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Research of the supply chain of medical equipment for educational institutions of the Kyrgyz Republic

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Introduction

Medicine is one of the most dynamically developing areas of human activity, which is due to the constant growth of the need for qualified specialists. These specialists must be able to perform a number of important functions, including diagnostic, therapeutic and preventive, which makes their training especially important in the modern world. Modern technologies and scientific discoveries require continuous professional development of medical workers, as well as high-quality education based on international standards and recommendations.

Training doctors in accordance with international recommendations creates demand for educational services offered by higher professional education systems in many countries. In the conditions of a market economy, which is the main form of economic life, this demand is becoming increasingly significant. As a result, higher education systems, especially in the field of medicine, are becoming an important component of the global educational industry. Countries that are able to provide high quality education attract students from other countries, which contributes to the development of educational services exports.

Educational services exports are a significant part of the economy in many countries around the world. In a number of countries, educational services occupy leading positions among other export services in terms of profitability. For example, countries where universities and institutes provide higher education programs in medical fields are able to attract significant financial resources by educating foreign students. This phenomenon has become an important element of economic strategy for many developed and developing countries.

Today, the undisputed leaders in the global educational services market are the countries of Western Europe and North America. These countries set world standards in the field of training specialists, including medical workers. Their educational programs are recognized as the highest quality, which makes them attractive to students from different countries of the world. Business competition between the main partners in the educational services market is subject to the laws

of economic relations, which forces each country to improve the quality of its programs and create increasingly attractive conditions for students.

In response to growing competition in the global educational services market, Western European countries took the initiative to harmonize their educational systems. In 1999, the process of creating a unified system of higher education began, which was called the Bologna Process. The goal of the Bologna Process is to create a unified educational model that will allow European universities to integrate into the global educational system and compete on an equal footing with other regions. The European educational system, based on standardization and mutual recognition of diplomas and qualifications, allows students to move freely between educational institutions in different countries, which significantly expands the opportunities for obtaining a quality education. In the medical field, this is especially important, since the training of doctors requires uniform approaches and standards to ensure a high level of professionalism.

Thus, the export of educational services in the field of medicine is becoming an important element in the economy of many countries, and integration processes such as the Bologna Process allow Western European countries to occupy leading positions in the world market. These efforts are aimed at increasing the attractiveness of the higher education system, which contributes to the development of scientific research, the creation of new technologies and, ultimately, improving the quality of medical care at the global level.

The study of the medical equipment supply chain for educational institutions in the Kyrgyz Republic is a relevant topic, since high-quality medical education is impossible without modern equipment for practical classes and student training. Educational institutions specializing in medical sciences require constant supplies of both basic and specialized equipment to ensure a high-quality educational process.

The main problems in the medical equipment supply chain are insufficient infrastructure, logistical difficulties, high dependence on imported equipment, as well as bureaucratic procedures that can slow down procurement processes. In most

cases, educational institutions in Kyrgyzstan depend on international suppliers, which makes the process expensive and subject to fluctuations in global markets.

In addition, support from the state and international organizations, such as the Islamic Development Bank, which is actively involved in financing such projects, plays an important role. To optimize the supply chain, it is necessary to introduce modern logistics methods, cooperate with local manufacturers, and develop a flexible procurement regulation system.

This study will help identify bottlenecks in the current supply chain and propose solutions that will help improve the efficiency and availability of medical equipment for educational institutions in Kyrgyzstan.

Research objectives. First, analysis of the current state of the medical equipment supply chain for educational institutions in the Kyrgyz Republic. This stage is aimed at identifying the main participants in the supply chain, such as suppliers, manufacturers, logistics companies and educational institutions. The stages of equipment procurement, storage and delivery are also analyzed. The goal is to identify key aspects of this chain and understand how effectively it functions.

Second, studying the problems and barriers that educational institutions face in the process of purchasing and supplying medical equipment. This includes an analysis of logistical difficulties, such as transportation of equipment to remote regions, financial constraints of educational institutions, bureaucratic barriers, and dependence on international suppliers. This stage of the study is important for identifying weaknesses in the supply chain.

Third, proposing solutions and recommendations for supply chain optimization. Based on the identified problems, ways to improve logistics processes, opportunities for cooperation with local manufacturers, and ways to reduce administrative procedures will be proposed. This is aimed at increasing the efficiency and availability of medical equipment, which will ultimately improve the quality of training of medical specialists in educational institutions of the Kyrgyz Republic.

Research method

(1) Literature Review Method: Involves conducting an extensive review of domestic and foreign literature to understand the current state and progress in the study of medical equipment supply chains. This method will identify existing approaches and practices in this area.

(2) Comparative Analysis Method: Involves comparing various models of medical equipment supply chains, both at the level of the Kyrgyz Republic and international practices. This will help identify the strengths and weaknesses of existing approaches.

(3) Fieldwork Method: Includes conducting in-depth interviews with key participants in the supply chain, surveys of educational institutions and suppliers, as well as field research to obtain data on the actual supply process.

(4) Combination of Qualitative and Quantitative Methods: Using both qualitative (interviews, observations) and quantitative methods (data analysis, statistical research) to obtain a comprehensive picture of the supply chain and proposals for its optimization.

Research purpose

The aim of this study is to analyze and optimize the supply chain of medical equipment for educational institutions in the Kyrgyz Republic in order to increase their availability, efficiency and sustainability. The study aims to identify current problems and limitations in the existing supply system, as well as to develop recommendations for improving logistics processes and procurement management, which will improve the quality of medical education and training of specialists in the country.

Research results and significance

The findings of this study provide a comprehensive understanding of the current structure of the medical equipment supply chain in educational institutions in the Kyrgyz Republic, identifying key bottlenecks, logistical challenges, and dependencies on foreign suppliers. By analyzing these issues, the study highlights specific areas where the supply chain can be optimized to improve efficiency, reduce

costs, and ensure timely delivery of essential medical equipment to educational institutions.

The findings of the study highlight the important role of Public-Private Partnerships and international organizations in strengthening the supply chain infrastructure. Recommendations for sustainable improvements, including collaboration with local suppliers and streamlining bureaucratic procedures, are aimed at promoting a more resilient and self-sufficient supply chain.

Research innovative

(1) A comprehensive approach to analyzing the medical equipment supply chain: Unlike most studies that focus on individual aspects (such as logistics or procurement), this study examines the supply chain in its entirety — from purchasing equipment to delivering it to educational institutions. This allows us to identify interdependencies between different stages and determine key bottlenecks.

(2) Comparative analysis with foreign practices: The study uses a comparative analysis with successful models of medical equipment supply chains in other countries. This allows us to adapt best practices and apply them to the conditions of the Kyrgyz Republic, taking into account regional characteristics and constraints.

(3) Using technologies to optimize the supply chain: For the first time, digital solutions such as data-driven demand forecasting, real-time inventory management systems, and automation of procurement processes are offered to optimize the supply chain of medical equipment in educational institutions of the Kyrgyz Republic. These innovations will create a more efficient and adaptive supply chain.

(4) Approach to sustainable supply chain development: The study examines the environmental and economic aspects of the supply chain, including reducing reliance on imported equipment and encouraging local production. Introducing sustainable practices such as optimizing transport routes and reducing waste will help build a greener and more sustainable supply chain.

Approval of works and implementation of research results

The main scientific provisions, methodological recommendations and practical results of the dissertation were tested and implemented through publications in peer-reviewed scientific journals included in international databases.

In particular, the problems of quality control of logistics services in the B2C sector based on the economic approach were discussed in detail in the article by Orozonova, A., Akmatova, A., Kazakov, A. (2024) “B2C-oriented quality control of logistics services based on an economic perspective”, published in the journal Advanced Logistic Systems – Theory and Practice (vol. 18, no. 2, pp. 42–50, DOI: 10.52566/msu-econ2.2024.42).

Of practical importance are the results presented in the collective work of Kazakov, A., Musaeva, N., Goncharova, I., Mambetkulova, A., Orozonova, A. et al. (2024) “Sustainable Logistics Management of Public Procurement of Medical Equipment”, published in BIO Web of Conferences (vol. 120, article no. 01066), where ways of optimizing procurement in the field of medical care are substantiated, taking into account the principles of sustainable development.

Additional application of methodological approaches in the field of logistics is presented in the article Mosiiuk, S., Voitovych, S., Sorokoumov, H., Saichuk, V., Kazakov, A. (2023) “Logistics Management of Health Resorts and Tourism Facilities”, published in the Journal of Education and Learning (vol. 12, no. 4, pp. 609–615, DOI: 10.55365/1923.x2023.21.63). In addition, the provisions concerning the role of logistics in the regional economy are reflected in the work of Sun, X., Zhumadilov, A., Myrzalieva, M., Kazakov, A., Akmatova, A. (2024) “Current State of Logistics Development and Its Role in the China’s Regional Economy”, published in Qubahan Academic Journal (vol. 4, no. 4, pp. 361–373). Thus, the results of the dissertation research have undergone comprehensive testing in leading scientific publications, which confirms their scientific and practical significance.

Chapter I: Theoretical basis and literature review

1.2. Theoretical and methodological features of logistics

The term «logistics» comes from the Greek word λόγος, which means «the art of calculating, reasoning». In Ancient Greece, logisticians were officials who exercised control over economic, trade and financial activities. According to Archimedes, there were ten logisticians in Ancient Greece.

There is evidence that in the Roman Empire there were also servants who bore the title of «logisticians» or «logistics»: they were engaged in the distribution of food products.

In the 1st millennium AD, the term «logistics» appeared in the military lexicon of a number of countries, where logistics began to be understood as the activity of providing the armed forces with material resources. Thus, during the time of the Byzantine Emperor Leo VI (865-912), it was stated that the tasks of logistics were arming the army, supplying it with all property, and taking care of the food needs of the army.

The creator of the first scientific works on military logistics in its classical sense is considered to be the prominent military theorist and historian of the early 19th century, Antoine Henri Jomini (1779–1869), who summarized the experience of wars of the late 18th – early 19th centuries. Jomini divided the system of troop control into strategy, tactics and logistics, the latter he considered as the practical art of maneuvering troops. He claimed that logistics includes not only transportation, but also planning, management and supply of troops, determining their location, as well as the construction of bridges and roads.

The mid-19th – early 20th centuries were marked by the end of the formation and establishment of logistics as a science. It was used in planning military campaigns by many outstanding military leaders and commanders. In the modern interpretation, military logistics is understood as a clear and effective system of providing the active army, supplying troops with ammunition, provisions, medical equipment and managing their movement in order to achieve success in a military

campaign. Along with tactical, operational and intelligence, logistics is still considered one of the main elements of military science. There is also a mathematical interpretation of the concept of logistics. It was developed in the works of the German philosopher, mathematician, physicist and linguist Gottfried Wilhelm Leibniz (1646–1716), who used the term «logistica» as a mathematical name for numerical operations, inherited by calculus ratiocinator. The most complete embodiment of Leibniz's idea was realized later in works on logic, and the term «logistics» itself in this meaning was established at the philosophical congress in Geneva in 1904.

One of the first officially recognized and widely used definitions of the term "logistics" is as follows:

"Logistics is the science of planning, managing and controlling the movement of material, information and financial resources in various systems."

This definition was formulated and adopted at the First European Congress on Logistics, held in Berlin from 20 to 22 March 1974 [1].

This congress became a turning point in the institutionalization of logistics as an independent scientific and practical discipline. It contributed to the systematization of key logistics functions and laid the foundation for the integration of logistics into business management, production planning and supply chain coordination. As a result, logistics began to be perceived not only as a set of operational tasks, but also as a strategic tool that ensures the efficiency and competitiveness of organizations.

In the following decades, the evolution of logistics theory and practice was influenced by the works of leading scientists and practitioners. For example, Donald J. Bowersox and David J. Kloss contributed significantly to the development of strategic logistics management in the United States, emphasizing the integration of logistics with marketing and finance. In Europe, Herbert Kotzab and Stefan Suering advanced research in the field of sustainable supply chains and logistics networks. The Japanese approach, especially under the influence of Taiichi Ohno, introduced

just-in-time (JIT) logistics and lean thinking, which revolutionized manufacturing logistics worldwide.

The formation of logistics as a scientific discipline occurred gradually, under the influence of various factors: military needs, economic reforms, technological progress and globalization. In different historical periods, the concept of logistics was transformed from the military art of supply to a systems approach to managing material, information and financial flows.

One of the turning points in the institutionalization of logistics was the First European Logistics Conference, held in Berlin from March 20 to 22, 1974, where the first official definition of logistics was proposed as a science of planning, management and control of the movement of resources in various systems. From that moment on, logistics began to be perceived not only as an applied function, but also as an interdisciplinary direction, actively studied in the scientific community.

Development of logistics in the USA

The most significant contribution to the formation of logistics as a separate scientific field was made by American researchers. Among them, Donald J. Bowersox and David J. Closs stand out, whose works laid the foundation for a systems approach to logistics and supply chain management. Bowersox was one of the first to consider logistics in a strategic context, including interaction with marketing, finance and information technology. His joint work with Closs and Cooper - Logistical Management: The Integrated Supply Chain Process - became a fundamental work for many scientific schools.

A significant contribution was also made by Douglas M. Lambert, who developed a model for managing relationships in supply chains, and James R. Stock, one of the first to formulate scientific approaches to reverse logistics (RL). The development of this sub-industry was also supported by Paul R. Murphy and Richard F. Poist, who identified the importance of reverse flows in logistics systems.

German School of Logistics

In Germany, logistics developed in close connection with engineering, production management and business economics (Betriebswirtschaftslehre). The

contribution of Herbert Kotzab and Stefan Seuring to the formation of sustainable logistics systems and logistics networks was widely recognized in Europe. They raised questions of environmental friendliness, social responsibility and economic efficiency in logistics. At the same time, Wolfgang Kersten actively researched the digitalization of logistics processes and the integration of IT into logistics infrastructure.

Chinese Contribution to the Development of Logistics

In China, the scientific understanding of logistics began to take shape in the 1990s against the backdrop of the country's reforms and opening up. Among the Chinese scholars who have studied the essence of logistics, Wang Zhenyu, who studied logistics as part of the state economic strategy, Chen Xiangming, who focused on the role of logistics in the urbanization process, and Liu Jianyong, who analyzed the development of logistics parks and infrastructure, stand out.

Logistics in China is viewed not only as an economic tool, but also as a factor in spatial development, national competitiveness and supply sustainability. At the same time, Chinese studies emphasize the importance of government regulation, transport policy and information technology.

Japanese approach: lean logistics

The Japanese school of logistics was based on the principles of lean manufacturing and Just-in-Time (JIT). The key representative of this school was Taiichi Ohno, who developed the Toyota Production System. His approach radically changed the understanding of production logistics, focusing on minimizing losses, synchronizing supplies and adaptability of supply chains.

European and international logistics

In the UK, the development of logistics is associated with the name of Martin Christopher, who promoted the concepts of logistics flexibility, sustainability and supply chain integration. His research became the basis for understanding logistics as a competitive advantage in conditions of high uncertainty and global risks.

In the Netherlands, Rommert Dekker made a special contribution by focusing on the mathematical modelling of logistics processes, including the design of reverse

logistics systems. His work at Erasmus University became the basis for the development of analytical approaches to logistics networks.

In recent decades, logistics has undergone a significant transformation, becoming one of the key disciplines actively studied in the scientific community. The number of publications on logistics is steadily growing, which indicates a growing interest in this area from both academia and business practitioners.

Analysis of international scientific databases such as Scopus, Web of Science and Google Scholar shows that since the early 2000s, there has been an exponential increase in the number of studies devoted to logistics. Works are published especially intensively in the following areas: Supply Chain Management (SCM); Digital logistics and process automation; Green (ecological) logistics and sustainable development; Information technology in logistics (IoT, Big Data, AI); E-commerce logistics and reverse logistics; Global logistics networks and risks in unstable conditions.

In addition, topics related to the optimization of transport routes, inventory management, integration of logistics with production processes, as well as logistics in emergency situations (for example, during the COVID-19 pandemic) remain relevant. The countries with the greatest scientific activity in the field of logistics are the USA, Germany, China, Great Britain and the Netherlands. In recent years, the contribution of the CIS countries has also increased, especially in terms of adapting logistics models to the post-Soviet space and cross-border cooperation.

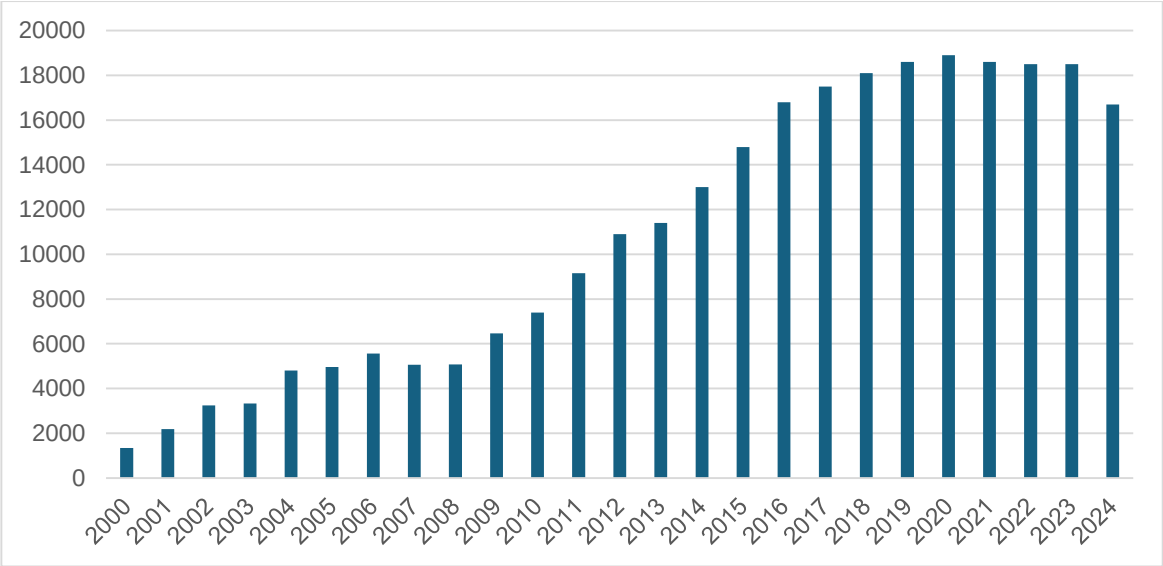


Figure 1. Annual publication of articles on the topic in the period 2000-2024 in the CIS countries.(Google Scholar)

An analysis of quantitative data on annual publications in the field of logistics in the CIS countries for the period 2000–2024 allows us to identify several characteristic stages in the development of scientific activity in this area.

In the initial period (2000–2005), there is a moderate increase in the number of publications: from 1,340 to 4,960 articles. This is explained by the gradual recognition of logistics as a separate discipline important for economics and management. During this period, basic scientific schools are formed and a theoretical base is accumulated.

From 2006 to 2011, the pace of publication activity noticeably accelerates — the number of articles more than doubles: from 5,560 to 9,150. This reflects the growing interest in logistics in the context of the integration of the CIS into the global economy and the need to optimize internal and external trade flows.

The period 2012–2020. is characterized by the most active growth: the number of publications increases from 10,900 to 18,900. During this period, logistics is actively developing under the influence of digital technologies, e-commerce and sustainable development concepts. In addition, the challenges associated with global crises (for example, COVID-19) stimulated research in the field of sustainability and adaptability of logistics systems. Since 2021, there has been stabilization and a slight

decline in publication activity (to 16,700 in 2024), which is due to partial saturation of the topic, changes in research priorities or foreign economic factors.

Thus, logistics in the CIS countries remains a significant area of scientific research, demonstrating sustainable dynamics and strategic importance for the development of the region.

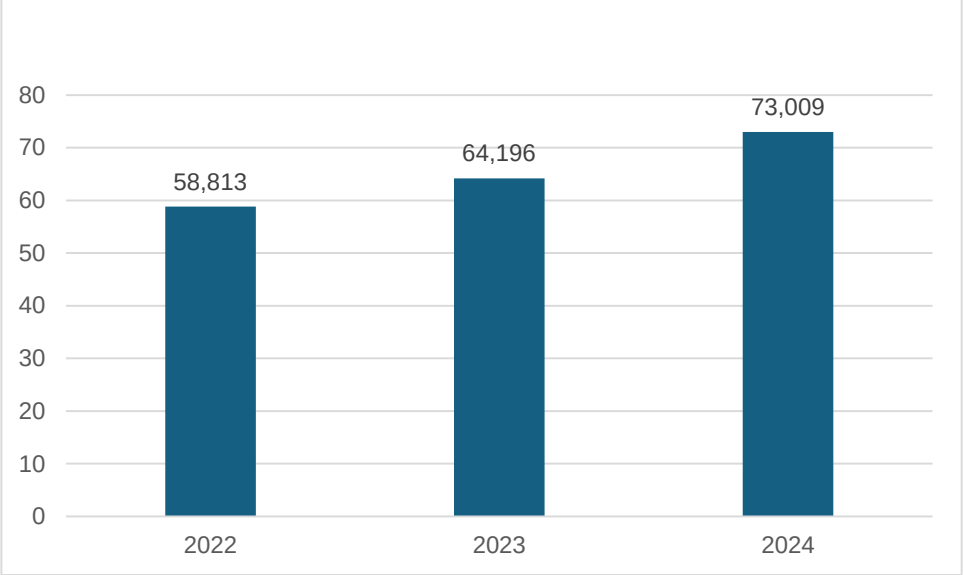


Figure 2. Analysis of publication activity on the topic «logistics» in the Scopus database (2022-2024)

According to the international database of scientific publications Scopus, over the past three years there has been a steady positive trend in the number of scientific articles devoted to logistics issues. In 2022, 58,813 publications were registered for the query «logistics». Already in 2023, this figure increased to 64,196, and in 2024 it reached 73,009 scientific papers.

Such growth (approximately 24% over two years) indicates a high and growing interest of the global scientific community in logistics issues. This is due to several global trends: active development of e-commerce and digital supply platforms; implementation of innovative technologies (Big Data, IoT, artificial intelligence) in logistics chains; growing importance of sustainable and green logistics solutions; the need to adapt logistics systems to crises (COVID-19, geopolitical instability, resource shortages).

The increase in the number of publications also indicates the expansion of interdisciplinary research: logistics is increasingly considered in the context of management, information technology, ecology, economics and social sciences.

Thus, Scopus data confirms that logistics remains one of the most dynamically developing and researched areas in the modern scientific environment.

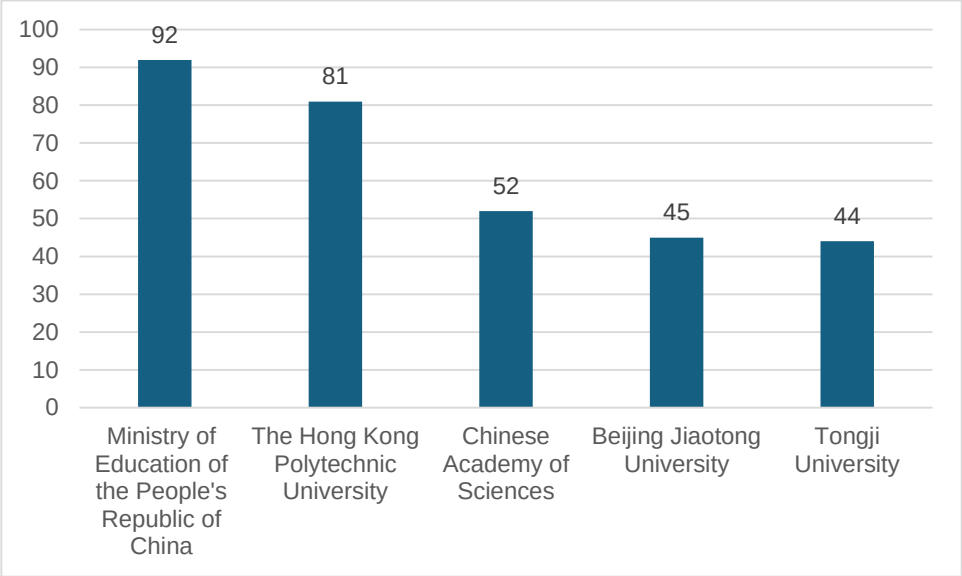


Figure 3. Top 5 organizations by number of publications in the field of logistics (Scopus, 2024).

