed at improving production processes are developed and implemented. The following measures may be implemented:

– Process standardization – development and implementation of standard operating procedures (SOPs) for all stages of production. This helps to reduce process variability and minimize the risk of errors.

– Workplace optimization – improvement of work areas to reduce unnecessary staff movements and simplify workflows.

– Automation – implementation of automated systems for process management, quality control, and reduction of operation execution time.

– Staff training – conducting seminars and training sessions to familiarize employees with new working methods and ensure the successful implementation of Lean manufacturing principles (Lapin, 2017).

4. Staff training and the formation of a Lean manufacturing *culture*

The successful implementation of Lean manufacturing requires a cultural transformation within the organization. All employees must be actively involved in the change process. It is important that staff understand the principles of Lean manufacturing and realize how their individual actions affect overall operational efficiency. To this end, regular training sessions and seminars are organized, and the practical application of Lean manufacturing principles by employees is encouraged.

Creating a "Lean manufacturing culture" in an enterprise means creating an environment in which every employee is focused on improving processes and reducing waste (Vlasov et al., 2015).

5. Monitoring and continuous improvement

After implementing improvements, it is necessary to monitor the results obtained. The degree to which the set

goals have been achieved and the actual impact of Lean manufacturing implementation are assessed. To evaluate the success of the changes, key performance indicators such as production time, defect rate, inventory levels, and other relevant parameters are tracked. Adjustments are made as necessary (Kuznetsov, 2020).

The key element of this stage is continuous improvement. According to the Lean manufacturing philosophy, changes do not end at the initial implementation stage. There should be ongoing work to find new ways to increase efficiency, improve quality, and reduce costs. The Kaizen principle of continuous, gradual improvement is the foundation of Lean manufacturing and requires systematic changes over time to ensure long-term effectiveness (Holweg, 2007).

6. Assessment of Lean manufacturing *implementation and final results*

Upon completion of all stages, it is necessary to assess the final results of Lean manufacturing implementation. This includes comparing key indicators such as reduction in production time, reduction in defect rates, reduction in raw material consumption, and other relevant metrics. Such an assessment allows you to determine not only the effectiveness of Lean manufacturing strategies, but also to identify areas that require further improvement.

Based on the data obtained, new action plans can be developed to improve and optimize future processes (Mikhailov et al., 2019).

The implementation of Lean manufacturing principles in pharmaceutical companies, as discussed in this paper, presents several key advantages:

1. Cost reduction and productivity improvement

Due to the implementation of Lean manufacturing, pharmaceutical companies can significantly reduce cost operations while increasing production efficiency. Losses associated with overproduction, excess inventory, and unnecessary movements are eliminated. Process optimization and elimination of inefficient stages contribute to reducing production and operating costs, as well as reducing production cycle time, which overall increases productivity (Fedorov, 2022).

2. Improving product quality and innovation

Lean manufacturing methods aim to improve product quality by minimizing defects and strengthening quality control. Standardization and continuous improvement ensure a higher level of quality. In addition, Lean manufacturing stimulates innovation and promotes continuous process modernization, which plays an important role in improving the technological level of the enterprise (Chernyshov, 2020).

3. Increased flexibility and adaptability

Lean manufacturing enhances a company's ability to respond quickly to changes in market conditions, thereby supporting the sustainable development of the pharmaceutical sector. Lean manufacturing systems help companies adapt flexibly to fluctuations in demand and new regulatory requirements, strengthening their competitive position (Holweg, 2007).

4. Improving working conditions

Process optimization within Lean manufacturing leads to improved working conditions. Eliminating unnecessary movements and organizing workplaces more rationally reduces physical strain, improves occupational safety, and contributes to employee satisfaction (Mikhailov et al., 2019).

5. Compliance with regulatory requirements

Lean manufacturing technology promotes compliance with regulatory requirements for the quality and safety of pharmaceutical products. Standardized and controlled processes ensure compliance with legislative and industry standards, helping companies meet and exceed regulatory expectations (Lapin, 2017).