In 2024, the field of logistics saw high research activity from Chinese research institutions. The Ministry of Education of the People's Republic of China led the way in terms of the number of publications with 92 papers. This reflects the strategic support for scientific research in China at the national level. The Hong Kong Polytechnic University (81 publications) came in second, traditionally holding a strong position in the applied aspects of logistics, especially supply chains and sustainable solutions.

The Chinese Academy of Sciences, with 52 publications, demonstrates contributions to fundamental and interdisciplinary research, including logistics digitalization, artificial intelligence, and supply chain optimization. Beijing Jiaotong University (45 publications) and Tongji University (44 publications) are actively developing topics in transportation logistics, intelligent transportation systems, and urban logistics solutions.

The overall analysis shows that China has significantly strengthened its position in the global logistics research agenda. The dominance of Chinese organizations in publication activity indicates large-scale investments in scientific research, technological development and international cooperation. Trends point to an interest in sustainable logistics, digital platforms and the integration of logistics with innovative technologies, which will determine the development vector of the industry in the coming years.

In 2024, authors from various countries stood out in the scientific publications on logistics, especially from Asia, the Middle East and Latin America. The most active researchers were from China, which demonstrated leadership in both the number of publications and the coverage of topics in the field of logistics. Among them, Li Wei (China), representing Tsinghua University, actively publishes on digital supply chains. Zhang Yong (China, Shanghai Jiaotong University) and Chen Ming (China, Beijing Jiaotong University) study transport logistics and freight optimization.

Wang Xia and Liu Jie (both from China) publish on sustainable and urban logistics, applying modern digital tools such as artificial intelligence and blockchain.

Among the international researchers, Mohamed Al-Farsi from Saudi Arabia, who works on logistics efficiency in the Middle East, and Rahul Kumar from India, who analyzes logistics in the context of emerging markets and digital platforms, stand out.

Fatemeh Ahmadi from Iran studies the adaptation of logistics strategies in an unstable economic environment, and John Mokoena from South Africa contributes to the development of regional logistics and infrastructure on the African continent. Luis García from Mexico studies cross-border logistics and sustainable supply in Latin America.

Thus, 2024 has shown an increase in international interest in logistics and the active participation of researchers from different regions of the world.

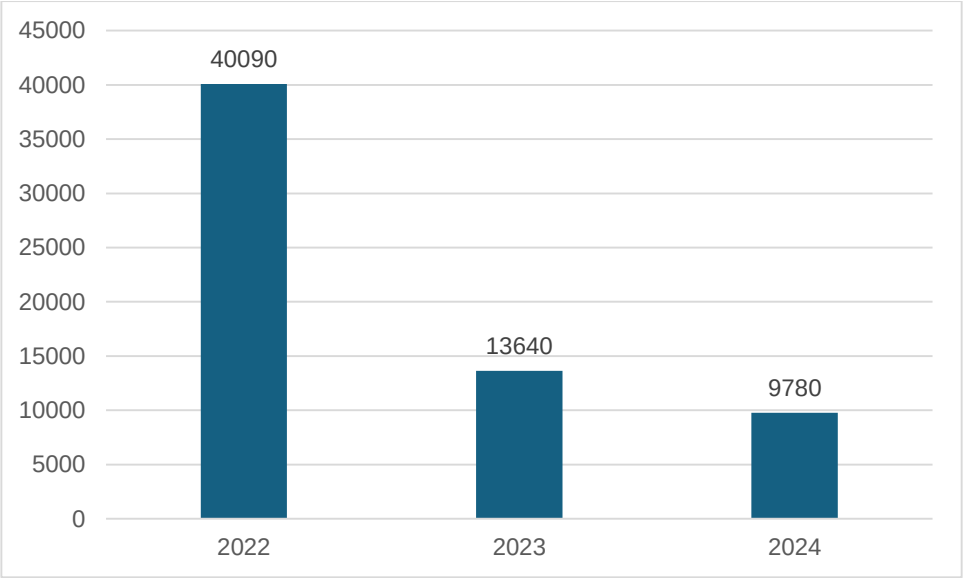


Figure 4. Publication activity on the topic «Healthcare Supply Chain Management» (2022–2024)

Scientometric analysis of publications by the keywords “healthcare supply chain management” for the period from 2022 to 2024 shows a clear decline in scientific activity. In 2022, a record number of publications was recorded - 40,090, which may be due to the consequences of the COVID-19 pandemic, when logistics issues in healthcare became especially relevant. Scientists around the world were actively studying weaknesses in the supply chains of medical equipment, drugs, vaccines, as well as logistics in emergency situations.

In 2023, the number of publications decreased by more than half - to 13,640, which indicates a shift in scientific focus towards other pressing problems, as well as the saturation of the academic field with basic research.

By 2024, the number of publications continues to decline - to 9,780, but this can be explained by both a temporary shift in the indexing of articles and stabilization of interest in the topic. Despite the decline, healthcare logistics remains an important interdisciplinary field that combines elements of economics, management, information technology and medicine.

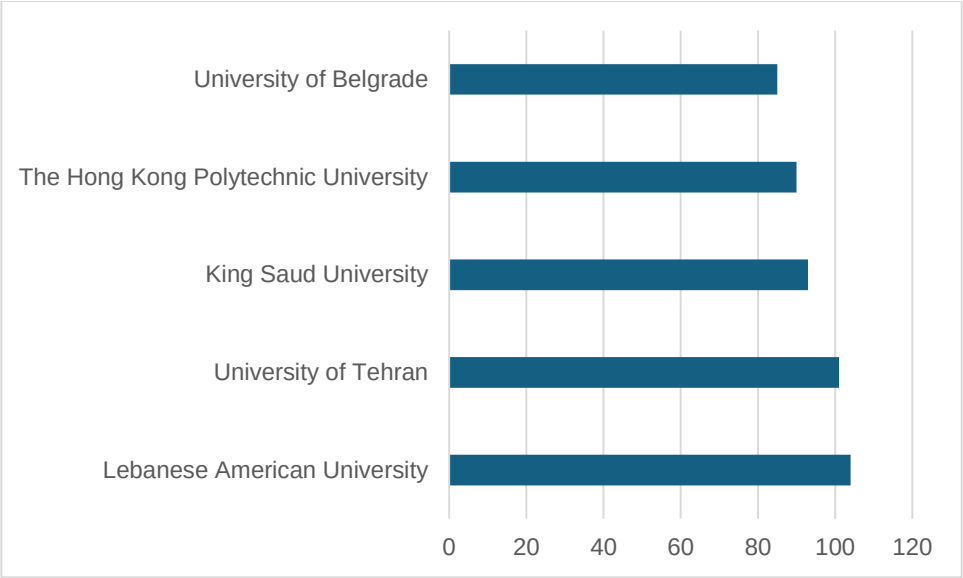


Figure 5. Top 5 universities by number of publications in "Healthcare Supply Chain Management" (2022–2024)

In the period from 2022 to 2024, universities from the Middle East, Asia and Europe showed the greatest activity in scientific publications on the topic of Healthcare Supply Chain Management. The leader was the Lebanese American University with 104 publications, which indicates a high level of interest among researchers in the issues of healthcare logistics in the context of developing countries and regional healthcare systems.

In second place is the University of Tehran (Iran) with 101 publications. This reflects active scientific work in the field of medical supply logistics in the context of economic and infrastructural constraints. King Saud University (Saudi Arabia) also showed high results (93 publications), focusing on the efficiency of supply chains, especially in public hospitals and institutions.

Among Asian universities, The Hong Kong Polytechnic University (90 publications) stands out, actively researching digital solutions, logistics automation and supply chain sustainability. The University of Belgrade (Serbia) rounds out the top 5 with 85 publications, indicating growing interest in the topic in the South-Eastern Europe region.

Overall, the data demonstrates the broad geography and relevance of the HSCM topic, especially in the post-pandemic period, when the efficiency of medical resource supplies has become critical.

Supply chain management (SCM) is a critical area in both business practice and academic research because it focuses on coordinating and optimizing all processes involved in the production, shipping, and delivery of goods from suppliers to end customers. SCM encompasses several interrelated activities, including purchasing, manufacturing, transportation, and logistics, all of which are aimed at maximizing efficiency, reducing costs, and increasing customer satisfaction. This literature review provides an overview of key concepts, theoretical frameworks, and recent advances in the field of SCM.

The concept of SCM emerged in the 1980s as companies began to recognize the importance of coordinating activities across departments and with external partners to improve competitiveness. Early research on SCM focused on logistics and the efficient movement of goods within individual organizations. Pioneering work by researchers such as Bowersox (1989) and Mentzer (1987) emphasized the role of logistics in minimizing costs and improving service quality within organizations.[1][2] This early focus on logistics laid the foundation for SCM as a field that prioritizes aligning supply chain activities with organizational strategy.

By the 1990s, globalization and advances in information technology had expanded SCM into a multifaceted discipline encompassing both local and international supply chain networks. Key developments during this period included the introduction of just-in-time (JIT) and lean manufacturing techniques, which were aimed at reducing waste and streamlining inventory management. These practices were particularly influenced by the Japanese manufacturing model, and authors such as Ohno (1988) and Womack & Jones (1990) contributed to the development of Lean principles [3][4]. In addition, advances in information technology allowed companies to integrate systems for real-time data exchange and inventory tracking, allowing for more effective coordination of supply chain partners (Christopher, 1992)[5].

Overall, the evolution of SCM during this period reflected a shift from isolated logistics functions to a holistic view of the supply chain, emphasizing efficiency, flexibility, and collaboration across global networks.

Following the seminal developments of the 1980s and 1990s, research in supply chain management (SCM) has continued to evolve, placing increasing emphasis on creating integrated, adaptive, and resilient supply chains. Below are some of the key research areas and advances that have shaped SCM since the 2000s: Supply Chain Integration and Collaboration. Researchers such as Lambert, Cooper, and Pugh (1998) emphasized the need for collaboration among supply chain partners, introducing the supply chain integration and partnership management models [6]. This approach emphasized that close relationships with suppliers and customers can improve the flow of information, reduce inefficiencies, and create value throughout the supply chain. Simchi-Levi et al. (2003) expanded on this by examining the role of integrated supply chains in responding to demand variability and improving operational flexibility. Their work provided a framework for achieving integration through joint planning and information sharing [7].

Supply Chain Risk and Resilience Management. As global supply chains have become more complex and vulnerable to disruption, risk management has gained importance. Christopher and Peck (2004) were among the pioneers who emphasized the importance of building resilience in supply chains, advocating for risk mitigation strategies such as diversified sourcing and inventory buffers [8]. - Following the 2008 financial crisis and subsequent disruptions such as natural disasters, scholars such as Wagner and Bode and Tan focused on developing risk assessment frameworks and strategies to enhance supply chain resilience, ensuring business continuity during crises [9] [10].

Sustainable and Green Supply Chain Management. Environmental sustainability has become a central focus of SCM research, driven by growing awareness of climate change and corporate social responsibility. Srivastava provided a comprehensive review of green supply chain management, outlining practices such as waste reduction, green sourcing, and energy-efficient logistics [11]. Carter and

Rogers introduced the concept of sustainable supply chain management by incorporating environmental, social, and economic aspects and examining how companies can integrate sustainability into their supply chain practices without sacrificing profitability [12]. Digitalization and the Impact of New Technologies.
With the rise of the digital economy, SCM research has begun to focus on the transformative impact of new technologies, including the Internet of Things (IoT), artificial intelligence (AI), blockchain, and big data analytics.Ivanov and Dolguy discussed the role of digital supply chains and digital twins, emphasizing how these technologies improve visibility, real-time monitoring, and decision making [13]. Wang, Gunasekaran, and Ngai examined the impact of big data on supply chain performance, showing how data-driven insights can lead to improved forecasting, risk management, and customer satisfaction [14]. Smart and Agile Supply Chain. Agility and responsiveness have become essential attributes of modern supply chains, especially in fast-moving industries such as technology and fashion. Li discussed the "Triple-A" supply chain concept of agility, adaptability, and consistency as the key to managing demand uncertainty and improving responsiveness to market changes. Yusuf, Gunasekaran, and Adeleye also contributed to the study of agile supply chains by examining how lean and agile processes can improve the performance and sustainability of supply chains [16].

Thus, logistics as a scientific field has come a long way - from the ancient system of military supply to a modern interdisciplinary science. Initially performing the functions of providing the army in Ancient Greece and Rome, logistics gradually became institutionalized and acquired a theoretical and methodological basis, which was reflected in the works of such thinkers as A. Jomini and G. Leibniz. An important stage in the formation of the conceptual apparatus was the adoption of the official definition of logistics at the First European Congress in Berlin in 1974, where logistics was defined as the science of planning, management and control of resource flows.

The contribution of foreign schools to the development of logistics is extremely significant. American scientists (Bowersox, Kloss, Lambert, Stock)

focused on strategic supply chain management. European researchers (Kotzab, Soering, Christopher) developed the areas of sustainable and digital logistics. The Japanese school (Ohno) has implemented the principles of lean manufacturing and JIT. Chinese scientists have been actively developing issues of public logistics and digital logistics platforms since the 1990s.

Analysis of publication activity (Scopus, Web of Science, Google Scholar) shows a significant increase in interest in logistics from both the scientific community and practitioners. Areas related to digitalization, sustainable development, reverse logistics and healthcare logistics are developing especially actively. The leading countries in terms of the number of publications are China, the USA and Germany.

Thus, logistics is today considered not only as an applied tool, but also as a strategic category that ensures the efficiency, adaptability and sustainability of socio-economic systems.

1.2 Relevant Theoretical basis and literature review

Supply Chain Management (SCM) is a strategic approach to managing the flow of goods, services, information, and finances across multiple stakeholders within a supply network. The theory of SCM has evolved over decades, integrating concepts from logistics, operations management, and strategic planning (Mentzer et al., 2001; Christopher, 2016). The healthcare sector, including the supply chain for medical equipment in educational institutions, presents unique challenges due to the critical nature of the products and the regulatory frameworks governing their distribution (Govindan et al., 2018)

John Fernie introduced the concept of supply chain management (SCM) to the UK National Health Service (NHS), one of the first examples of SCM being applied in the service sector[1].

[1] Fernie, John and Clive Rees. (1995). “Supply chain management in the national health service”,The International Journal of Logistics Management, Vol. 6 No. 2, pp. 83-92

Katawala and Abdu conducted a study on the application of supply chain management concepts in the service industry, focusing on the importance of process integration and alignment to improve the efficiency and quality of service delivery.[2]

Evolution of Supply Chain Management (SCM)

1950	The beginning of the existence of the logistics concept, which outlined the basic approach to managing the flow of goods and materials.
1970	Formation of the established logistics concept, when logistics became an independent area of management.
1980	The beginning of the formation of the SCM concept, in which logistics is viewed as a single supply chain, covering the entire process from production to the consumer.
1990	Active implementation of SCM in industry, with an emphasis on the coordination of supplies and resource management between different enterprises.
1995	Implementation of SCM in the service sector, expanding the concept beyond manufacturing industries and adapting it to the service sector.
2007	The emergence of educational SCM, including SCM in training programs for the preparation of qualified specialists.
2010	Emergence of digital technologies such as Big Data, IoT and AI, which increase supply chain transparency and efficiency.
2019	Development of risk management and global supply chains – In the face of global crises such as the COVID-19 pandemic, there is an increased focus on supply chain resilience, supplier diversification and risk management.
2020	Development of sustainable and green SCM, with a focus on sustainability, recycling and carbon reduction.
2021	Integration of SCM and AI – With the introduction of AI and machine learning, SCM reaches a new level of automation, allowing for rapid data processing, demand forecasting and automated process management.

It should be emphasized that SCM is closely related to marketing, since in order to effectively manage a business, companies need to know their target segment, study customer trends and needs, and monitor changes in the market. This allows for customer-oriented activities. SCM also interacts with production,

[2] Kathawala, Yunnus and Khaled Abdou. (2003).“Supply chain evaluation in the service industry: a framework development compared to manufacturing”, Managerial Auditing Journal, Vol. 18 No. 2, pp.140-149

strategic, and operational management, as well as with economic informatics, since it combines modern principles and the capabilities of information technology. Due to this, SCM is considered a holistic concept of doing business.

According to research of Vasyukova A. I. and Kalashnikova M. A., the transportation of medicines and medical equipment requires strict compliance with established rules and conditions to ensure their safety and security. It is important to consider temperature and light conditions, chemical and physical properties of the products, and also to use specialized transport and packaging. The carrier is also required to have the necessary license and documentation confirming the legality of the activity and the qualifications of the employees involved[3].

According to the authors Ablyaev E. A. and Sheiko A. V., effective logistics management in the medical field requires competent planning, flexibility and prompt information services, which ensure fast document flow and the creation of a single information space. These factors contribute to the smooth operation of medical institutions and the optimization of flows of medicines and equipment in the regions[4].

Moreover, the development of logistics and supply chain management education in Central Asia has been significantly influenced by national scientific schools. In Kyrgyzstan, the founder of the Kyrgyz school of logistics is rightfully considered to be the Director of the International Higher School of Logistics, Doctor of Economics, Professor Akylbek Umetaliev, who made a substantial contribution to both theoretical and applied logistics in the country. Under his authorship, the first textbooks on logistics were published in Kyrgyz and Russian languages, marking an important milestone in the formation of a national logistics education system.

Among his notable works is the textbook *"Logistics and Supply Chain Management"*, which addresses essential topics such as logistics systems design, inventory control, procurement, distribution, warehousing, and transportation.

[3] Васюкова А. И., Калашникова М. А. Логистика автомобильных перевозок лекарственных препаратов и медицинского оборудования //Развитие логистики и управления цепями поставок. – 2022. – С. 270-273.
[4] Абляев Э. А., Шейко А. В. Инновационный подход к логистике в медицине //Евразийский союз ученых. – 2016. – №. 33-1. – С. 46-48.

Additionally, his monograph *"Public Procurement Management – an Effective Instrument of the State Fiscal Policy"* explores the rational use of public resources in the context of sustainable development. These academic resources are widely used in universities across Kyrgyzstan and contribute significantly to the training of highly qualified specialists in logistics and supply chain management, including in the field of healthcare logistics.

Definition and Evolution of SCM. The concept of SCM emerged from logistics and operations research in the mid-20th century. Keith Oliver (1982) is credited with coining the term "supply chain management," highlighting the importance of inter-organizational coordination in improving efficiency. Since then, various researchers have expanded the definition to include strategic sourcing, supplier relationships, risk management, and digital transformation.

Mentzer et al. (2001) define SCM as "a systemic, strategic coordination of traditional business functions and the tactics across these functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole." Christopher (2016) emphasizes that SCM is not just about logistics but also about creating competitive advantage through the effective integration of supply chain activities.

The evolution of SCM can be divided into several key phases: Traditional Logistics (1960s-1980s) – Focus on transportation, warehousing, and inventory control (Bowersox & Closs, 1996). Integrated Supply Chain (1990s-2000s) – Development of strategic partnerships and lean supply chains (Lambert et al., 1998). Digital Supply Chains (2010s-present) – Emphasis on automation, blockchain, and artificial intelligence (Ivanov et al., 2019). Core Components of SCM. SCM consists of several key components, each playing a critical role in ensuring efficiency and effectiveness: Procurement and Supplier Management.

Procurement is the process of sourcing, evaluating, and contracting suppliers to provide goods and services. Effective supplier management is crucial for medical equipment supply chains, as it ensures product quality, compliance with regulations,

and cost efficiency (Handfield & Nichols, 1999). The Kraljic Matrix (1983) is often used to categorize suppliers based on their strategic importance and supply risk. In the context of medical equipment for educational institutions, procurement decisions must consider factors such as: Reliability of suppliers – Ensuring timely delivery of high-quality medical devices (Monczka et al., 2015). Regulatory compliance – Adherence to WHO and local health standards (WHO, 2020). Cost-effectiveness – Balancing affordability with product longevity (Caniato et al., 2012).

Logistics and Distribution. Logistics involves the transportation, storage, and distribution of medical equipment. Chopra and Meindl (2019) highlight the role of logistics in ensuring that products reach their destination efficiently and at the lowest possible cost.

Key logistical challenges in medical supply chains include: Cold chain logistics – Necessary for temperature-sensitive equipment (Christopher, 2016). Infrastructure limitations – Particularly relevant in developing countries like the Kyrgyz Republic (Govindan et al., 2018). Inventory optimization – Preventing overstocking or shortages (Silver et al., 1998). Inventory Management. Effective inventory management ensures that medical training institutions maintain optimal stock levels of equipment without overburdening storage facilities. The Economic Order Quantity (EOQ) model by Harris (1913) provides a framework for determining the most cost-effective order quantity.

Methods of inventory control include:Just-in-Time (JIT) inventory – Reducing waste by ordering only when needed (Womack & Jones, 1996).

- ABC analysis – Prioritizing inventory items based on their value and usage frequency (Gupta & Starr, 2014).
- RFID and barcode tracking – Enhancing real-time visibility of medical assets (Kumar & Srivastava, 2017).

Supply Chain Integration. Integration across various stakeholders is essential for improving efficiency and reducing operational risks. Stevens (1989) introduced the concept of supply chain integration, which involves aligning processes across suppliers, manufacturers, distributors, and end users.

Types of integration include: Vertical Integration – Direct control over multiple supply chain stages (Porter, 1985). Horizontal Integration – Collaboration between institutions to improve procurement efficiency (Simchi-Levi et al., 2008). Technology Integration – Use of ERP and cloud-based platforms for data sharing (Ivanov et al., 2019). SCM Theories and Models. Several theoretical frameworks have been developed to explain SCM dynamics: Resource-Based View (RBV) Theory – Barney (1991) suggests that competitive advantage comes from unique organizational resources, including supply chain capabilities. Transaction Cost Economics (TCE) – Coase (1937) and Williamson (1985) emphasize cost minimization in supplier relationships. Lean Supply Chain Management – Womack and Jones (1996) propose minimizing waste and optimizing value flow. Risk Management Framework – Tang (2006) highlights risk assessment strategies in global supply chains. SCM in the Healthcare Sector. The healthcare supply chain has distinct challenges compared to traditional industries. Arlbjørn and Halldórsson (2011) argue that medical supply chains must balance cost reduction with quality and regulatory compliance.

Specific issues in medical SCM include: Product lifecycle management – Ensuring timely maintenance and replacement (Caniato et al., 2012). Regulatory and ethical considerations – Managing counterfeit risks and safety standards (Govindan et al., 2018). Supply chain resilience – Adapting to global disruptions such as the COVID-19 pandemic (Ivanov & Dolgui, 2020).

SCM in the Kyrgyz Republic. The development of logistics and supply chain management in the Kyrgyz Republic faces multiple challenges, including outdated infrastructure, inefficient transportation networks, and regulatory barriers [Шербекова & Ысыраилова, 2024; Бекбоев et al., 2017]. The country's reliance on imports for medical equipment further complicates supply chain efficiency, increasing costs and extending delivery times [Аманкулов et al., 2022].

Several researchers have identified key factors affecting supply chain efficiency in Kyrgyzstan:

- Transport Infrastructure Limitations – The lack of modern transport corridors increases costs and delays in medical equipment delivery [Советбеков, 2014].
- Logistics System Risks – Inefficient risk management in supply chains affects reliability and responsiveness [Бровко & Борисенко, 2017].
- International Logistics Development – The need for better integration with global supply chains to enhance efficiency [Береналиев, 2020].

To address these challenges, experts recommend improving transportation logistics, enhancing digital tracking systems, and developing public-private partnerships in the logistics sector [Мейманкулова & Алджембаева, 2021].

International experience of Medical Equipment Supply Chain

The United States of America is one of the most developed examples of building an effective and sustainable medical equipment supply chain (MESC) system. In the context of a highly decentralized healthcare system, multi-level logistics infrastructure and active participation of the private sector, the United States has formed an integrated supply chain management model based on the principles of digitalization, demand forecasting and regulatory framework.

Organizational and management structure of supply chains

The key participants in the American MSC system are large distribution corporations (Cardinal Health, McKesson Corporation, Owens & Minor), which carry out wholesale purchases, storage, sorting and delivery of medical products to healthcare and educational institutions. Their activities are based on long-term

contracts with medical institutions, including university clinics and colleges. The operating model involves ensuring a full logistics cycle - from the moment of concluding the contract to the technical maintenance of the supplied equipment.

The peculiarity of the American system is the widespread use of outsourcing of logistics functions, as well as the application of the "single window" principle, in which customers interact with one supplier responsible for the comprehensive provision of the institution's needs.

Digitalization and technological integration

The United States demonstrates a high level of digitalization of logistics processes. The use of identification and tracking technologies (RFID, UDI, barcoding), warehouse management systems (WMS) and resources (ERP) allows for the automation of inventory management, order formation and logistics planning. Predictive analytics and machine learning are used to model demand and optimize logistics routes, which is especially important in conditions of high variability of the external environment.

Regulatory framework

Regulatory support for the CPMO system in the United States is carried out at the federal level. The Food and Drug Administration (FDA) has implemented a mandatory Unique Device Identification System for medical devices, which allows for monitoring and tracking of the movement of products throughout the supply chain. There is also a Strategic National Stockpile program aimed at creating reserves of critical equipment for emergency situations.

Pandemic crisis and the resilience of supply chains

The US experience during the COVID-19 pandemic has demonstrated both the advantages and vulnerabilities of existing supply chain mechanisms. In the context of a sharp increase in demand and global shortages, the system has demonstrated the ability to quickly adapt due to flexible decentralization and the availability of digital management tools. At the same time, a high dependence on the import of critical components was revealed, which became an incentive for supplier diversification and partial transfer of production (reshoring, nearshoring).

Provision of educational institutions.

The supply of medical equipment to US educational institutions is carried out both through government procurement mechanisms (GSA Schedules) and through direct contracts with manufacturers. Leading universities and colleges are equipped with certified simulators, diagnostic devices and simulation systems, the supply of which requires compliance with special storage and transportation conditions. Particular attention is paid to the compliance of the equipment with educational standards and student safety requirements.

Thus, the American model of medical equipment supply chain management is characterized by a high level of integration, regulatory transparency, digital maturity and logistical flexibility. The most significant elements subject to transfer to the practice of other countries, including the Kyrgyz Republic, include: digital platforms for tracking medical devices; implementation of predictive inventory management systems; formation of partnerships with private logistics operators; creation of strategic reserves and crisis protocols.

These approaches are of particular value in the context of modernization of the CPME and increasing the sustainability of educational and medical infrastructure.

Germany: Public-Private Partnerships and Sustainability of Medical Equipment Supply Chains

Germany, with one of the most developed healthcare systems in Europe, demonstrates a high degree of institutionalization and technological maturity of medical equipment supply chains (MESCs). A characteristic feature of the German model is the close integration of the private sector, government agencies and scientific institutes, which ensures stability, security and sustainability of supplies in normal and crisis conditions.

Organizational and structural features

The MSC system in Germany is organized within the framework of a decentralized federalism model, where a significant part of the powers in the field

of procurement and management of medical equipment belongs to the federal states and municipalities. At the same time, strategic regulation is carried out at the level of the Federal Ministry of Health (Bundesministerium für Gesundheit) in cooperation with the Robert Koch Institute (Robert Koch-Institut) and the Federal Institute for Drugs and Medical Technology (BfArM).

In practice, the logistics infrastructure relies on a well-developed network of distributors such as B. Braun, Drägerwerk, Siemens Healthineers, as well as specialized logistics operators (e.g. DHL Supply Chain Healthcare), which provide delivery, technical support, and disposal of equipment.

Digitalization and technology integration

Digital solutions in the field of supply chain management have been actively developing in Germany since the early 2010s. The main focus is on the implementation of eHealth infrastructure, ERP systems, track & trace (tracking of product movements), as well as interdepartmental platforms such as GS1 Germany, which facilitate the standardization of the identification of medical devices.

In addition, barcoding and UDI (Unique Device Identification) technologies have become widespread, ensuring transparency and traceability of deliveries right up to the end user. The German experience is particularly indicative in terms of the implementation of Just-in-Time logistics in combination with backup strategies (Just-in-Case) in case of emergencies.

National regulation and risk management

German law strictly regulates the approval, labeling, transport and disposal of medical equipment. In accordance with EU Regulation 2017/745 (MDR), Germany has implemented mandatory certification and risk monitoring procedures along the entire supply chain. Control and audit bodies and incident notification systems also play an important role.

Particular emphasis is placed on logistics risk management. Following the COVID-19 pandemic, Germany revised its strategy for securing critical equipment supplies by establishing the Nationale Reserve Gesundheitsschutz, a national reserve of medical products that includes masks, ventilators and laboratory tests.

Education and teaching infrastructure

The supply of medical equipment to higher education institutions, especially university hospitals, is coordinated both through centralized procurement and through project grants from the Federal Ministry of Education and Research (BMBF). Within the framework of the Digitalpakt Schule and Medizindidaktik-Initiativen programs, simulation centers and training laboratories are equipped with modern diagnostic, resuscitation and surgical simulators.

Technical universities such as TU Munich and TU Berlin, in cooperation with manufacturers, are implementing projects to test and implement new solutions in the logistics of medical equipment, including mobile and telemedicine platforms.

German experience in managing the supply chain of medical equipment demonstrates a holistic and systemic model based on: deep digital transformation of logistics processes; clear regulatory framework at the European and national levels; high degree of resilience to external shocks; interaction of the scientific and educational environment with industrial and logistics structures.

Foreign experience: Features of the development of medical equipment supply chains in China

In the context of rapid economic growth and urbanization, the People's Republic of China (PRC) has demonstrated significant success in the development of medical equipment supply chains (MESCs), forming a model based on state coordination, digitalization of logistics processes and the development of industrial clusters. The Chinese experience is of interest in terms of large-scale coverage of territories, diversification of supply sources and the use of innovative technologies.

MESCs in China are regulated within the framework of the national strategy "Healthy China 2030", which pays special attention to ensuring the availability and quality of medical services, including the logistics of equipment and consumables. The central role in managing the system is played by the National Health Commission of the PRC, coordinating the activities of regional departments and medical institutions.

An important component of the logistics policy is the integration of the CPMO into the state procurement system through the China Government Procurement Network platform, as well as the development of regional distribution centers operating on the principle of centralized tenders and contracts.

China is actively introducing digital technologies into supply chain management. At the hospital and university level, inventory management systems (Inventory Management Systems), medical device tracking systems (UDI, RFID), real-time supply monitoring platforms based on Big Data, IoT and AI technologies are being implemented.

Particular attention is paid to the platform integration of logistics data between manufacturers, logistics operators and medical institutions. Examples include the use of JD Logistics Healthcare, Cainiao Health and Tencent Healthcare Cloud systems, which provide end-to-end visibility across the entire supply chain, including analytics, forecasting and risk management.

Manufacturing Clusters and Export-Import Flows

One of the characteristic features of the Chinese model is the formation of powerful manufacturing clusters of medical equipment in provinces such as Guangdong, Jiangsu and Zhejiang. Clusters include full cycles - from R&D and production to logistics and export. This allows not only to quickly respond to domestic demand, but also to ensure exports to more than 180 countries, including Central Asian and African countries.

At the same time, China is diversifying logistics channels through participation in the Belt and Road Initiative, forming transnational logistics corridors for the supply of medical equipment, including multimodal routes by land (China-Europe railway) and sea.

The COVID-19 pandemic has become a test for China's CPMS system, but it has also demonstrated its ability to quickly adapt. Distribution hubs were set up to supply hospitals in Wuhan in the shortest possible time, mobile warehouses were deployed, and customs clearance procedures for international humanitarian supplies were accelerated. The role of online platforms (Alibaba Health, JD Health) in providing

end users with protective equipment and medical devices was strengthened. In the post-pandemic period, China has strengthened measures to localize the production of critical products, create reserve funds, and develop national standards in logistics.

Logistics for Medical Education

In the field of higher education, China has been centralizing the supply of medical equipment to university hospitals and simulation centers through programs of the Ministry of Education and local governments. Medical schools such as Peking University, Shanghai University of Traditional Chinese Medicine, and Zhejiang University receive equipment through centralized bidding and research grants.

The supplied equipment includes training dummies, simulators, ultrasound and diagnostic systems, which are delivered by certified logistics operators in compliance with temperature conditions and sterility requirements.

China's experience demonstrates a model that combines state strategic planning, a high degree of digitalization, a focus on localization of production and export potential. The most valuable practices include: creation of medical logistics platforms based on AI and Big Data; integration of logistics into industrial and scientific clusters; decentralization of supplies with regional coordination; development of reserve funds and emergency logistics.

International Experience: Medical Device Supply Chains in India

I ndia is one of the largest and fastest growing medical device markets in Asia. Given its population, regional diversity, uneven infrastructure and high import dependence, India is a unique example of developing a medical device supply chain (MDSC) that combines elements of public policy, private sector and digital innovation.

The medical device sector is regulated by the Central Drugs Standard Control Organisation (CDSCO), which operates under the Ministry of Health and Family Welfare of India. The regulatory framework was significantly updated with the Medical Device Rules (MDR) 2017, which established a separate regulatory regime for medical devices, rather than the earlier general category of drugs.

To expedite procurement and logistics of medical devices in the public sector, the Government e-Marketplace (GeM) and the National Health Mission (NHM) programme, which includes logistics components for hospitals and teaching hospitals, are in place.

Medical equipment logistics in India faces a number of challenges, from the lack of cold chain in rural areas to gaps in regulatory traceability of products. However, large logistics operators such as TCI Supply Chain Solutions, DHL India Healthcare, Apollo LogiSolutions play a major role in ensuring comprehensive coverage of the country. The private sector is actively involved in supplying university hospitals, research institutions, and simulation centers.

Supply chains include both direct distribution from manufacturers (domestic and foreign) and models through distribution centers with a regional redistribution network. A significant share of equipment is imported from the US, Germany, China, and Japan, but localization of production is growing under the Make in India and Production-Linked Incentive (PLI) Scheme programs.

Digitalization and Innovative Practices

India is actively implementing digital solutions in the field of supply management. The Electronic Vaccine Intelligence Network (eVIN), originally created for vaccine logistics, is being expanded to include equipment. Public-private platforms are being developed with integration into ERP systems and mobile apps to track shipments, equipment status, stock levels and maintenance deadlines.

RFID, IoT and blockchain technologies are also being implemented to ensure supply chain transparency, especially in the fight against counterfeit products.

During the pandemic, the Government of India quickly set up the COVID-19 India Supply Chain System (iSCS) platform for centralized distribution of medical supplies (ventilators, oxygen equipment, ventilators, PPE), which allowed for increased logistics capacity and real-time redistribution of resources between states. Military logistics channels were mobilized, and rail and air corridors were used to deliver equipment to remote areas.

Supply to Educational Institutions

Supply of medical equipment to medical colleges and universities in India is coordinated by the Ministry of Education and the National Medical Commission. Equipment for education is supplied under the Prime Minister's Swasthya Suraksha Yojana (PMSSY), AIIMS Expansion Scheme and World Bank grants.

Universities such as the All India Institute of Medical Sciences (AIIMS), Christian Medical College (CMC) and JIPMER have simulation labs equipped to international standards. Supplies are secured through tender procedures, with priority given to products made in India.

India demonstrates an adaptive model for the development of CPME, combining:

government strategy (Make in India, PLI Scheme); digitalization of logistics and traceability of supplies; hybrid distribution models; crisis resilience (iSCS, military corridors); integration with educational and research institutions.

An analysis of international experiences in developing medical equipment supply chains (MESCs) reveals different approaches shaped by national healthcare systems, regulatory environments, technological maturity, and economic structures. The United States demonstrates a highly integrated, digitally advanced, and market-oriented model. It relies on large private distributors, predictive analytics, and a regulatory framework that ensures traceability and resilience, especially during crises such as the COVID-19 pandemic. This model emphasizes agility, technological integration, and outsourcing efficiency.

The German approach is characterized by public-private partnerships, strict regulatory compliance under the EU MDR, and a digital infrastructure based on platforms such as GS1 and UDI. The German model is notable for its balanced use of Just-in-Time and Just-in-Case logistics strategies, risk management systems, and the role of federalism in procurement and educational supply.

China represents a state-coordinated model with rapid digitalization and industrial clustering. Its experience integrates big data, AI, and IoT into logistics platforms while maintaining centralized procurement. China's ability to mobilize emergency

logistics and support large-scale production for both domestic and export needs makes it a unique example of integrated resilience.

India presents a hybrid model that combines public policy (Make in India, PLI), digital innovation (eVIN, iSCS), and private sector logistics. Despite infrastructure challenges, India's decentralized, adaptive approach enables delivery to educational and rural institutions.

Taken together, these cases illustrate that resilient and sustainable MESCs are built on digital integration, clear rules, multi-sector collaboration, and investment in education and emergency preparedness. These practices offer valuable insights for improving the medical logistics framework in developing countries like the Kyrgyz Republic.

1.3. Supply chain in educational universities and its problems

Supply Chain Management (SCM) in educational institutions, particularly universities, plays a crucial role in ensuring the smooth flow of goods, services, and information necessary for academic and research activities. Universities rely on supply chains for acquiring teaching materials, laboratory equipment, medical instruments, and IT infrastructure. Effective supply chain management enhances operational efficiency, reduces costs, and ensures uninterrupted educational services [Christopher, 2016; Chopra & Meindl, 2019]. However, universities face unique challenges in managing their supply chains due to factors such as budgetary constraints, bureaucratic procurement processes, fluctuating demand, and supplier reliability issues. These challenges are particularly pronounced in developing countries, including the Kyrgyz Republic, where logistics infrastructure and financial resources are often limited [Шербекова & Ысыраилова, 2024; Береналиев, 2020]. Key Components of Supply Chain in Universities. University supply chains consist of several critical elements, including:

1. Procurement and Supplier Management – The acquisition of academic materials, laboratory equipment, and medical supplies must be done cost-effectively while ensuring quality and compliance with regulations [Handfield & Nichols, 1999].

2. Inventory Management – Universities must manage supplies efficiently to avoid shortages or excessive stockpiling, especially for perishable or technology-based equipment [Silver et al., 1998].
3. Logistics and Distribution – Timely delivery of goods is crucial, particularly for universities that depend on imported equipment [Christopher, 2016].
4. Financial and Budgetary Constraints – Public universities often operate under strict financial regulations, leading to slow procurement processes and difficulties in supplier negotiations [Mentzer et al., 2001].

Problems in University Supply Chains. Bureaucratic Procurement Procedures.

Budget Constraints and Funding Issues. Universities often face financial restrictions that limit their ability to acquire high-quality equipment or implement modern SCM technologies. Many educational institutions depend on government funding, which may not always be allocated efficiently or in a timely manner

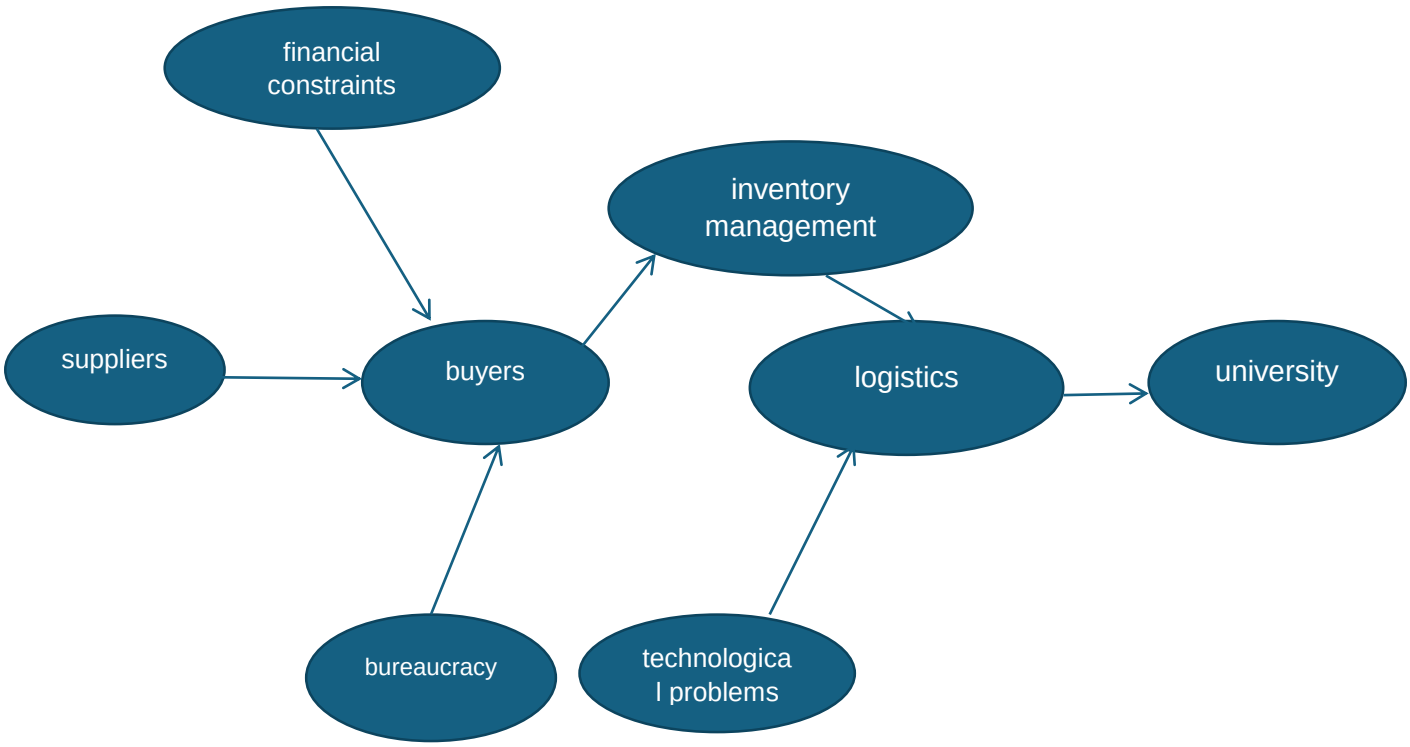


Figure 1. Supply chain management in an educational university.

In the case of private universities, high operational costs may affect investment in supply chain optimization. Supplier Reliability and Quality Issues. Ensuring the quality and reliability of suppliers is a persistent challenge. Universities often deal with multiple vendors, and inconsistencies in product quality, delivery

timelines, and pricing fluctuations can impact academic operations [Kraljic, 1983; Monczka et al., 2015]. In the Kyrgyz Republic, supply chain disruptions are often caused by reliance on imported goods and inefficient supplier networks [Советбеков, 2014]. Logistics and Infrastructure Challenges.Limited transportation infrastructure and inefficient logistics services create additional hurdles for universities in many developing regions. Delays in equipment delivery, lack of proper warehousing facilities, and high transportation costs affect supply chain efficiency [Бровко & Борисенко, 2017]. A lack of integration between logistics providers and university systems exacerbates these challenges, making it difficult to track and manage inventory efficiently [WHO, 2020].

Digital Transformation and Technology Adoption Issues

While many universities worldwide have adopted digital SCM solutions, institutions in developing countries often lag in implementing these technologies due to financial and technical limitations [Ivanov et al., 2019]. The absence of centralized digital procurement systems and automated inventory tracking increases operational inefficiencies [Уметалиев, 2013].

Implications for Universities in the Kyrgyz Republic

In the Kyrgyz Republic, universities experience several supply chain inefficiencies due to structural and economic challenges:

- Heavy Dependence on Imported Educational and Laboratory Equipment – This leads to high procurement costs and long delivery times [Аманкулов et al., 2022].
- Inadequate Logistics Infrastructure – Poor road networks and transportation services delay the distribution of critical supplies [Береналиев, 2020].
- Lack of Coordination Among Stakeholders – Universities, suppliers, and logistics providers often operate in silos, leading to communication gaps and inefficiencies [Шербекова & Ысыраилова, 2024].
- Limited Government Funding for University SCM Improvement – Budget restrictions limit investments in modern supply chain management solutions and digital transformation [Мейманкулова & Алджембаева, 2021].

Supply chain management in universities plays a vital role in ensuring the smooth operation of academic and research activities. However, challenges such as bureaucratic procurement processes, financial constraints, unreliable suppliers, and logistics inefficiencies hinder effective SCM implementation. In developing countries like the Kyrgyz Republic, addressing these issues requires investment in digital SCM solutions, improved supplier management strategies, and infrastructure enhancements. Future research should focus on integrating smart technologies into university supply chains and developing sustainable procurement models tailored to educational institutions

University Procurement Theory

University procurement refers to the strategic acquisition of goods, services, and infrastructure necessary for the functioning of higher education institutions. It encompasses a structured process that ensures transparency, cost-efficiency, compliance with regulations, and the fulfillment of academic and operational needs. Procurement in universities includes everything from office supplies and IT equipment to large-scale contracts for construction, research materials, and specialized educational tools (Schapper et al., 2006). Higher education institutions operate under distinct procurement models due to their unique governance structures, funding mechanisms, and accountability requirements. Unlike corporate procurement, university procurement must align with public sector regulations, ethical considerations, and long-term institutional goals (Purchase et al., 2009). Evolution of University Procurement. The procurement process in universities has evolved alongside broader public procurement practices. Several key phases mark this evolution: Traditional Procurement (Pre-1990s): Universities followed decentralized purchasing models, with departments making independent procurement decisions. This often led to inefficiencies and redundant spending (Knight et al., 2007). Strategic Procurement (1990s-2000s): Institutions began centralizing procurement operations to leverage economies of scale, improve compliance, and reduce costs (Schapper et al., 2006). Digital and Sustainable Procurement (2010s-Present): Universities increasingly integrate e-procurement

systems, green purchasing policies, and data-driven decision-making to enhance efficiency and sustainability (Brammer & Walker, 2011). Core Components of University Procurement. University procurement consists of several key elements that ensure efficiency, accountability, and alignment with institutional goals: a) Procurement Policies and Compliance. Universities operate under strict regulatory frameworks, which vary by country and funding source. Compliance requirements include: Public Procurement Regulations: Many universities, particularly public institutions, must adhere to government procurement laws (Arrowsmith, 2010). Ethical Procurement: Ensuring fairness, transparency, and avoidance of conflicts of interest (Brammer & Walker, 2011). Sustainability Standards: Universities increasingly adopt green procurement policies to minimize environmental impact (Preuss, 2009). b) Supplier Selection and Contracting. Universities must balance cost, quality, and strategic relationships when selecting suppliers. Common frameworks include: Kraljic Matrix (1983): Used to classify suppliers based on strategic importance and procurement risk. Total Cost of Ownership (TCO): Evaluating suppliers based on lifetime costs rather than just purchase price (Ellram, 1995). Public Tendering and Competitive Bidding**:** Many universities use open tendering processes to ensure fairness and cost-effectiveness (Thai, 2001). *c)* Procurement Models in Universities. Universities adopt different procurement structures based on their size, funding, and governance model: Decentralized Procurement: Individual departments manage their own purchases, allowing flexibility but leading to inefficiencies. Centralized Procurement**:** A university-wide procurement office manages purchasing, achieving cost savings through bulk purchasing and standardization (Schapper et al., 2006). Hybrid Procurement: A combination of centralized policies and department-level decision-making, balancing efficiency and autonomy. d) E-Procurement and Digitalization. *The* adoption of e-procurement systems has transformed university purchasing by: Reducing paperwork and processing times. Improving supplier communication and contract management. Enhancing data analytics for better decision-making (Neupane et al., 2012). Theoretical Frameworks for University Procurement

Several academic theories help explain university procurement practices: Resource-Based View (RBV): Universities leverage procurement as a strategic asset to gain competitive advantage through efficient resource management (Barney, 1991). Transaction Cost Economics (TCE): Institutions seek to minimize transaction costs by optimizing procurement structures (Williamson, 1985). Principal-Agent Theory: Addresses challenges in aligning the interests of university leadership, procurement officers, and suppliers (Eisenhardt, 1989). Sustainable Procurement Theory**:** Focuses on integrating environmental and social responsibility into procurement decisions (Walker & Brammer, 2012). Challenges in University Procurement. Despite improvements, university procurement faces several persistent challenges: Budget Constraints: Limited public funding necessitates cost-effective purchasing strategies (Teixeira et al., 2012). Compliance and Bureaucracy: Lengthy procurement procedures can slow down critical acquisitions (Schapper et al., 2006). Supplier Management Issues: Ensuring quality, reliability, and ethical standards among vendors (Brammer & Walker, 2011). Sustainability Considerations: Balancing cost efficiency with green procurement policies (Walker & Brammer, 2012). University Procurement in Developing Countries. In developing economies, university procurement faces additional obstacles such as: Poor supply chain infrastructure (Kalim et al., 2018). Corruption risks and lack of transparency (Ameyaw et al., 2017). Limited access to international suppliers (Akenroye, 2013). University procurement is a complex, evolving field that integrates strategic sourcing, supplier management, compliance, and sustainability. As higher education institutions continue to modernize, digital transformation and strategic partnerships will play an increasing role in procurement efficiency. Future research should explore the impact of artificial intelligence, blockchain, and sustainability initiatives in university procurement practices.