After assessing these advantages, a model plan for implementing Lean manufacturing in pharmaceutical companies was developed (table 2). This plan was structured according to different scenarios with detailed content, limitations, and risk considerations for each option.

The study confirms that the implementation of lean manufacturing technologies in pharmaceutical companies reduces production costs, improves product quality and optimizes processes (Tetteh-Caesar et al., 2024). A systematic Lean manufacturing approach-identifying losses, standardizing processes, training personnel, and ensuring continuous improvement-provides sustainable efficiency gains.

The findings align with international studies showing Lean manufacturing's effectiveness in both the pharmaceutical industry and healthcare. Moreover, integration with digital technologies (ERP, IoT, AI) strengthens quality control and adaptability.

However, there are limitations when using Lean manufacturing: organizational transformation may be hindered by a lack of qualified personnel or weak managerial support, while "soft" implementation scenarios may lead to limited results (Bortolotti et al., 2014). Some expected effects, such as increased flexibility or reduced number of defects, may only manifest themselves after a longer adaptation, which underscores the need to introduce the Kaizen culture (Chiarini et al., 2018).

Future research should focus on the environmental impact of lean manufacturing and the development of customized methods for small and medium-sized pharmaceutical companies, in particular for Kazakhstan.

Table 2

Typical Plan for Lean Manufacturing Technology Implementation in Pharmaceutical Enterprises

Scenario	Description	Limitations and Risks
Scenario A: Maximum	Full-scale implementation of project management. Organization of a dedicated project office within a specific department, including a portfolio manager, methodology expert (Lean implementation leader), project managers, and administrators. Revision and adoption of a comprehensive project management standard.	Significant workload for consultants; strict implementation of all designated projects required. High financial and resource demands. Major challenges in staff recruitment (relying on current or former employees may not resolve the issue).
Scenario B: Moderate-Optimal	Appointment or hiring of a portfolio manager (serving as both project management methodologist and Lean manufacturing implementation leader). Formation and execution of a project portfolio. Minimal organizational changes: current department staff participate in project work. Many project managers also hold functional management roles. Revision and adoption of the project management standard.	Consultants are involved with a planned workload; all designated projects are implemented. Potential difficulties in selecting a qualified portfolio manager (may require internal or former employees).
Scenario C: Soft	The firm's director temporarily assumes the functions of the portfolio manager. Consultants handle methodological guidance during the initial phase and assist with selected projects. The number of active projects should not exceed 3–4. No organizational restructuring. Selective application of project management standards.	Consultant workload may become critical, especially if issues or new projects emerge. This approach can be preferred initially, with a transition to Scenario B once a portfolio manager is hired. Only a limited number of projects will be implemented. The overall benefits realized may be minimal.

Conclusions. The review shows that Lean manufacturing principles, complemented by digitalization tools, systematically eliminate losses, reduce inventory and defects, accelerate flows, and improve the quality and productivity of pharmaceutical production. Against the background of rising costs, stricter standards and environmental requirements, Lean manufacturing is becoming a strategic factor for competitiveness and compliance with international standards, especially for developing countries (including Kazakhstan). A step-by-step model of lean manufacturing implementation in pharmaceutical enterprises is presented, including assessment of the current state, identification of losses, development and implementation of improvements, staff training and formation of a Lean manufacturing culture, as well as monitoring and continuous improvement.

For the first time, a standard plan for the implementation of lean manufacturing in pharmaceutical enterprises was developed, which includes three scenarios – "maximum", "moderate-optimal" and "soft", differing in the scale of organizational changes, the workload on staff and the resources required. This approach allows companies to flexibly choose their implementation strategy depending on their human and financial capabilities.

The practical significance of the research lies in the possibility of applying its results in the implementation of Lean manufacturing in pharmaceutical enterprises, in particular in The Republic of Kazakhstan.

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