Sustainable Procurement Theory

Public procurement is an essential tool for transitioning to sustainable development. First and foremost, public procurement constitutes a significant share of national budgets. According to the European Commission, public procurement

accounts for 13.67% of GDP in European countries (Public Procurement Indicators, 2014). In OECD countries, public procurement expenditures range from 45% to 65% of the national budget, representing 12–17% of GDP (Procurement & Public-Private Partnerships). In Russia, more than 6.6 trillion rubles were spent on public procurement in 2015, exceeding 10% of GDP (Monitoring Report, 2015). As the largest buyer, the government can shape demand for environmentally friendly and socially responsible goods and services. This makes public procurement a powerful tool for supporting sustainable production, developing small businesses, fostering innovation, and promoting energy-efficient technologies (Preuss, 2009; Brammer & Walker, 2011). Furthermore, government authorities have power, political will, and responsibility for addressing social issues. Unlike private businesses, public institutions establish long-term strategic objectives aimed at regional economic development, environmental protection, and improving social standards (Qiao, Thai & Cummings, 2009). If a government seeks economic sustainability, a healthy environment, and social cohesion, its procurement policies must reflect these goals. The adoption of sustainable procurement policies demonstrates a government's commitment to sustainable development and enhances its reputation (Perera, Chowdhury & Goswami, 2007; Nija & Worrel, 2012). Government demand for environmentally safe products stimulates the market, encouraging private consumers to follow suit. This, in turn, promotes the production of environmentally friendly products and the growth of socially responsible businesses (Preuss, 2009). Ultimately, sustainable public procurement contributes to economic, environmental, and social development.

Conclusions. Supply Chain Management (SCM) plays a critical role in ensuring efficiency, cost-effectiveness, and reliability in various sectors, including healthcare and education. Over the years, SCM has evolved from traditional logistics to integrated and digital supply chains, incorporating advanced technologies such as automation, blockchain, and artificial intelligence. The implementation of SCM in medical and educational institutions highlights its importance in maintaining supply efficiency and compliance with regulatory frameworks.

In the context of educational institutions, particularly universities, supply chain management presents unique challenges, including bureaucratic procurement processes, financial constraints, supplier reliability issues, and logistical inefficiencies. These challenges are exacerbated in developing countries like the Kyrgyz Republic, where outdated infrastructure, weak transportation networks, and inefficient risk management further complicate SCM operations. The reliance on imported goods increases costs and leads to supply delays, affecting the overall efficiency of academic and medical institutions. To enhance SCM efficiency, universities and healthcare institutions must adopt best practices such as strategic supplier selection, inventory optimization techniques, and technology-driven logistics solutions. The integration of e-procurement, RFID tracking, and ERP systems can significantly improve supply chain transparency and operational efficiency. Additionally, fostering public-private partnerships and investing in sustainable procurement models will contribute to long-term supply chain resilience.

Future research should focus on the impact of digital transformation in SCM, the role of sustainability in procurement, and the development of innovative solutions tailored to educational and healthcare supply chains. Addressing these challenges will ensure a more robust and adaptive supply chain system that meets the growing demands of the sector.

Literature Review: Supply Chain Management of Medical Equipment for Educational Institutions

The supply chain of medical equipment plays a crucial role in equipping educational institutions with the necessary resources to train healthcare professionals. The efficiency of these supply chains directly impacts the quality of medical education and the accessibility of modern technologies for students and faculty. The scientific literature shows a growing interest in this topic; however, many aspects remain underexplored. Specifically, the unique challenges of supplying medical equipment to educational institutions require additional attention, presenting opportunities for further research.

A review of academic publications highlights several key research directions in the study of medical equipment supply chains for educational institutions:

Optimization of Logistics Processes Tang & Lee [8] emphasize the importance of adaptive supply chains to enhance the logistics efficiency of medical equipment. Porter [5], in his work Competitive Advantage, highlights the role of strategic supply chain management in improving organizational competitiveness.

Ma Shihua views the supply chain not only as a logistical, informational, and financial chain connecting suppliers with consumers but also as a value-added chain where materials increase in value through processes such as processing, packaging, and transportation.

Risk Management in the Supply Chain. Simchi-Levi [7] identifies risk management as a central aspect of medical equipment logistics, proposing models for predicting crisis situations. Godsell & Harrison [3] analyze the impact of supply chain disruptions on the resilience of medical equipment supplies. Chen Gongyu notes that relationships between enterprises and their suppliers, distributors, and consumers form strategic partnerships that include comprehensive cooperation, shared benefits, and risk distribution.

Economic Efficiency and Sustainability. Sheffi [6] underscores the importance of resilient supply chains in times of economic instability. Handfield & Nichols [4] examine the costs associated with medical equipment procurement and propose models for cost optimization. Ma Shihua also emphasizes that the supply chain represents a value-added chain where materials increase in value through various processes, bringing corresponding benefits to enterprises.

Innovations and Digitalization. Dooley & Peters [2] analyze the use of digital technologies, such as IoT and blockchain, to enhance transparency and efficiency in medical equipment supply chains.

Choi, Wallace & Wang [1] explore the application of artificial intelligence in demand forecasting and inventory management of medical equipment. Shen Houcai considers the supply chain as a business process model consisting of value creation

chains among various participants, including raw material suppliers, product manufacturers, and end consumers.

Identified Research Gaps. Despite extensive research, several gaps have been identified: Limited research focused on educational institutions [4]. Lack of empirical data [7]. Weak integration of sustainable solutions [6]. Insufficient attention to digital technologies in the educational sector [2].

The literature review indicates that research on medical equipment supply chains is actively developing, but significant gaps remain concerning educational institutions. Future studies could focus on exploring logistics strategies, implementing digital solutions, and developing sustainable supply chain management models.

Chapter II: Analysis of the current state of medical equipment supply for educational institutions of the Kyrgyz Republic

2.1. Regulatory and Institutional Framework for the Supply of Medical Equipment to Educational Institutions of the Kyrgyz Republic

Educational institutions, particularly those that train specialists in medicine and healthcare, require high-quality medical equipment to ensure an effective learning process. Modern trends in medical education demand the use of advanced technological devices, simulators, diagnostic tools, and laboratory equipment. However, the supply of medical equipment to educational institutions in the Kyrgyz Republic faces several challenges related to supply chain management, regulatory frameworks, financing, and logistics.

Improving the system of medical equipment supply to educational institutions requires a thorough analysis of the current situation, the identification of key problems, and the development of effective solutions. To achieve this, it is necessary to examine the regulatory framework, determine the main market participants, study the existing procurement mechanisms, and analyze the needs of educational institutions for medical equipment.

The supply of medical equipment is a complex process that involves several stages, including planning, procurement, logistics, installation, and technical maintenance. It is also crucial to consider funding sources, as a significant portion of the equipment is purchased using government funds, grants from international organizations, and private investments. Therefore, particular attention should be paid to the efficiency of public procurement procedures and the transparency of tendering processes.

The current challenges in the supply chain of medical equipment for educational institutions include: Financial constraints – a lack of budgetary funds for purchasing modern equipment, the high cost of medical devices, and the need for long-term financing. Logistical barriers – difficulties in transportation and storage, as well as a shortage of qualified personnel for installation and maintenance. Bureaucratic obstacles – lengthy tendering processes, inefficiencies in the regulatory

framework, and challenges in coordinating various government and private sector entities. Lack of standardized regulations – the absence of unified standards for medical equipment in educational institutions, leading to inconsistencies in the procurement of necessary devices.

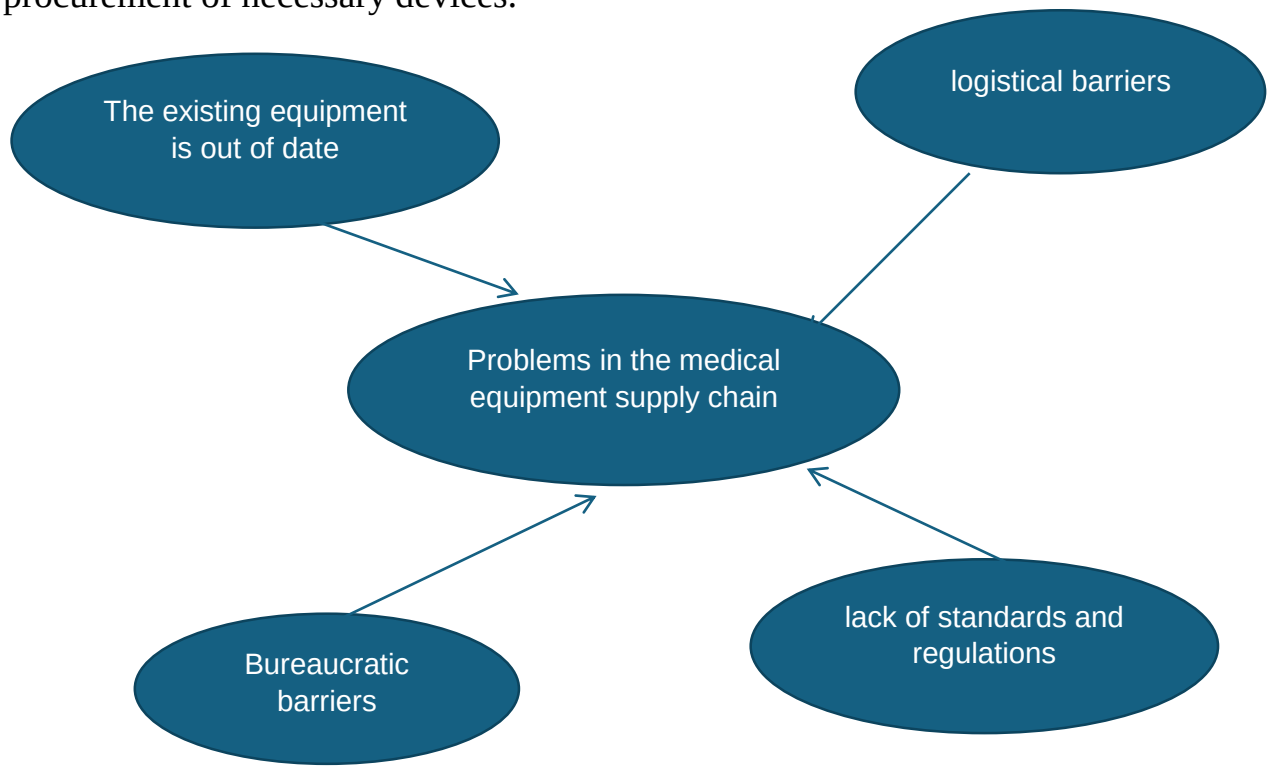


Figure 2 Challenges in the medical equipment supply chain

Outdated equipment – many educational institutions use obsolete technology, which reduces the effectiveness of medical training. This chapter aims to analyze all aspects of the medical equipment supply system for educational institutions in the Kyrgyz Republic. It examines the regulatory framework, key market participants, procurement mechanisms, and the main problems and limitations. Special attention is given to assessing the current level of equipment in educational institutions, their specific needs, and potential development prospects.

The results of this analysis will help identify key areas for improving the supply system and propose measures to optimize logistical, financial, and administrative processes. Ultimately, this will contribute to enhancing the quality of medical education in the country and preparing well-qualified professionals for the healthcare system.

Overview of the Regulatory Framework

Government Regulation of Medical Equipment Supply. In the Kyrgyz Republic, the supply of medical equipment is governed by national legislation that oversees procurement, certification, and utilization of medical devices. The primary regulatory bodies in this domain include the Ministry of Health, the Ministry of Education and Science, and the State Antimonopoly Service.

Procurement of medical equipment for educational institutions, especially medical universities, colleges, and schools with a medical focus, is conducted through a state tender system. The procurement procedures are defined by the Law of the Kyrgyz Republic «On Public Procurement» (No. 27, April 14, 2022), which establishes principles of transparency, equal participation, and efficient use of budgetary funds[5]

Beyond procurement, government regulation encompasses certification and licensing of medical devices. Medical equipment intended for educational purposes must comply with technical requirements set by the State Agency for Technical Regulation and Metrology**.** Imported equipment is subject to mandatory certification to ensure that only high-quality and safe devices are utilized in educational settings.

Additionally, the state regulates the disposal of obsolete medical equipment. According to legislative norms, medical devices that have exceeded their service life must be disposed of in accordance with environmental standards. This prevents the use of defective equipment and reduces health risks for students.

Laws and Regulations Governing Procurement and Supply in Education and Healthcare

The legal framework of the Kyrgyz Republic concerning the procurement and supply of medical equipment includes several key documents:

- The Law of the Kyrgyz Republic «On Public Procurement»(No. 27, April 14, 2022) – regulates the process of acquiring goods, works, and services using public funds. It defines procedures for conducting tenders, criteria for selecting suppliers, and conditions for contract conclusion.

[5] Law of the Kyrgyz Republic "On Public Procurement" (No. 27, April 14, 2022) – https://cbd.minjust.gov.kg/112361/edition/1279682/ru

The Law «On Education» (No. 179, August 11, 2023) – establishes the fundamental principles of state policy in the field of education, as well as the legal, socio-economic, and organizational foundations of educational activities in the Kyrgyz Republic.

The Law «On the Fundamentals of Health Protection of Citizens» – regulates the use of medical equipment in educational institutions, university-affiliated medical centers, and practical training facilities for students.

Government Decree on Medical Equipment Certification – establishes the procedure for certifying medical devices, including those imported from abroad. Sanitary and Epidemiological Regulations (SanPiN) for Educational Institutions – contain requirements for medical equipment used in the educational process, as well as conditions for its operation.

These legal acts provide a regulatory basis for transparency and efficiency in procurement, ensuring that medical equipment meets educational and healthcare standards. However, in practice, challenges exist related to lengthy tender procedures, bureaucratic barriers, and limited financial resources.

International Standards and Their Impact on the Supply Chain

International standards play a crucial role in ensuring the quality and safety of medical equipment used in educational institutions. Among the key standards applied in the Kyrgyz Republic are:

- ISO 13485 – an international standard regulating the quality management system for medical devices. Equipment that complies with this standard guarantees safety and effectiveness in the educational process.
- IEC 60601 – an international standard defining safety and electromagnetic compatibility requirements for medical equipment. The use of equipment meeting this standard minimizes risks for students and instructors.
- World Health Organization (WHO) Recommendations on Medical Equipment – WHO regularly develops guidelines on classification, usage, and procurement of medical equipment, assisting countries in aligning their supply systems with international requirements.

- Harmonization with the Eurasian Economic Union (EAEU) – The Kyrgyz Republic is a member of the EAEU, which necessitates aligning national standards with Union requirements, particularly in the certification and circulation of medical products.

The influence of international standards on the supply chain lies in their role in determining the requirements for medical equipment that can be procured and used in educational institutions. While this enhances equipment quality, it also increases costs associated with certification and importation.

In summary, the regulatory framework governing the supply of medical equipment to educational institutions in the Kyrgyz Republic comprises national laws, government decrees, and international standards. Despite the existence of well-defined rules, challenges persist, including lengthy procurement procedures, high compliance costs with international standards, and insufficient funding. The following sections of this chapter will examine key supply chain participants, procurement mechanisms, and major challenges hindering the efficient provision of medical equipment to educational institutions.

Forms and methods of medical simulation training

The history of medical simulation in the training of doctors goes back many millennia and is inextricably linked with the development of medical knowledge and scientific and technological progress. The development of the chemical industry led to the emergence of plastic mannequins, and progress in computer technology became the basis for the creation of virtual simulators and patient simulators.

A wide range of simulation technologies is used in the modern healthcare system: phantoms, models, dummies, simulators, virtual simulators and other training tools that allow simulating clinical processes and various aspects of the professional activities of medical workers. Simple phantoms, which are used to practice basic practical skills, have been used in some educational institutions for a long time. However, only in recent years have complex virtual simulators and systems for managing their use in the educational process become widespread. By now, considerable experience has been accumulated in the application of simulation

methods in medical training, as described in the work of Naigovzin N.B., Filatov V.B., Gorshkov M.D., Gushchina E.Yu., and Kolysh A.L[6].

For novice doctors, mastering the practical skills of performing medical interventions requires a long time. For example, doctors specializing in endovideosurgery need to perform from 10 to 200 laparoscopic cholecystectomies, as well as 20-60 fundoplications, to master the techniques, as mentioned in the work of Petrov S.V., Strizheletsky V.V., Gorshkov M.D., Guslev A.B., and Schmidt E.V[7].

Virtual simulators allow physicians not only to master basic skills, but also to practice complex interventions without risk to patients, as shown in studies by Dongen K.W., Zee D.C., and Broeders I.A.M.J. These technologies are becoming an important element of the medical education system and allow simulating situations that may not always be available in real practice, which helps physicians of different experience levels perform surgeries more efficiently and confidently[8].

According to the authors Carter F.J., Farrell S.J., Francis N.K., Adamson G.D., Davie W.C., Martindale J.P. and Cuschieri A., virtual technologies are the only effective and safe way to practice practical skills in modern medicine. Computer modeling allows students to practice actions in situations that actively respond to their manipulations, completely simulating the patient's physiological responses or tissue reactions to the surgeon's actions. Doctors who have gained practical experience with virtual simulators demonstrate more confident and professional results in real interventions. In addition, the use of objective patient data, such as MRI, CT or ultrasound, allows you to model and practice upcoming

[6] Найговзина Н.Б., Филатов В.Б., Горшков М.Д., Гущина Е.Ю., Колыш А.Л. Общероссийская система симуляционного обучения, тестирования и аттестации в здравоохранении. В кн.: II Съезд Российского общества симуляционного обучения в медицине РОСОМЕД-2013. Москва, 2013. Available at: http://www.laparoscopy.ru/doktoru/view_thesis.php?theme_ id=43&event_id=16

[7] Петров С.В., Стрижелецкий В.В., Горшков М.Д., Гуслев А.Б., Шмидт Е.В. Первый опыт использования виртуальных тренажеров. Виртуальные технологии в медицине. 2009; 1(1): 4–6.

[8] Dongen K.W., Zee D.C., Broeders I.A.M.J. Can a virtual reality simulator distinguish between different experience levels in endoscopic surgery? In: Abstracts 13th EAES Congress. Venice, Lido, Italy, 1–4 June 2005. Surg Endosc. 2006 Apr; 20 Suppl. 1: 54–8

studies and operations in advance, which reduces potential risks and improves the quality of medical care[9].

According to Rosen, the origins of simulation in medicine can be defined as "the imitation of a real object, state, or process" for skill practice, problem solving, and decision-making. From the earliest simulators such as the "blue box" for pilot training, and the significant role of the military in transferring modeling and simulation technology to medicine, the global acceptance of simulation education continues to grow. Large, collaborative simulation centers are expected to enhance opportunities for interdisciplinary, interprofessional, and multimodal learning. Both immersive and web-based virtual worlds are at the forefront of innovation in medical education[10].

The article by Bradley, P. discusses the significant impact of clinical simulation on medical education at the undergraduate and postgraduate levels. The author notes the diversity of simulation technologies, but emphasizes the need for further research to substantiate their effectiveness[11].

Levels of Simulation Training in Medicine

1. Visual level – use of traditional educational technologies: diagrams, posters, anatomy models. This also includes simple e-books and computer programs. The basis of visual training is familiarization with the correct sequence of actions when performing medical manipulations, but it does not provide an opportunity for practical training.

2. Tactile level – practicing manual skills using phantoms that imitate a passive reaction. Students can improve coordinated movements and automate individual manipulations, which helps to acquire technical skills.

3. Reactive level – phantoms respond to the student's actions with simple active reactions. This allows you to evaluate the accuracy of actions at a basic level,

[9] Carter F.J., Farrell S.J., Francis N.K., Adamson G.D., Davie W.C., Martindale J.P., Cuschieri A. Content validation of LapSim cutting module. In: Abstracts 13th EAES congress. Venice, Lido. 2005. Surg Endosc. 2006 Apr; 20 Suppl. 1: 35–7

[10] Rosen, K. R. (2008). The history of medical simulation. *Journal of critical care*, *23*(2), 157-166.

[11] Bradley, P. (2006). The history of simulation in medical education and possible future directions. *Medical education*, *40*(3), 254-262.

simulators are usually made of plastic and equipped with electronic controllers to control reactions.

4. Automated level – the mannequin responds to external influences using computer technology. Scripts program reactions to certain actions, which contributes to the development of cognitive skills and sensory motor skills.

5. Hardware level – reproduction of the environment of a medical office or operating room. Training systems at this level help develop confidence and readiness to act in conditions similar to real clinical practice.

6. Interactive level – complex interaction of the simulator with medical equipment and the student. The manikin imitates physiological changes in response to the administration of drugs or errors, which allows assessing professional qualifications.

7. Integrated level – a combination of simulators and medical devices, such as virtual trainers displaying patient indicators. At this level, psychomotor and sensorimotor skills are practiced. The transition to the next level of realism requires significantly greater financial costs (the “triple” rule).

8. Virtual level – the use of virtual reality for full immersion in the educational process. Students practice complex clinical scenarios in an interactive environment that models critical situations, which allows them to develop skills in conditions that imitate reality.

9. Hybrid level – a combination of various simulation technologies, such as mannequins, virtual reality and interactive programs. This approach allows students to develop both manual skills and cognitive abilities, preparing them for multi-tasking scenarios.

10. Multimodal level – creating a full-fledged clinical environment, including mannequins, virtual models, medical equipment and software modules. This most advanced level of simulation training provides comprehensive training, allowing students to practice all aspects of professional activity in realistic conditions.

These levels of simulation training provide educational institutions with the opportunity to gradually improve the quality of training specialists, ensuring the transition from basic forms to full immersive models.

According to Osanova M.V., Timerbaev V.Kh., Valetova V.V. and Zvereva N.Yu. modern simulation educational technologies can be divided into two concepts. The first is training in practical skills and algorithms using specialized simulators and mannequins. The second is clinical modeling of critical situations using a training system in which the main component is a multifunctional computerized mannequin simulating a real patient[12].

The first approach to training using simulation is aimed at developing specific practical skills or a set of them, methods and algorithms using simulators or mannequins of varying levels of complexity. Its main goal is to teach a specialist to perform specific manipulations, such as intubation, providing vascular access, defibrillation and other actions that require practicing their hands. Within the framework of this approach, specialists practice individual methods and algorithms, allowing them to study in detail and remember the sequence of actions in critical situations. Training is carried out individually, without the need to simulate teamwork or fully recreate the patient's appearance and emergency care conditions.

The second approach - simulation in emergency medicine - covers a broader context. It aims to prepare a specialist to interact with a patient in a critical situation, bringing the training conditions as close as possible to real ones. This training simulates the patient's appearance, his vital functions (conversation, breathing, pulsation in peripheral vessels, sounds of the heart, lungs and gastrointestinal tract, as well as parameters on medical equipment monitors). The computer program allows changing the patient parameters and creating scenarios of various critical conditions so that students can apply their knowledge, analytical and practical skills, use medical equipment and develop clinical experience. Simulation training is based on creating conditions that imitate as much as possible all aspects of a real critical

[12] Осанова М.В., Тимербаев В.Х. , Валетова В.В., Зверева Н.Ю. Опыт реализации симуляционных образовательных программ последипломного обучения врачей в неотложной медицине и анестезиологии. Медицинское образование и профессиональное развитие. 2011

situation, including reproduction of the scene (operating room, intensive care unit, ambulance). If appropriate, the simulation can include psychological elements, using "actors" to create them – students, medical personnel or volunteers.

A survey of 200 students at a medical university in Kyrgyzstan revealed the following results and opinions about the educational process and the use of simulation technologies in training.

Section 1: Overall satisfaction with the educational process

- Most students (about 70%) expressed satisfaction with the quality of education at the university. They noted the availability of educational materials and resources, but 40% would like to see improvements in this aspect.

- About 60% of students feel partially prepared for practical work, but noted a lack of practical classes with real patients.

Section 2: Evaluation of simulation training

- 85% of respondents confirmed participation in simulation classes, with about 65% noting the high level of realism of the simulators used.

- More than half of the students consider the frequency of simulation classes insufficient, and 75% of respondents indicated that simulation training significantly helps in developing practical skills.

- Students most often work with mannequins and computer simulators, while 45% would like more virtual reality training.

Section 3: Practical training

- About 55% of students believe that practical training at their university is insufficient for their specialization.

- The question about time allocation showed that many students would like to have more time to practice practical skills.

- 60% of respondents expressed confidence in performing manipulations after simulation training, but many noted a desire to practice complex procedures such as intubation and vascular access more often.

Section 4: Interaction with teachers and mentors

- Most students (70%) reported regular feedback from teachers, although 30% believe that teachers could explain errors more.

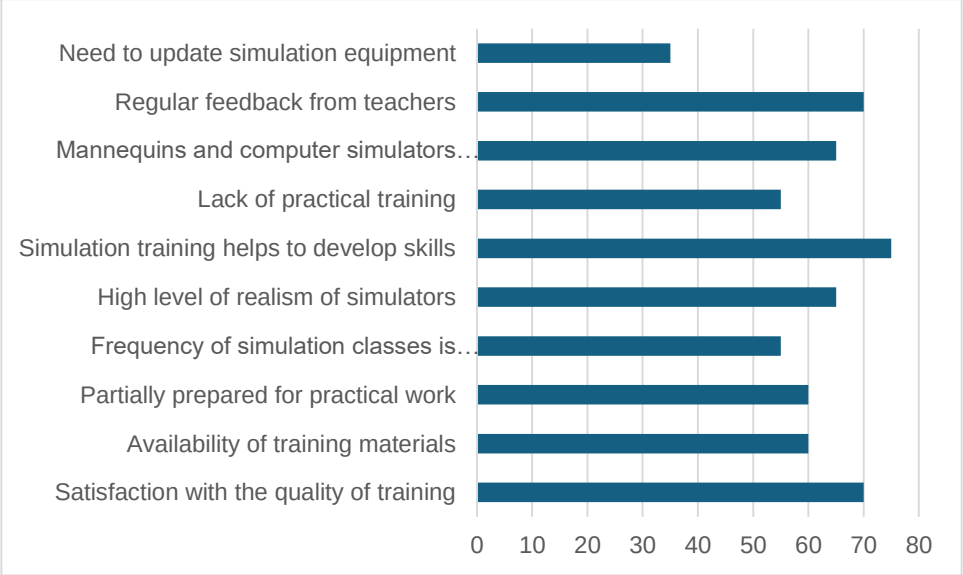
- Students generally rate the competence of teachers in using simulation equipment as high, but 20% noted that teachers could improve their skills in working with simulators.

Section 5: Assessing the Conditions and Resources

- 65% of students are satisfied with the state of the simulation labs, but 35% believe that the equipment needs to be updated.

- More than 50% of students noted a lack of simulators, especially when the student flow is high.

- Among the suggestions for improvement, students highlighted the need for additional simulators and more classes.



Results of a survey of students of a medical university in Kyrgyzstan on satisfaction with the educational process and simulation training

Most students believe that simulation training significantly improves their practical training, but they note the need for updated equipment, increased frequency of classes, and greater access to virtual reality.

The results of a survey of students at the Medical University of Kyrgyzstan indicate that the state of simulation equipment is one of the important issues affecting the quality of training of future medical specialists. According to the

survey, about 65% of students were satisfied with the current state of simulation laboratories; however, 35% of respondents believe that equipment needs to be updated. The lack of modern equipment limits the opportunities for practical training of students' skills in conditions close to real clinical practice.

Most students also note the lack of simulators, which leads to queues for access to available equipment, especially with a large number of students in the course. This situation not only slows down the conduct of classes, but also reduces the effectiveness of the educational process due to the need to divide time between using simulators and limiting the opportunity for in-depth mastery of educational skills.

Students emphasized the importance of using modern technologies in education, such as virtual reality, which significantly improves the realism of the educational process. However, significant funding is required to integrate such technologies and update training simulators - this is becoming a problem for most universities in the country.

To solve this problem, it is necessary to attract funding from the state and private companies, as well as use international grants. Updating and expanding equipment for simulation training will not only improve the quality of practical training of students of medical universities in Kyrgyzstan, but will also help them meet international standards in the field of medical education.

2.2. Analysis of state budget expenditure on education and medical training in the Kyrgyz Republic

State expenditures and development of higher education and medicine in Kyrgyzstan Macroeconomic analysis

To better understand Kyrgyzstan's fiscal capacity to support education and health training, it is necessary to analyze the overall economic context. One of the key macroeconomic indicators in this regard is the Gross Domestic Product (GDP), which reflects the country's economic performance and serves as the basis for calculating the relative share of public expenditure. The following figure presents the dynamics of GDP in current US dollars over recent years, which provides a basis for assessing the proportionality and sustainability of budget allocations to education and health.

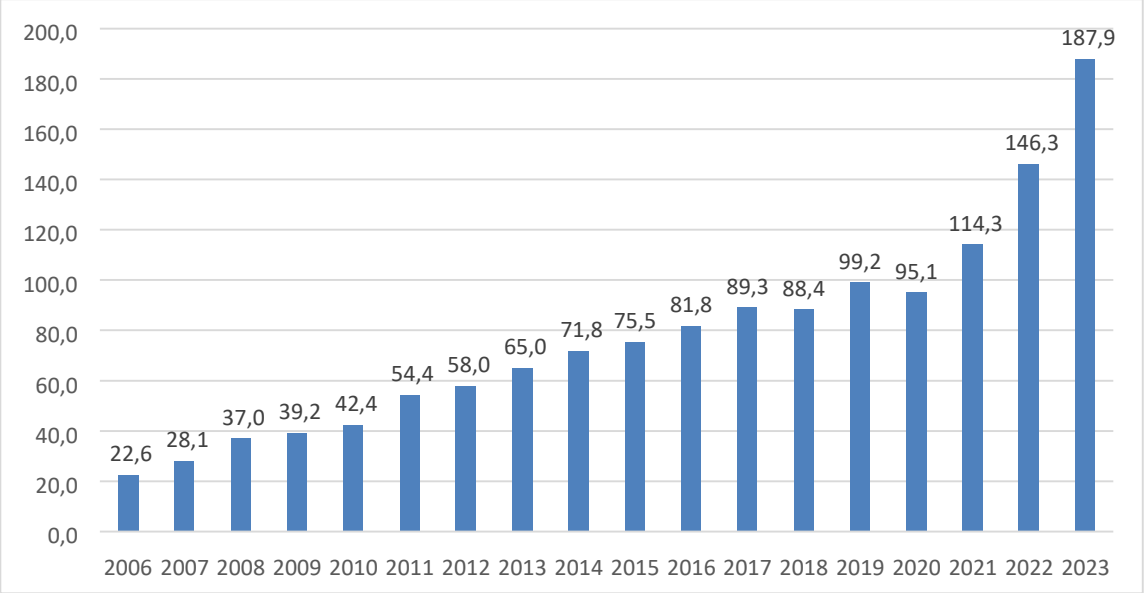


Figure Gross domestic product (US$ million)

Source: compiled based on data from the National Statistics Committee of the Kyrgyz Republic.

The dynamics of the gross domestic product (GDP) of Kyrgyzstan for 2006–2024 shows a general growth trend with periodic declines. In 2007–2008, GDP increased significantly (by more than 34%), which could be due to active investment and economic growth. However, in 2009, a decline of 9.3% was observed, which is probably due to the consequences of the global financial crisis. Despite the overall

growth of the gross domestic product, a more accurate picture of economic development is given by an analysis of GDP per capita. This indicator allows us to take into account demographic changes and assess how economic resources are distributed among the population.

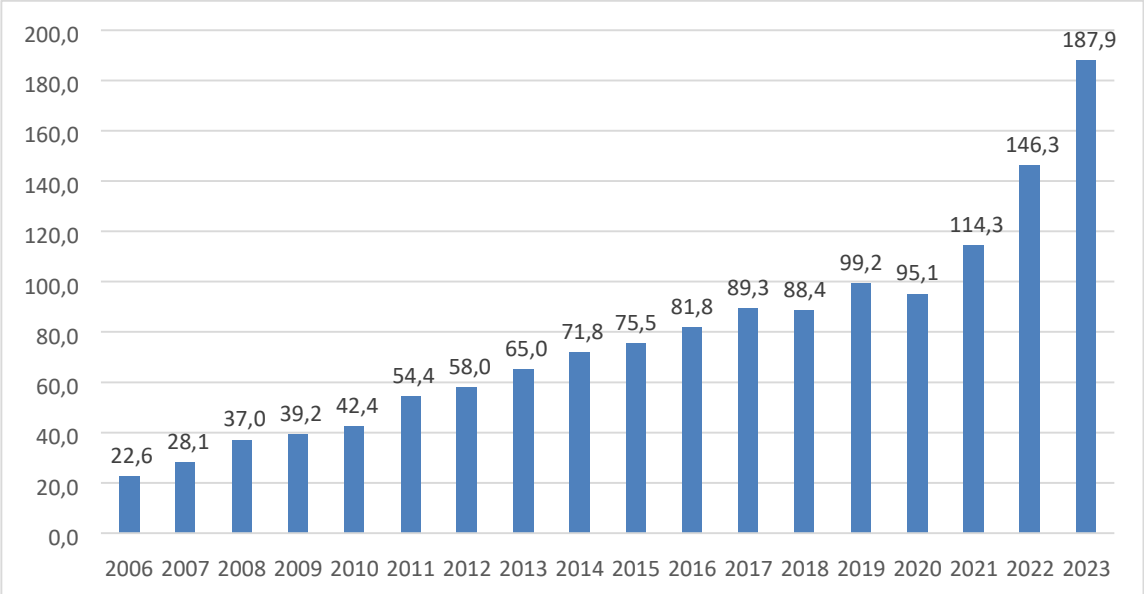


Figure Analysis of the dynamics of GDP per capita in Kyrgyzstan (2006–2023) (thousand soms).

Source: compiled based on data from the National Statistics Committee of the Kyrgyz Republic.

Gross domestic product (GDP) per capita is an important indicator of the level of economic development and well-being of citizens. In the period from 2006 to 2023, Kyrgyzstan saw a steady growth in this indicator, but the dynamics were uneven.

In 2007–2008, significant growth in GDP per capita was recorded - by 24.3% and 31.7%, respectively, and in 2009, the growth rate slowed to 5.9% due to the effects of the global financial crisis.

In the period 2010–2019, GDP per capita increased, although there was a slight decrease in 2018. In 2020, the indicator decreased to 95.1 thousand soms, which is explained by the economic consequences of the COVID-19 pandemic.

Active growth begins in 2021: GDP per capita increased from 114.3 thousand soms in 2021 to 187.9 thousand soms in 2023. This increase may be due to economic

recovery, increased investment, including Chinese investment, as well as inflationary processes.

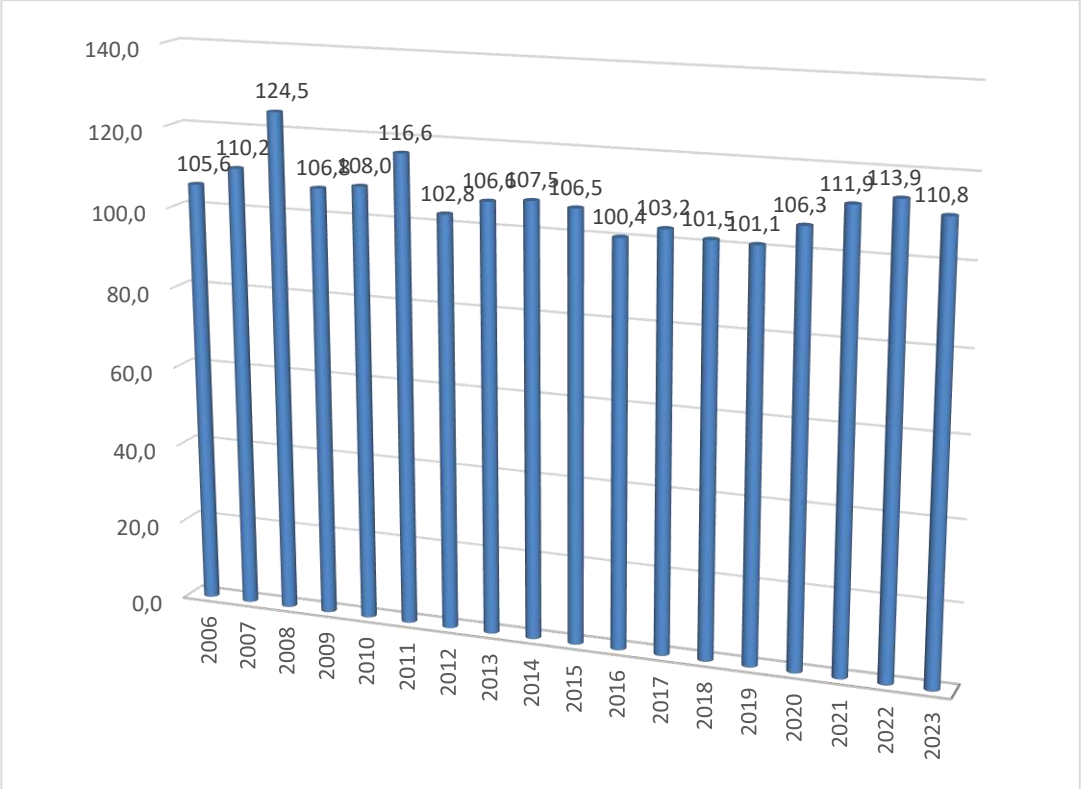


Figure Consumer Price Index (CPI) (as a percentage of the previous year) Source: compiled based on data from the National Statistics Committee of the Kyrgyz Republic.

The Consumer Price Index (CPI) is a key indicator of inflation, reflecting the level of change in prices for goods and services. In the period 2006–2023, Kyrgyzstan experienced significant fluctuations in inflation processes, which affected the standard of living of the population and purchasing power. In 2008, the highest inflation rate (124.5%) was recorded for the period under review, which could have been caused by the global financial crisis, rising food and energy prices. Stabilization was observed in subsequent years: from 2009 to 2016, inflation fluctuated in the range of 100.4–116.6%, indicating a moderate increase in prices. The minimum inflation rate was recorded in 2016 (100.4%), which may indicate a decrease in consumer demand. Since 2020, a new inflation cycle has begun, associated with the COVID-19 pandemic, disruption of global supply chains and rising energy prices. In 2021, the index was 111.9%, in 2022 - 113.9%, which led to

a decrease in the real purchasing power of the population, despite the growth of GDP. In 2023, there is a slight decrease in inflation (110.8%), which may indicate stabilization of the economic situation/

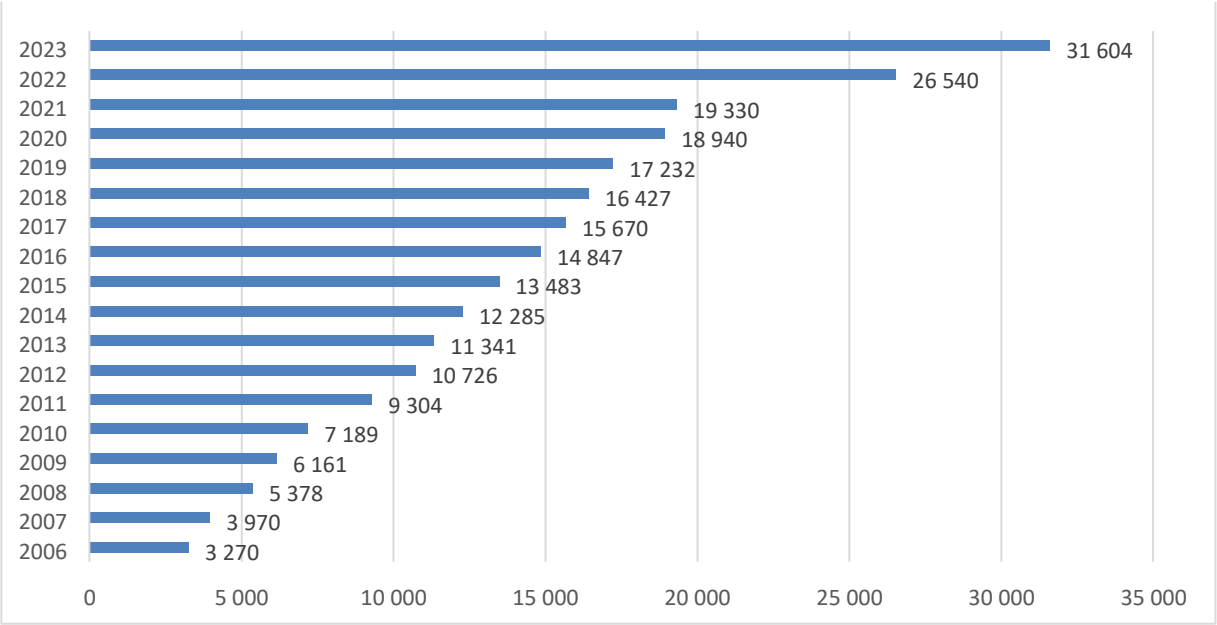


Figure Analysis of the dynamics of the average salary in Kyrgyzstan (2006–2023) Source: compiled based on data from the National Statistics Committee of the Kyrgyz Republic.

The average salary is an important indicator of economic development and the level of well-being of the population. In the period 2006–2023, Kyrgyzstan saw a steady increase in salaries, but the growth rate was uneven.

From 2006 to 2008, the average salary increased from 3,270 to 5,378 soms, an increase of 35.5% in 2008, which is due to an increase in income in various sectors of the economy.

However, in 2009, against the backdrop of the global financial crisis, the growth rate slowed to 14.6%, but since 2010 it has begun to increase again.

In 2011–2020, wages grew at a stable pace, reaching 18,940 soms in 2020. However, real incomes could decline due to inflation. For example, in 2015–2016, wage growth was less significant amid economic difficulties in the region.

Since 2021, there has been a sharp increase in the average salary. In 2022, it reached 26,540 soms, and in 2023 – 31,604 soms. This increase is due to the revision of salaries in the public sector, an increase in the minimum wage.

The growth of wages has a direct impact on the formation of the tax base and, accordingly, on revenues to the state budget.

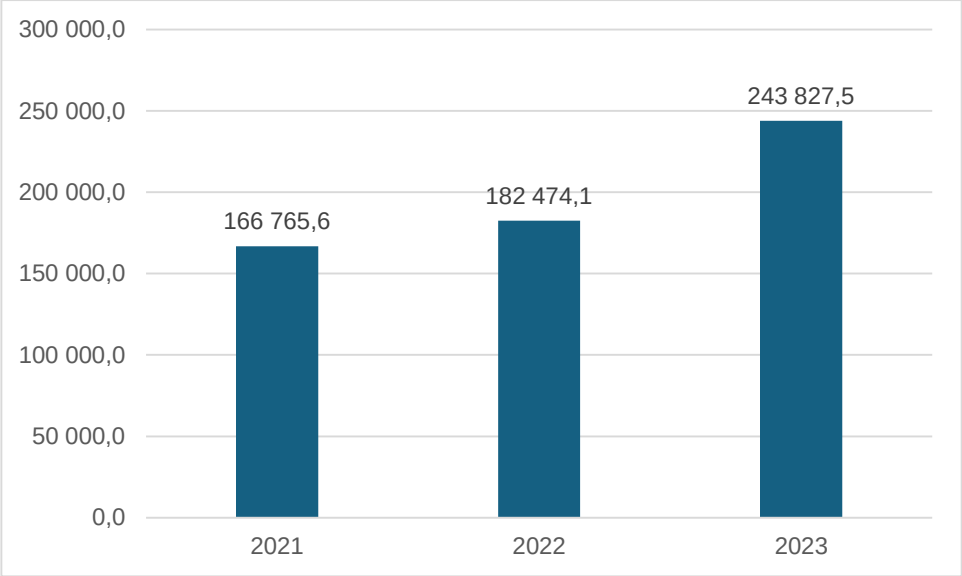


Figure Dynamics of investments in non-financial assets, 2021–2023 (million soms)

The inflow of foreign investments in US dollars peaked in 2021 ($9,025.6 million), but fell to $7,110.6 million by 2023. The main share is made up of “other investments” (83.5–91.8%), while foreign direct investments are unstable, their share fluctuating from 7.8% to 15.9%. Portfolio investments are virtually absent.

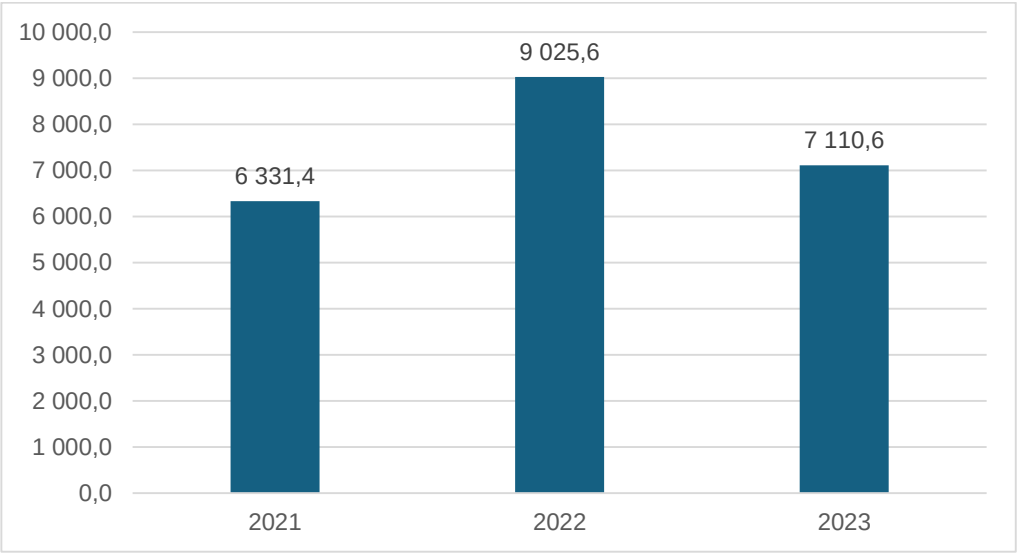


Figure Change in the volume of foreign investment in the Kyrgyz Republic (2021–2023) (million soms)

The growth in 2022 is associated with the economic recovery from the COVID-19 pandemic.

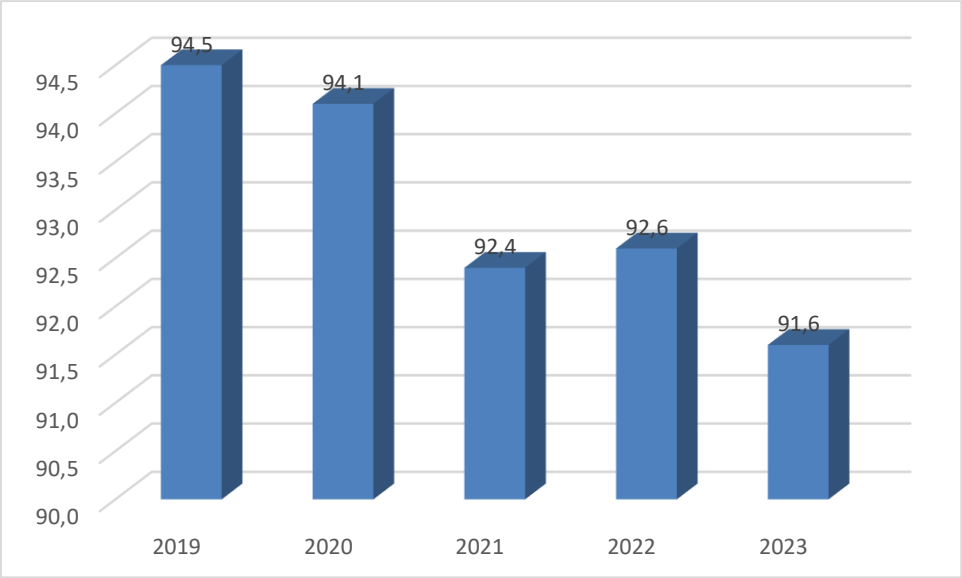


Figure Investments in fixed assets

As a percentage of total

Investments in fixed assets remain dominant, but show a slight decrease: from 94.5% in 2019 to 91.6% in 2023. This indicates an increase in investments in other areas.

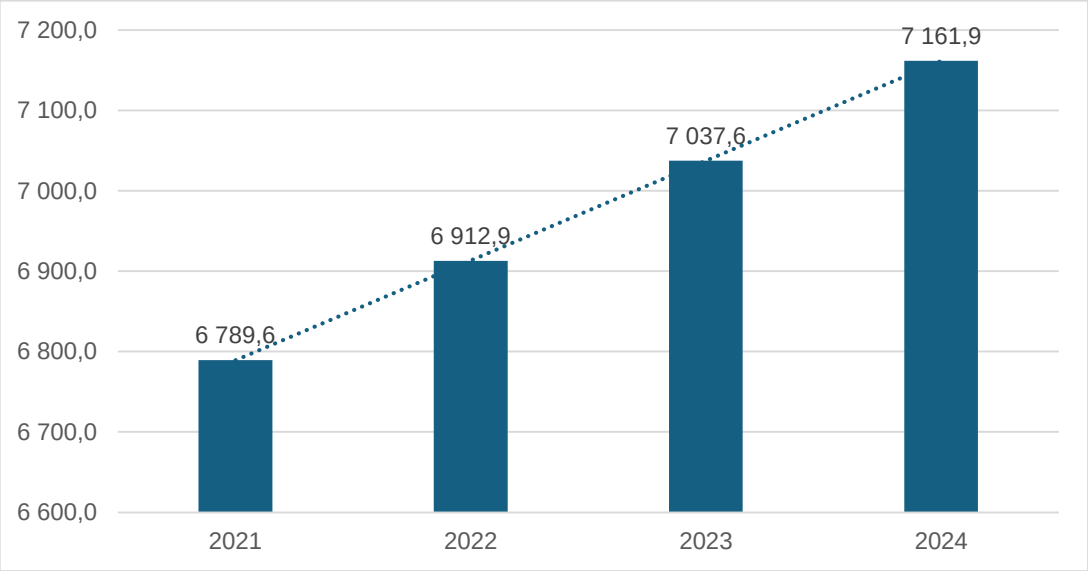


Figure Dynamics of the permanent population (people)

Data for 2021-2023 show an increase in the population of Kyrgyzstan: from 6,789.6 thousand people in 2021 to 7,037.6 thousand people in 2023. The number of births decreased from 150,164 in 2021 to 145,977 in 2023, indicating a decrease in the birth rate. At the same time, the number of deaths decreased - from 38,875 to

31,500 people, this is due to improved healthcare. Migration processes show an increase in the number of immigrants (from 8,229 to 14,453 people) and a decrease in the number of emigrants (from 8,998 to 4,610 people), which increases the overall population growth.

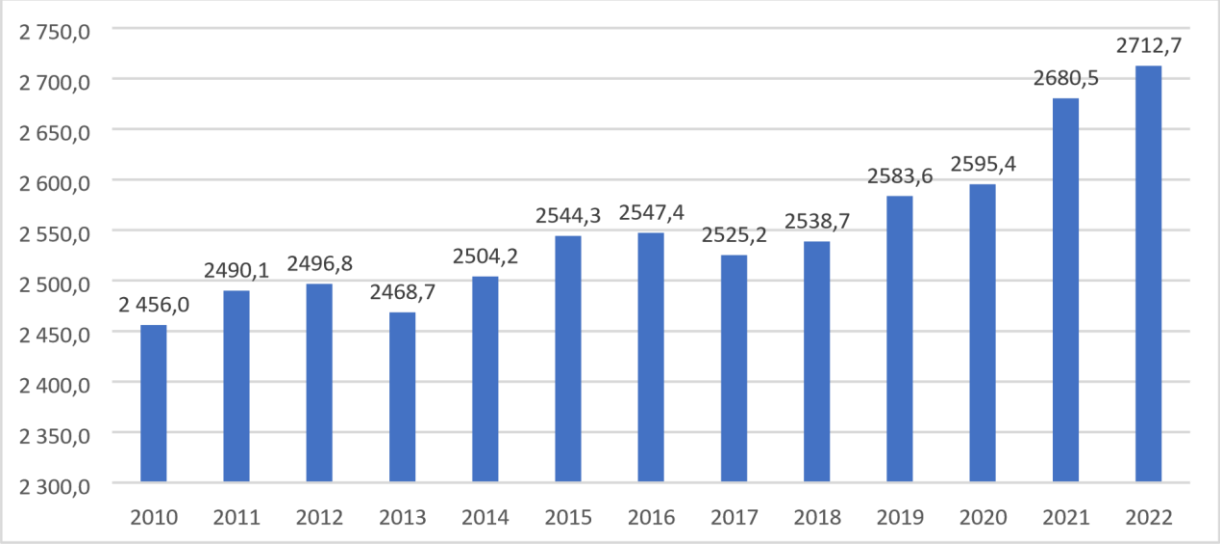


Figure Labor force potential in the Kyrgyz Republic (2010-2022), thousand people.

Analyzing the data shown in Figure 2.17, we can see that the general employment trend in the period under review is growing and has accelerated significantly since 2017. As for unemployment in the country, the level of available labor resources in the pre-pandemic period (2019) was 2,538.7 thousand people. The situation that caused a large-scale suspension of production in many sectors of Kyrgyzstan due to the COVID-19 pandemic led to a partial reduction in many companies, industries and jobs, resulting in an increase in the army of unemployed.

In addition, for the above reason (the pandemic), Kyrgyz labor migrants who were forced to return to their home countries turned out to be redundant and unnecessary in other countries, and they were also looking for jobs. The return of a large number of migrants to the country creates a number of social problems: firstly, the urgent provision of their employment, and secondly, the tension in the domestic labor market increases, which contributes to an increase in the number of unemployed people who demand and expect the state to pay them unemployment benefits.

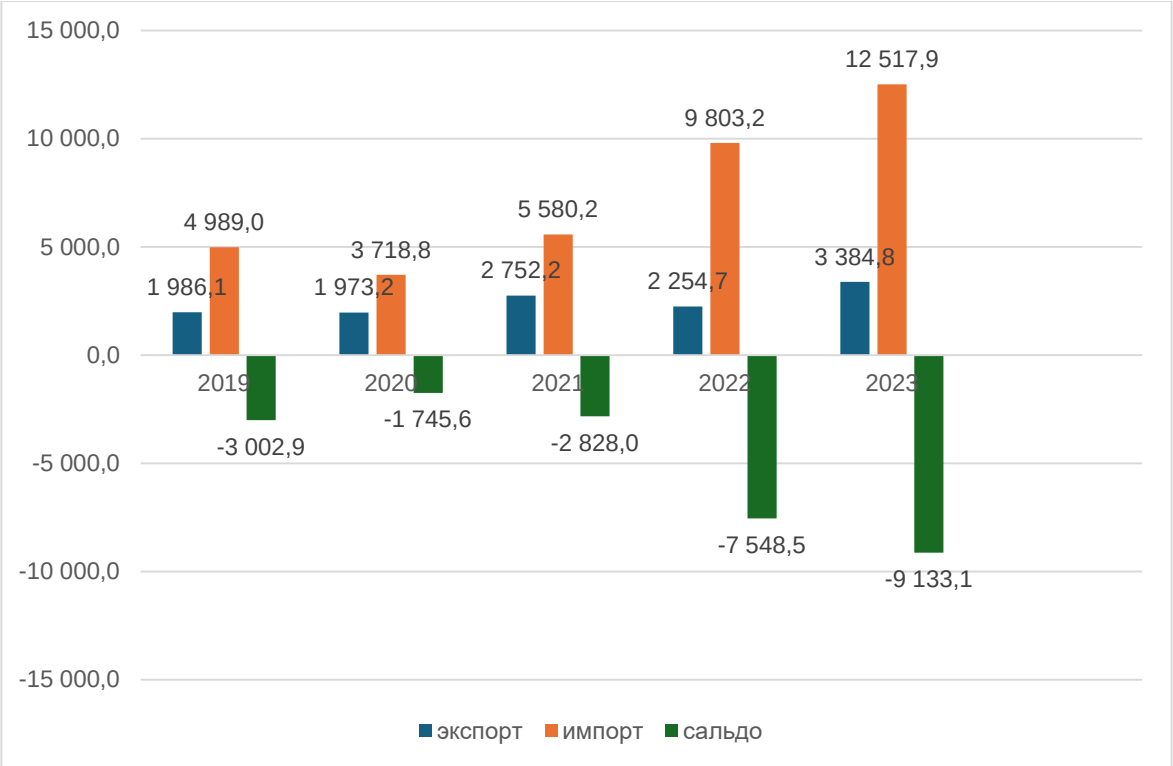
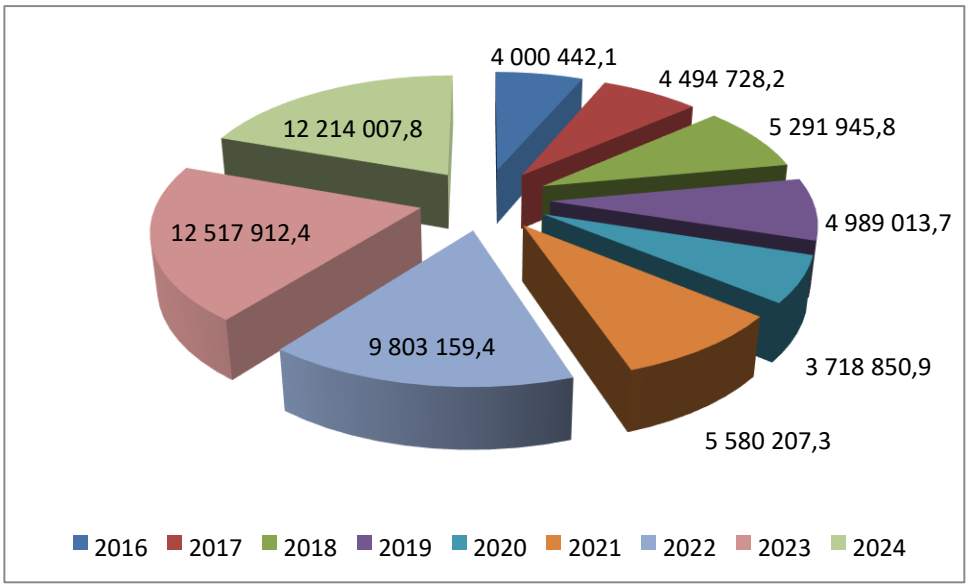


Figure Export-import operations of the Kyrgyz Republic in 2019-2023 (in thousands of US dollars)

Export-import operations of the Kyrgyz Republic for 2019-2023 demonstrate a significant increase in trade volumes, but are accompanied by an increase in the negative trade balance. Exports increased from $1,986.1 million in 2019 to $3,384.8 million in 2023, indicating a strengthening of the country's position in international markets. However, imports over the same period increased from $4,989.0 million to $12,517.9 million, more than twice the growth in exports.

The negative trade balance increased from -$3,002.9 million in 2019 to -$9,133.1 million in 2023, which is associated with an increase in domestic demand for imported goods. The main challenges remain dependence on imports and limited export opportunities.



Volume of goods imports (thousand US dollars)

In 2016–2024, Kyrgyzstan's import volume increased significantly. In 2017, imports increased by 12.3% compared to 2016. In 2018, the growth was 17.7%, but in 2019, imports decreased by 5.7%. The largest decrease occurred in 2020 – -25.5%, probably due to the COVID-19 pandemic.

The recovery began in 2021 (+50.0%), and in 2022, imports increased sharply by 75.7%, reaching $9.8 billion. In 2023, growth continued (+27.7%), reaching a peak of $12.5 billion

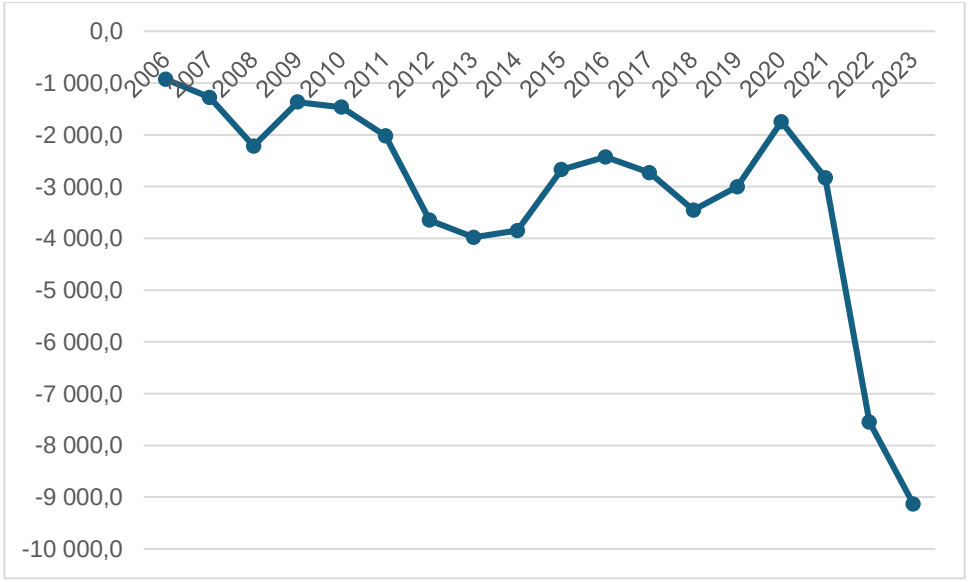


Figure Trade Balance of the Kyrgyz Republic (2006–2023, USD million)

From 2006 to 2023, the trade balance of the Kyrgyz Republic shows a persistent deficit, indicating that imports exceed exports. During this period, the

deficit increased significantly from -$924.1 million in 2006 to a record -$9,133.1 million in 2023.

In 2006–2009, the deficit increased moderately, reaching -$1,367.2 million. In 2010–2013, there was a sharp increase, especially from 2011 to 2013 (from -$2,019.0 to -$3,980.2 million), which is associated with an increase in imports. In 2014–2016, the deficit slightly decreased due to changes in foreign economic policy. The period 2017–2020 is characterized by volatility: an increase to -$3,002.9 million in 2019 and a decrease to -$1,745.7 million in 2020 due to the pandemic. However, in 2021–2023, the deficit increased, reaching a historical maximum.

In recent years, international education has increasingly developed as an export sector of the economy, occupying important positions in terms of profitability among other export services and sectors. Medicine is a particularly popular area among foreign students. As one of the most dynamically developing areas of activity, medicine requires highly qualified specialists capable of performing specific functions - diagnostic, therapeutic and preventive. This increases the demand for high-quality medical education that meets international standards. In the 21st century, education is becoming an increasingly important part of export activities. The financial indicators of the global educational services market reach 100 billion dollars, with higher education bringing in over 50 billion. In a number of countries, educational services occupy leading positions in terms of profitability among export services. For example, in the United States in 2022-2023, the income from international education amounted to approximately $ 50 billion, which brought it to 5th place among export services. In Australia, where about 20% of the total number of international students study, the export of educational services ranks third, behind only coal and iron ore.

Thus, international education has become one of the most profitable and promising sectors, generating real income and contributing to the growth of the national economy. This highlights the importance of investing in educational

infrastructure and quality of teaching to attract international students, especially in such in-demand fields as medicine.

The analysis of the 2009 and 2022 census data on the level of education of young people (15-24 years) in Kyrgyzstan reveals important changes in the structure of education. The total number of young people decreased from 1,192,022 in 2009 to 1,074,446 in 2022, which is likely due to demographic changes.

Educational level of the population aged 15-24 years
(according to population census data; in percent)

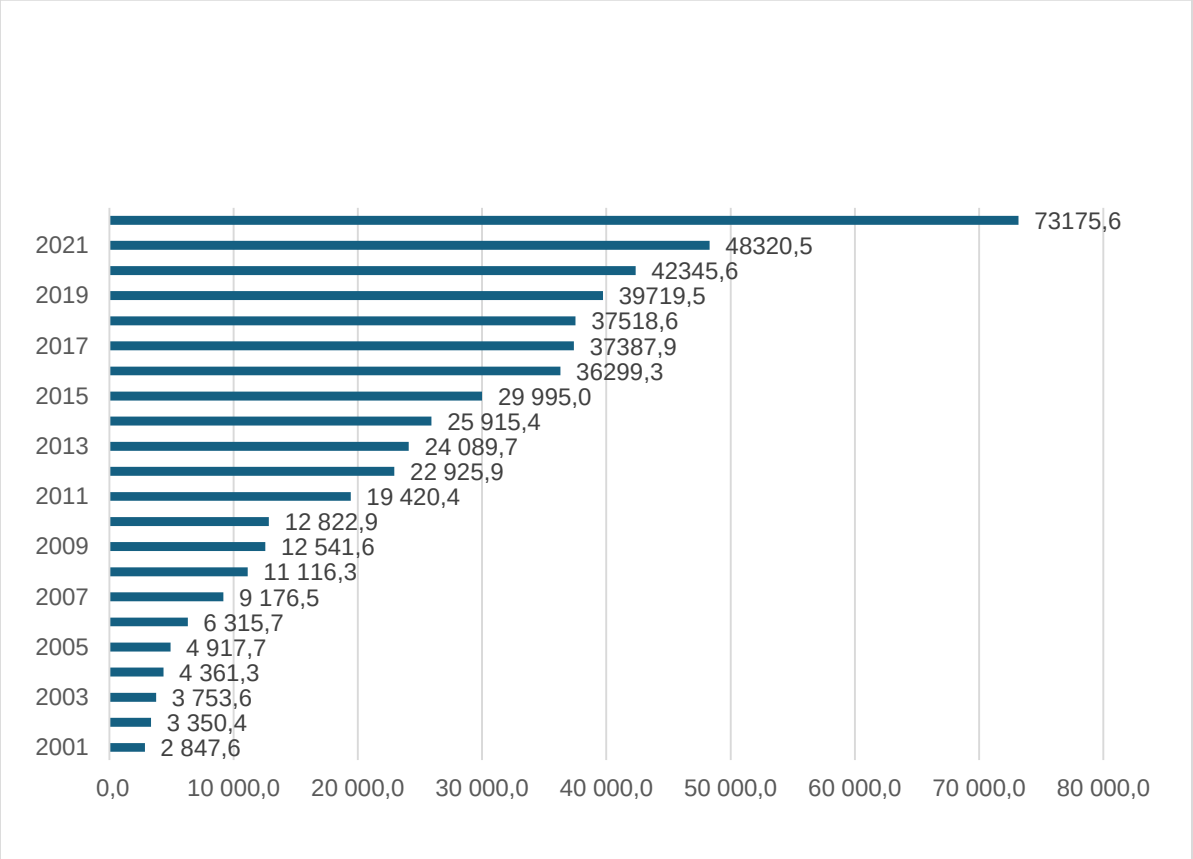
	Total, person		As a percentage of the total	
	2009	2022	2009	2022
Population aged 15-24	1 192 022	1 074 446	100,0	100,0
of which those with professional education:				
higher	44 652	111 789	3,7	10,4
incomplete higher education (unfinished higher education)	96 500	107 359	8,1	10,0
secondary (secondary special)	25 788	137 846	2,2	12,8
primary (vocational)	21 890	54 595	1,8	5,1
General education:				
average	592 566	318 150	49,7	29,6
basic (incomplete secondary)	254 368	195 899	21,3	18,2
initial	144 818	129 742	12,2	12,1
those who do not have primary general education	11 440	19 066	1,0	1,8

Vocational education shows significant growth. The share of young people with higher education increased from 3.7% (44,652 people) in 2009 to 10.4% (111,789 people) in 2022, indicating improved accessibility of higher education. There is also an increase in the number of people with incomplete higher education from 8.1% to 10.0%, indicating a desire to learn despite incomplete completion of courses. The growth of secondary specialized education from 2.2% to 12.8% and primary vocational education from 1.8% to 5.1% is particularly noticeable, which indicates the popularization of short-term training and practical specialties.

General education shows a decline: the share of young people with secondary education decreased from 49.7% to 29.6%. This is due to the transition to vocational and higher education. Basic (incomplete secondary) education also decreased from

21.3% to 18.2%, indicating the desire of young people for further education.

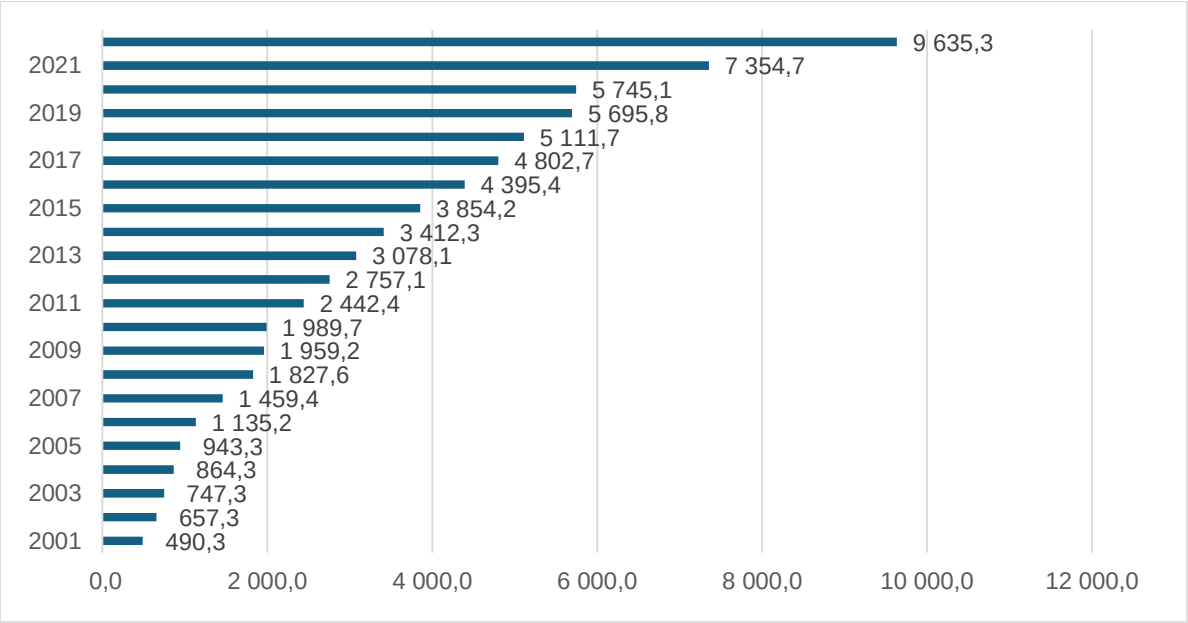
At the same time, the share of young people without primary education increased from 1.0% to 1.8%, which may indicate socio-economic difficulties.



Structure of state budget expenditures on education in the Kyrgyz Republic (million soms)

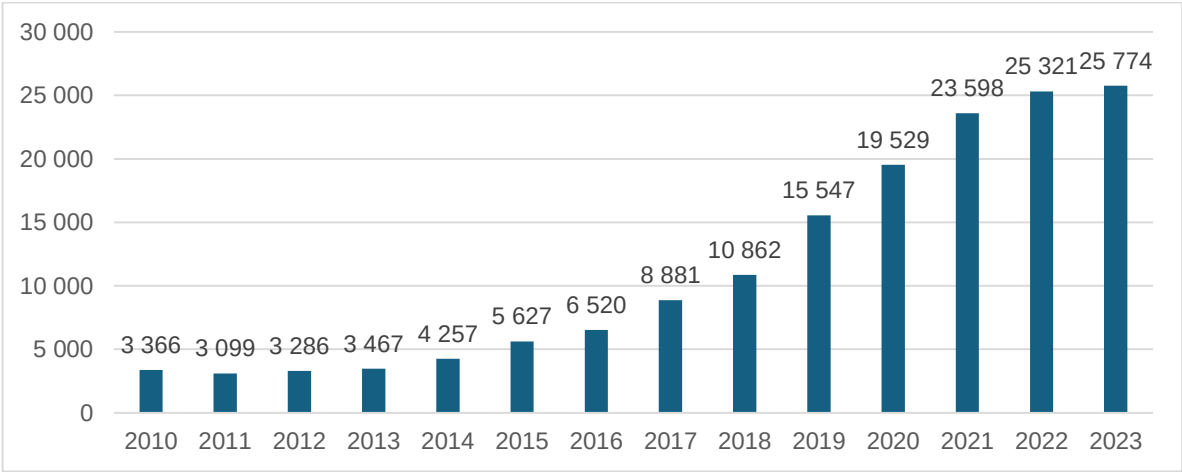
The analysis of the figure shows an increase in state budget expenditure on education from 2001 to 2022, including spending on higher education. The total budget for education has been steadily increasing, especially since 2010, reaching 73,175.6 million soms in 2022, reflecting the state's priority in this area.

Expenditures on higher education have also grown, from 490.3 million soms in 2001 to 9,635.3 million in 2022. The share of funds for higher education has gradually increased, emphasizing the importance of training qualified personnel and increasing the availability of higher education in the country.



Structure of state budget expenditures on higher professional education (million soms)

The figure shows the number of non-CIS students enrolled in educational institutions at the beginning of the academic year from 2010 to 2023. The total number of non-CIS students increased from 3,366 in 2010 to 25,774 in 2023. The largest increase was observed after 2017.



The number of students from countries outside the CIS (Total)

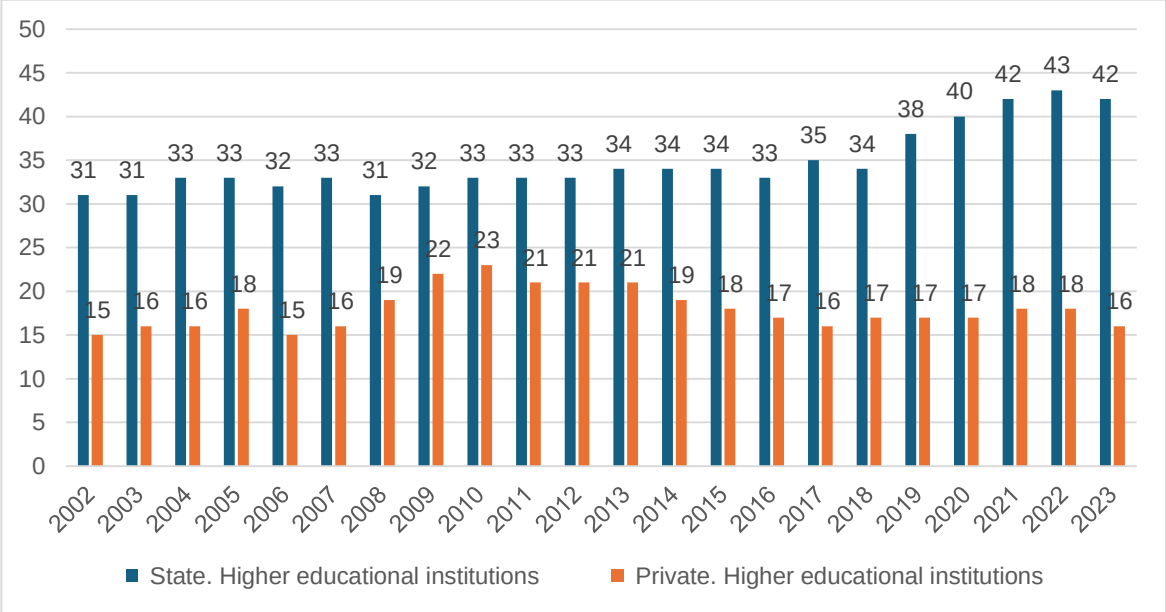
(at the beginning of the school year, persons)

The number of students from countries outside the CIS

(at the beginning of the school year, persons)

Name of indicators	Afghanistan	China	India	Iran	Mongolia	Nepal	Syria	Pakistan	Turkey	Georgia	Other countries
2010	73	539	581	17	13	82	27	955	793	5	281
2011	74	433	788	21	7	50	24	928	727	4	43
2012	54	385	1 137	25	2	21	43	778	772	3	66
2013	66	255	1 709	2	1	45	7	628	679	1	74
2014	107	267	2 377	7	8	23	15	559	696	2	196
2015	123	187	3 917	7	8	17	16	413	695	1	243
2016	148	269	4 745	2	6	15	14	390	655	-	276
2017	169	273	6 828	1	9	24	16	579	624	-	358
2018	161	220	8 662	3	13	11	20	830	510	1	431
2019	141	204	10 749	9	19	7	24	3 533	532	2	327
2020	49	99	12 272	7	26	3	21	6 003	509	1	539
2021	274	216	14 377	3	26	1	10	7 498	499	1	693
2022	347	399	15 306	10	20	4	23	8 407	467	-	338
2023	358	494	14 424	2	14	9	16	9 589	425	-	443

India and Pakistan stand out for their significant increase in student numbers, especially since 2015. By 2023, students from India made up the largest group at 14,424, while those from Pakistan accounted for 9,589. The number of students from China decreased significantly from 539 in 2010 to 494 in 2023.



Number of educational institutions

(units)

The data in the figure shows the changes in the number of public and private higher education institutions from 2002 to 2023. The analysis shows that the number of public universities fluctuated, starting from 31 in 2002, and gradually increased to 42 in 2021, with a slight decrease to 42 in 2023. The largest increase was recorded

between 2018 and 2020. Thus, the number of private universities increased from 15 in 2002 to a peak of 23 in 2010, after which it began to decrease, reaching 16 in 2023.

Number of students in higher professional education institutions by educational profile

(at the beginning of the school year, people)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Number of students	164 585	183 778	214 157	230 206	227 582
including by educational profile:					
humanities humanities	76 365	82 322	93 428	95 394	94 748
of which:					
management	6 290	6 303	7 656	5 151	4 847
health care	23 673	30 694	34 674	38 725	34 793
technical sciences	26 385	30 403	30 464	38 235	38 865
service	1 922	2 277	2 187	2 153	2 146

An analysis of the number of students in Kyrgyz universities in various fields from the 2018-2019 to 2022-2023 academic years shows a steady increase in the total number of students, although a slight decrease has been observed over the past year. From 2018-2019 to 2021-2022, the number of students increased from 164,585 to 230,206, but by 2022-2023 it had decreased to 227,582.

This growth indicates continued interest in higher education, with the exception of a slight decline last year. Humanities continue to be one of the most popular fields of study, attracting more and more students: from 76,365 students in 2018/2019 to 94,748 in 2022/2023, despite a slight decrease over the past two years. Within this management field, there is a decrease in the number of students from 7,656 in 2020/21 to 4,847 in 2022/23, which may indicate changes in labor market demands and a decline in interest in management specialties.

Healthcare shows a steady increase: from 23,673 students in the 2018/19 academic year, the number increased to a peak of 38,725 in 2021/22. In the next academic year 2022/23, there was a slight decrease to 34,793, but interest in health specialties remains high due to the increasing demand for professional health workers. The field of engineering also sees a steady increase in the number of

students from 26,385 to 38,865, indicating an increasing interest in technical specialties and a high demand for such data scientists. The catchment area remains small, with a stable student population of around 2,000.

Overall, the data point to increasing interest in technical and medical fields and stable but slightly declining interest in the humanities. This reflects trends in the labor market and educational priorities in Kyrgyzstan.

2.3. The Role of Educational Services Export in Strengthening the Supply of Medical Equipment to Higher Education Institutions in the Kyrgyz Republic

In recent years, the export of educational services has become an increasingly important component of Kyrgyzstan's economy. The influx of international students, particularly in the field of medicine, has contributed to the development of higher education and the financial stability of universities. The presence of students from countries outside the CIS, such as India, Pakistan, and Nepal, highlights the growing demand for medical education in Kyrgyzstan. The tuition fees paid by these students serve as a significant source of revenue for universities and contribute to the national budget.

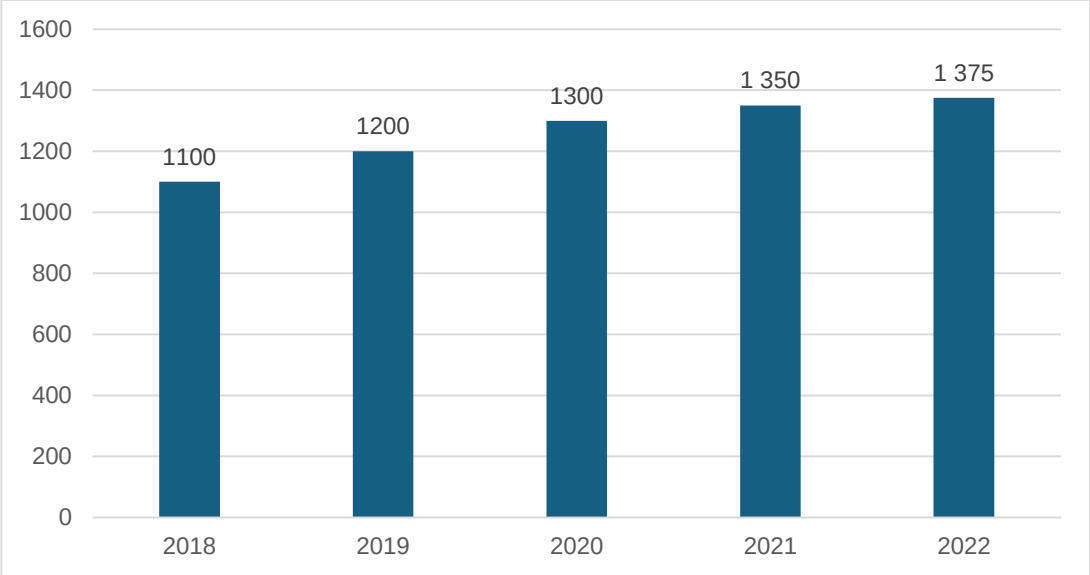


Figure. Dynamics of the volume of services exports in the Kyrgyz Republic (2018-2022) million US dollars

According to statistical data, the number of international students in Kyrgyzstan has increased significantly, from 3,366 in 2010 to 25,774 in 2023, with a particularly sharp rise after 2017. The largest groups of students come from India and Pakistan, accounting for over 50% of all foreign students in recent years. This growth has positioned Kyrgyzstan as an attractive destination for medical education due to affordable tuition fees, relatively low living costs, and the global recognition of its medical degrees.

The export of educational services in Kyrgyzstan not only generates economic benefits but also strengthens the country's position in the international academic community. To further develop this sector, investments in educational infrastructure, medical simulation technologies, and faculty training are essential. Improving the quality of education and aligning medical programs with international accreditation standards will ensure continued growth and competitiveness in the global education market.

Moreover, the government's commitment to expanding the education sector is reflected in policies aimed at increasing the accessibility of higher education for international students. Initiatives such as simplifying visa procedures, establishing partnerships with foreign educational institutions, and enhancing university facilities have further boosted the attractiveness of Kyrgyzstan as a hub for medical education. The increasing foreign student population has also stimulated the local economy, creating demand for housing, transportation, and various services, thereby benefiting multiple industries beyond the education sector. Looking ahead, strengthening collaboration with global accreditation bodies and adopting digital learning platforms will be crucial for maintaining the momentum of educational exports and positioning Kyrgyzstan as a competitive player in the international education market.

A Multiple Regression Model to Predict Public Expenditure on Education Based on GDP and Number of International Students

Years	GDP (million soms)	State budget expenditures on education, total (million soms)	The number of students from countries outside the CIS (at the beginning of the school year, persons)	Population	Income from admission to medical schools
2011	2859891	19 420,4	3 099	5 477 620	371880
2012	3104713	22 925,9	3 286	5 551 888	394320
2013	3552948	24 089,7	3 467	5 663 133	416040

2014	4006940	25 915,4	4 257	5 776 570	510840
2015	4304894	29 995,0	5 627	5 895 062	675240
2016	4763312	36 299,3	6 520	6 019 480	782400
2017	5304757	37 387,9	8 881	6 140 200	1065720
2018	5693856	37 518,6	10 862	6 256 730	1303440
2019	6540152	39 719,5	15 547	6 389 500	1865640
2020	6396886	42 345,6	19 529	6 523 529	2343480
2021	7828543	48 320,5	23 598	6 636 803	2831760
2022	10207446	73 175,6	25 321	6 747 323	3038520
2023	12288988	19 420,4	25 774	7 037 590	3092880

The results of multiple regression to predict government budget expenditure on education show the following equation: $Y = 33810 + (-0.0045) * X_1 + 2.34 * X_2$

where::

- (Y) State budget expenditures on education, total (million soms),
- (X_1) GDP (million soms),
- (X_2) The number of students from countries outside the CIS (at the beginning of the school year, persons)

Main results:

• Absolute term (β_0: 33.810) million soms, significant at the 0.007 level.

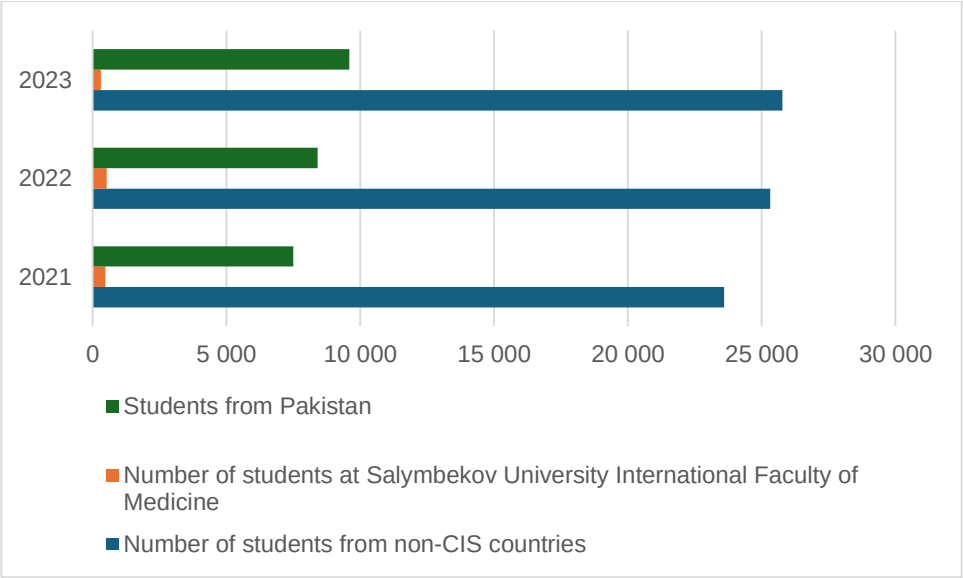
• Coefficient for X_1 (GDP): -0.0045, which means that with an increase in GDP by 1 million soms, spending on education decreases by 0.0045 million soms. This coefficient is insignificant (p=0.219).

• Coefficient for X_2 (number of students): 2.34, which indicates an increase in spending by 2.34 million soms with an increase in the number of students by one. The coefficient is almost significant (p=0.058).

Model Quality:

• R-Square: 0.459, which means that the model explains 45.9% of the variation in the dependent variable (public expenditure on education).

• F-Statistic: F-Value = 4.236 with ppp-value of 0.0465, which indicates statistical significance of the model as a whole.

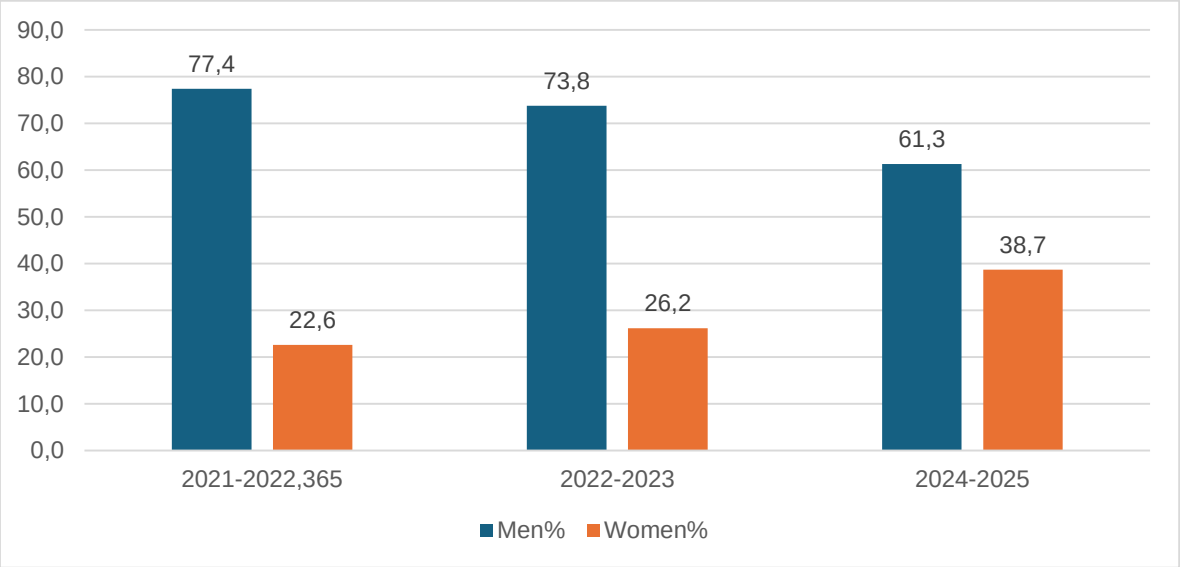


Graph of dynamics of the number of students at Salymbekov University International Faculty of Medicine (People).

Student Population Analysis (2021-2023) In 2021, students from Pakistan accounted for 31.77% of all students from non-CIS countries. In 2022, their share increased to 33.20%, and in 2023, it reached 37.20%. This indicates a steady increase in the number of students from Pakistan, which is due to the attractiveness of the university, accessibility of education, or interstate agreements. Proportion of students of the International Medical Faculty of Salymbekov University. The percentage of students of the Medical Faculty of Salymbekov University in relation to students from non-CIS countries remains similar: 31.77% in 2021, 33.20% in 2022, and 37.20% in 2023.

The number of students from non-CIS countries is growing, which indicates the popularity of the university among international applicants. The proportion of students from Pakistan is increasing, confirming the trend of growing demand for

education at this university.



Dynamics of gender distribution of students of the International Medical Faculty of Salymbekov University (2021-2025)

Analysis of the change in the proportion of men and women. Data analysis shows a gradual change in the gender composition of students. In the 2021-2022 academic year, men accounted for 77.4%, and women 22.6%. In 2022-2023, the proportion of men decreased to 73.8%, and women increased to 26.2%. In 2024-2025, the trend became more pronounced: 61.3% men and 38.7% women.

The increase in the number of female students indicates improved access for women to medical education, increased interest in medical specialties, as well as state support for women's education.

Analysis of the dynamics of the number of international students in PhD programs in the Kyrgyz Republic (2020-2022)

The data show a steady increase in the number of international students studying for a doctorate in the Kyrgyz Republic. In 2020, their number was 12,000, in 2021 it increased to 15,000 (an increase of 25%), and in 2022 it reached 18,000 (an increase of 20%). In general, the number of international students has increased by 50% over three years.

The main factors for this growth are strengthening international cooperation in the field of education, improving the quality of PhD programs, simplifying admission procedures and improving the academic infrastructure. In addition,

Kyrgyzstan can become an attractive educational platform due to the availability of education and its geographical location.

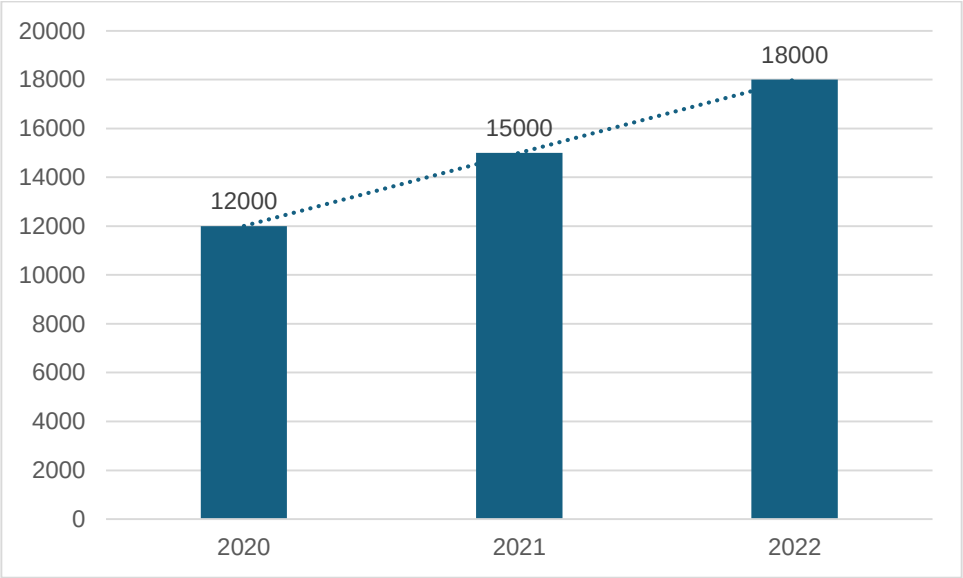


Figure: Number of international students in PhD programs in the Kyrgyz Republic (2020-2022)

However, there is a slight slowdown in the growth rate: if in 2021 the increase was 25%, then in 2022 it was 20%. This may indicate that a natural saturation point is approaching or that the attractiveness of educational programs needs to be further enhanced.

In the long term, the number of international students can be expected to continue to increase, but the growth rate may slow down. To maintain the positive dynamics, attention should be paid to the development of academic programs, improvement of student living conditions and expansion of international partnerships.

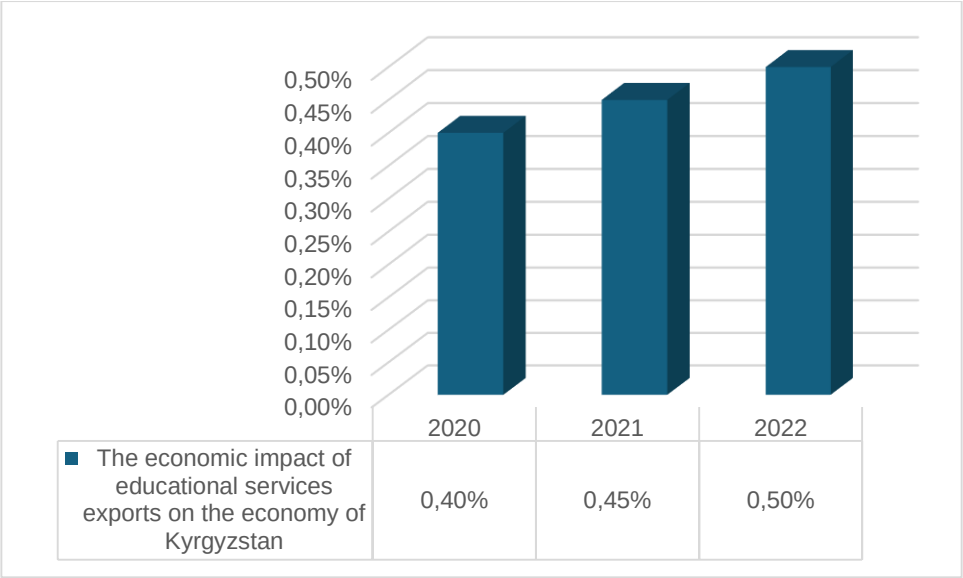


Figure: The economic impact of educational services exports on the economy of Kyrgyzstan

The data show a gradual increase in the contribution of educational services exports to the Kyrgyz Republic's GDP. In 2020, this figure was 0.4% of GDP, in 2021 - 0.45%, and in 2022 - 0.5%. This indicates a positive trend, the growth of which was 25% over three years.

The increase in the share of educational exports in GDP is associated with an increase in the number of foreign students, which leads to additional foreign exchange earnings. Visiting students contribute to the development of the economy through tuition fees, housing rental, consumption of goods and services, as well as through the creation of new jobs in the educational and service sectors.

Although the growth rate is positive, the overall contribution of the sector remains relatively low. To increase the economic effect, it is necessary to expand the export of educational services by attracting more foreign students, developing English-language programs and strengthening international academic ties.

If the current trend continues, further growth in the contribution of educational exports to GDP can be expected. However, to achieve a significant economic effect, more active government support and investment in higher education will be required.

Analysis of the supply chain of medical equipment for educational institutions of the Kyrgyz Republic

1. General characteristics of medical equipment

Data analysis shows that educational institutions of Kyrgyzstan have a wide range of medical equipment, including diagnostic, surgical, laboratory and resuscitation equipment.

Salymbekov University has:

- Ultrasound machines (Voluson E-8, PHILIPS iU22, new ultrasound),
- Operating tables, lamps, stands (DELMONT, Storz, BOWA),
- Ventilators (Mindray SV300, WATO EX-35),
- X-ray equipment (Jumong General, X-ray printer, digital detector),
- Electrocardiograph (ECG1200G Contec),
- Laboratory equipment (centrifuge, drying cabinet, analyzer, monitoring).

Bokonbaeva stands out for:

- Additional dental equipment (MEGAGEN IMPLANT NEXT chair, Vatech portable X-ray),
- Ultrasound and X-ray (Voluson E8, mobile ultrasound, DELL surgical X-ray),
- Laboratory and surgical equipment (SNIPE analyzer, urine analyzer, Lumenis Pulse 100H laser).

2. Supply chain structure

- Equipment is supplied in two directions:
- The main suppliers are international brands (Mindray, PHILIPS, Contec, Olympus, Armed).
- Local distributors – ensure adaptation to the needs of universities.

3. Impact on the educational process

Modern equipment improves the quality of training specialists, providing access to real clinical scenarios.

Barriers in the supply chain of medical equipment for educational institutions of the Kyrgyz Republic.

The supply of medical equipment for educational purposes faces a number of barriers, which can be divided into economic, logistical, administrative and technological.

1. Economic barriers

High cost of equipment – most modern medical devices (ultrasound, X-ray, artificial lung ventilation) are expensive, which requires significant budget expenditures.

Limited government investment – funding for educational institutions in Kyrgyzstan is limited, which limits the possibilities for purchasing modern equipment.

Currency fluctuations – most equipment is imported, and currency fluctuations make purchases unpredictable.

2. Logistic barriers

Transportation difficulties – medical equipment requires special transportation conditions (temperature conditions, insurance, certification).

Delays in deliveries – customs procedures and instability of international logistics chains can lead to delays.

Lack of local manufacturers – dependence on imports increases supply risks.

3. Administrative and regulatory barriers

Bureaucracy – certification, licensing and permits can slow down the procurement process.

Corruption risks – inefficient allocation of budget funds can hinder a transparent procurement process.

Complexities in contract procedures – lengthy tender processes increase the time it takes to receive equipment.

4. Technological barriers

Lack of maintenance specialists – complex equipment requires qualified personnel for operation and repair.

Lack of infrastructure for installation – some devices require special conditions (shielded rooms, uninterruptible power supplies).

Outdated technical standards – incompatibility of new equipment with old technologies in medical institutions and educational laboratories.

Conclusions and recommendations

To reduce barriers, it is necessary to:

Develop public-private partnership programs for equipment financing.

Optimize customs and certification procedures.

Encourage local production and assembly of equipment.

Implement training programs on operation and maintenance.

Removing barriers will help improve educational institutions' access to modern medical equipment and improve the quality of specialist training.

Barriers in the supply chain of medical equipment for educational institutions of the Kyrgyz Republic, taking into account the EAEU and sanctions restrictions

The supply of medical equipment to Kyrgyzstan, especially for educational institutions, faces a number of barriers. In addition to economic, logistical, administrative and technological factors, membership in the Eurasian Economic Union (EAEU) and sanctions restrictions have a significant impact.

1. The impact of membership in the EAEU

Kyrgyzstan is a member of the EAEU (Eurasian Economic Union), which affects the supply chain of medical equipment:

- Simplification of customs procedures - deliveries between the EAEU countries (Russia, Belarus, Kazakhstan, Armenia) are made without customs duties, which reduces the cost of purchases.
- Common certification market - equipment certified in one EAEU country is recognized in all the others.
- Dependence on dominant suppliers - imports mainly come from Russia and Kazakhstan, which reduces competitiveness and makes the market less diversified.
- Limited supplies from countries outside the EAEU – complex bureaucratic processes make imports from Europe and the US more difficult.

2. Impact of sanctions on medical equipment supplies

International sanctions imposed on Russia indirectly affect Kyrgyzstan and create new barriers to the import of medical equipment:

- Difficulties with payment and financing – banking restrictions complicate payments for equipment supplies, especially from countries that support sanctions.
- Logistics disruptions – sanctions have changed transport routes, extended delivery times and increased transportation costs.
- Limited access to Western technologies – it is becoming more difficult for Kyrgyzstan to purchase equipment from the EU and the US, as some manufacturers are ceasing cooperation with partners from the EAEU countries.
- Reorientation to alternative markets – increasing imports from China, Turkey and India as an alternative to Western technologies.

3. Key barriers to medical equipment supplies

Economic barriers:

- High cost of equipment and limited budgets of universities.
- Exchange rate fluctuations complicating procurement planning.
- Logistics barriers:
- Delays in deliveries due to sanctions and disruptions in transport routes.
- Limited access to modern medical equipment from Europe and the USA.

Administrative and regulatory barriers:

- Complex certification and licensing procedures for imports due to EAEU regulations.
- Long tender processes and the risk of corruption in public procurement.
- Technological barriers:
- Lack of specialists to service modern equipment.
- Incompatibility of new equipment with old medical laboratories and educational buildings.

4. Recommendations for improving the supply of medical equipment

Developing cooperation with China, Turkey, India – expanding supplier markets to reduce dependence on Western technologies.

Accelerating digitalization and certification procedures within the EAEU – automating customs processes and improving the medical equipment registration system.

State support for local production – stimulation of medical equipment assembly in Kyrgyzstan or EAEU countries.

Creation of repair and maintenance service centers – reducing dependence on foreign specialists.

Attracting foreign investment – searching for new partners not subject to sanctions.

Thus, sanctions and restrictions within the EAEU complicate equipment supplies, but with the right approach, Kyrgyzstan can diversify import sources and create a more sustainable supply chain.

Key Conclusions and Recommendations

1. Multiple Regression Model for Public Expenditure on Education

The model indicates that the number of international students significantly influences government spending on education, with a coefficient of 2.34 million soms per student. However, GDP does not have a statistically significant impact on education expenditure, suggesting that government spending decisions on education are influenced by other factors. The model explains 45.9% of the variation in public expenditure on education, meaning other variables (e.g., policy changes, economic priorities) may play a crucial role. Further research is needed to include additional explanatory variables, such as government priorities, inflation, or foreign aid.

2. Growth in the Number of International Students in Kyrgyzstan

The steady increase in non-CIS international students (from 12,000 in 2020 to 18,000 in 2022) highlights the attractiveness of Kyrgyz education. A significant increase in students from Pakistan (31.77% in 2021 to 37.2% in 2023) suggests growing demand from specific regions. Gender diversity is improving, with female student enrollment rising from 22.6% (2021) to 38.7% (2025). Universities should

strengthen partnerships with international institutions and offer more programs in English to attract a wider range of students.

3. Economic Impact of Educational Services Exports

The contribution of educational exports to GDP increased from 0.4% (2020) to 0.5% (2022), showing a 25% growth in three years. Foreign students contribute not only through tuition fees but also through housing, consumption, and job creation. However, the overall impact remains relatively low.

Recommendation: To enhance economic benefits, the government should support scholarship programs, marketing initiatives, and international accreditation of universities.

4. Supply Chain Challenges for Medical Equipment

Key barriers include high costs, complex import regulations, reliance on imported equipment, and lack of skilled technicians. Impact of EAEU membership: While customs procedures are simplified, dependency on Russia and Kazakhstan limits competition and increases risks. Impact of sanctions: Indirect restrictions complicate financial transactions and limit access to high-tech medical equipment from the US and Europe. Diversify imports by increasing cooperation with China, Turkey, and India.

Develop local manufacturing and assembly of medical devices.

Accelerate digital certification and customs processing to reduce bureaucratic delays. The education sector in Kyrgyzstan is experiencing significant growth, particularly in attracting international students. Economic benefits from education exports are increasing but remain modest. Medical equipment procurement faces logistical and financial challenges, exacerbated by EAEU regulations and global sanctions. Future strategies should focus on diversifying partnerships, digitalizing bureaucratic procedures, and improving infrastructure for sustainable development in both education and healthcare sectors.

CHAPTER III. Ways to optimize the supply chain of medical equipment for educational institutions of the Kyrgyz Republic

3.1. Strategic Approaches to Improving the Efficiency of Medical Equipment Supply Chains in the Education Sector

The effective functioning of medical educational institutions in the Kyrgyz Republic (KR) largely depends on the availability of modern medical equipment for training and research. However, challenges such as supply chain inefficiencies, high dependence on imports, and budget constraints hinder the optimal provision of necessary medical devices. This chapter explores strategies to optimize the supply chain of medical equipment for educational institutions in KR, emphasizing localization, cost reduction, and operational efficiency.

Current Challenges in the Medical Equipment Supply Chain. The supply chain of medical equipment for educational institutions in KR faces several obstacles:

High dependency on imports – Most medical devices are sourced from China, Russia, Germany, and Turkey, leading to logistical complexities and high costs. Budgetary constraints – Limited government funding restricts the procurement of high-quality and modern equipment.

Supply chain inefficiencies – Ineffective logistics, customs delays, and lack of coordination between suppliers and institutions result in equipment shortages and delivery delays. Lack of local servicing and maintenance – Imported equipment often lacks local service centers, making repairs costly and time-consuming.

Strategies for Supply Chain Optimization. Enhancing Local Production and Assembly. One way to optimize the supply chain is to develop local production and assembly of medical equipment, reducing reliance on imports. This can be achieved through: Establishing partnerships with international medical equipment manufacturers to set up assembly plants in KR.

Encouraging private investment in local manufacturing of basic medical devices.

Implementing government incentives such as tax exemptions and subsidies for local producers. Implementing Digital Supply Chain Management

Digital transformation can streamline procurement and distribution processes, making the supply chain more efficient. Key steps include:

Developing a centralized digital platform for real-time monitoring of medical equipment inventory across institutions.

Using blockchain technology to ensure transparent tracking of orders, shipments, and payments.

Employing artificial intelligence (AI) for demand forecasting to prevent shortages and overstocking.

Strengthening Public-Private Partnerships (PPPs). Public-private collaboration can enhance supply chain resilience by: Engaging private companies to supply and maintain medical equipment through long-term contracts. Establishing joint ventures with international suppliers to ensure sustainable and cost-effective procurement. Utilizing leasing and rental models to access high-end medical devices at lower costs.

Improving Logistics and Procurement Practices.

Optimizing logistics and procurement can reduce lead times and costs. Recommended actions include:

Centralized bulk purchasing for educational institutions to benefit from economies of scale.

Establishing regional distribution centers to reduce transportation costs and ensure timely delivery.

Streamlining customs procedures and import regulations to accelerate equipment clearance.

Enhancing Training and Maintenance Infrastructure

Ensuring sustainable medical equipment use requires skilled personnel and maintenance support. Strategies involve:

Developing training programs for technical staff on equipment usage and repair.

Setting up local maintenance hubs for quick servicing and spare parts availability.

Promoting technology transfer agreements to build local expertise in medical device maintenance.

Expected Outcomes. Implementing these strategies will lead to:

- Cost reduction through local production, efficient procurement, and optimized logistics.
- Improved equipment availability due to better inventory management and distribution.
- Enhanced quality of medical education by ensuring access to modern technology for students and researchers.
- Greater self-sufficiency by reducing reliance on imported medical equipment.

Optimizing the supply chain of medical equipment for educational institutions in KR is critical for advancing healthcare education and research. By focusing on local production, digitalization, public-private partnerships, and improved logistics, KR can enhance efficiency, reduce costs, and ensure sustainable access to high-quality medical equipment. These measures will contribute to the long-term development of the country's healthcare and education sectors.

Implementation of incentive customs procedures

To improve the efficiency of medical equipment supplies to educational institutions of the Kyrgyz Republic (KR), the following customs incentives can be implemented:

Preferential customs clearance for medical equipment. Introduction of zero or reduced customs duty on the import of components and equipment intended for educational and medical institutions.

Exemption from VAT and excise taxes on imported medical devices and technologies used for scientific and educational purposes.

Simplification of customs procedures. Introduction of accelerated customs clearance for medical equipment and its components intended for educational institutions.

Development of a "green corridor" for critical medical equipment to minimize customs clearance time.

Digitalization of customs administration - transition to online declaration and electronic customs certificates to speed up cargo processing.

Support for local production through customs benefits. Reduction of import duties on components for the assembly of medical equipment within the country.

Introduction of tax incentives and deferrals of customs payments for domestic manufacturers of medical equipment.

Simplified export procedures for supplies of equipment and medical products manufactured in the Kyrgyz Republic.

Development of a special customs regime for educational institutions

Creation of a separate customs regulation regime for medical universities, research centers and state educational programs so that they can receive equipment at reduced rates and with minimal administrative barriers.

Introduction of targeted customs quotas for the import of equipment for medical education, which will allow educational institutions to receive equipment under fixed conditions.

Expected results of the introduction of customs incentives

Reduction in the cost of medical equipment by reducing taxes and customs duties.

Accelerated deliveries due to simplified customs procedures.

Increased competitiveness of local production, since the import of components will become cheaper, and the production of medical equipment in the Kyrgyz Republic will be more profitable.

Expanding the availability of medical technologies for educational institutions, which will improve the quality of training of medical personnel.

Thus, effective reform of customs procedures is an important tool for stimulating the development of the supply chain of medical equipment and local production in the Kyrgyz Republic.

Legal framework for regulating customs procedures for medical equipment in the Kyrgyz Republic

Optimization of the supply chain for medical equipment for educational institutions in the Kyrgyz Republic (KR) requires taking into account the legal

framework of the Eurasian Economic Union (EAEU) and national legislation. The main regulations governing customs procedures include international agreements, laws of the Kyrgyz Republic and government decrees.

International and regional regulations of the EAEU

Customs Code of the Eurasian Economic Union (CU EAEU)

The main document regulating customs procedures in all EAEU member states.

Defines the procedure for import and export of goods, including medical equipment.

Establishes a list of preferential and special customs procedures.

Date of adoption: December 26, 2016, entered into force on January 1, 2018.

Decision of the EEC Council No. 107 of December 20, 2017

Establishes a single list of goods exempt from import customs duties, including certain types of medical equipment.

Regulates the application of zero duty rates when importing medical products.

Decision of the EEC Board No. 45 of April 5, 2022

Updates the classification of medical equipment and defines the criteria for the need for certification and sanitary control.

Defines the conditions for the temporary import and duty-free export of medical equipment.

National regulations of the Kyrgyz Republic

Law of the Kyrgyz Republic "On Customs Regulation" No. 85 of July 31, 2018

Incorporates the provisions of the EAEU Customs Code into the national legislation of the Kyrgyz Republic.

Defines the procedure for declaration, customs control and tax preferences for medical equipment.

Allows public medical institutions to use a simplified import mechanism.

Resolution of the Government of the Kyrgyz Republic No. 37 of February 12, 2019

Introduces benefits for the import of medical equipment for educational and public institutions.

Defines the mechanism for obtaining permits for the import of medical equipment.

Order of the Ministry of Health of the Kyrgyz Republic No. 289 of May 5, 2020

Defines the procedure for certifying medical equipment before its use in educational institutions.

Regulates technical requirements for medical equipment in educational institutions.

Conclusion

These regulations define the legal framework for optimizing the supply of medical equipment. To speed up and reduce the cost of import, it is necessary to:

Use the duty exemption mechanisms provided for by the decisions of the EEC.

Apply simplified customs control procedures for public educational institutions.

Develop local assembly of equipment using preferential processing regimes in the customs territory.

Achieve harmonization of national legislation with the rules of the EAEU to simplify logistics.

Effective application of these standards will significantly reduce costs, speed up the supply of medical equipment and increase the availability of modern technologies for medical education in the Kyrgyz Republic.

2.2. EAEU Customs Procedures and Their Impact on the Medical Equipment Supply Chain

The Customs Code of the Eurasian Economic Union (EAEU CC) provides for various customs procedures that regulate the import, export, storage and processing of goods, including medical equipment. Optimizing the use of these procedures can help improve the supply chain, reduce costs and speed up the logistics of medical equipment for educational institutions in the Kyrgyz Republic (KR).

The main customs procedures of the EAEU CC and their application in the medical equipment supply chain

Release for domestic consumption (Import to the KR). The most common procedure used to import medical equipment for its subsequent use in the country.

Requires payment of import duties, VAT and excise taxes (if applicable), as well as compliance with certification requirements.

Can be optimized through tax and customs benefits for medical institutions and educational organizations.

Customs warehouse. Allows you to import medical equipment and store it in a warehouse without paying customs duties until the goods are in demand.

Useful for educational institutions and hospitals, since the equipment can be purchased in advance and put into circulation as needed.

Temporary import (admission)

Allows you to import medical equipment for a limited period without paying customs duties, but with an obligation to re-export it.

Useful for rental medical equipment, temporary use in research and educational projects.

Applicable for international scientific exchanges and testing of new medical equipment.

Processing on customs territory. Allows you to assemble, upgrade or repair imported medical equipment within the country without paying duties.

Can be used for local assembly of medical equipment in the Kyrgyz Republic with the import of components from China, India, Turkey.

Processing outside the customs territory

Allows temporary export of equipment outside the EAEU for repair or modernization, with subsequent re-import without paying duties.

Useful in cases where repair of complex medical equipment is only possible abroad (for example, in Germany, South Korea).

Free customs zone. Allows placing goods in special economic zones (SEZ) without paying customs duties and taxes.

Can be used to organize production facilities for the assembly of medical equipment in the Kyrgyz Republic.

Re-import. Allows the return of previously exported medical equipment without paying customs duties.

Useful in the case of returning low-quality equipment or faulty batches.

Free warehouse

Allows placing medical equipment in a warehouse without customs clearance, and then exporting or importing as needed.

Can be useful for international companies operating in the Kyrgyz Republic that want to keep a stock of medical devices.

Export. Issued when exporting medical equipment outside the EAEU.

Exempts from paying internal taxes (VAT, excise taxes) and can be used when selling Kyrgyz medical technologies abroad.

Conclusion

Proper use of customs procedures of the EAEU Customs Code can reduce logistics costs, speed up deliveries and facilitate access to medical equipment. Particularly useful are mechanisms such as customs warehouses, temporary import, processing and free economic zones, which can contribute to the development of local production and import optimization.

To stimulate the supply of medical equipment to the Kyrgyz Republic, it is advisable to:

Simplify customs procedures for educational institutions (for example, exemption from duties).

Create mechanisms for temporary import for testing medical equipment in educational processes.

Develop local assembly through the processing procedure on the customs territory. Develop free economic zones to attract manufacturers of medical equipment. These measures will help provide medical educational institutions with modern technologies and reduce dependence on imports.

Conclusion

The dissertation research devoted to the analysis and improvement of medical equipment supply chains for educational institutions of the Kyrgyz Republic allowed to deeply reveal the specifics of logistics processes in the field of medical education, identify systemic barriers and substantiate practical directions for their elimination.

The results of the study confirmed that the effectiveness of medical personnel training in the Kyrgyz Republic largely depends on the quality and reliability of medical equipment supply chains to educational institutions. Providing universities with modern simulators, laboratory diagnostic equipment and educational visual aids is not only a logistical, but also a strategic task of national importance, directly affecting the sustainability of the healthcare system.

The analysis of the current state showed that the existing model of medical equipment supply suffers from institutional fragmentation, non-transparent public procurement procedures, high import dependence, insufficient digitalization of processes and the lack of systematic forecasting of needs. Particular attention is paid to the regulatory framework, including tender procurement procedures, where barriers that hinder the efficiency and quality of deliveries have been identified.

A comparative analysis with international practice (Germany, China, USA, India) revealed modern trends in the management of medical equipment supply chains, including:

• the use of smart logistics concepts with the integration of IoT and RFID technologies,

• digital transformation of supply chains (e-Procurement, SCM platforms),

• the implementation of sustainable supply principles (green & resilient supply chains),

• the use of blockchain technologies to increase the transparency of processes.

In the context of current challenges - a pandemic, import dependence, digital divide and institutional fragmentation - the topic acquires not only scientific but also applied significance.

The following main results were achieved during the study:

1. A conceptual model of the medical equipment supply chain in the education system was developed, including key logistics links: demand planning, procurement, transportation, installation, technical support and disposal. The model was adapted to the realities of the Kyrgyz Republic.

2. For the first time, a typology of barriers in supply logistics for educational institutions was conducted in the following areas: institutional, financial and economic, logistics, technological and personnel. The need to reform the regulatory framework and simplify procurement procedures was substantiated.

3. Practical recommendations were proposed for optimizing supply processes, including the transition to a centralized electronic platform e-Procurement, the introduction of KPIs for logistics operations, the use of tools for forecasting demand for equipment taking into account the specifics of educational programs.

4. A comparative analysis of international experience (Germany, China, USA, India) was conducted, based on which areas for adapting best practices were proposed: digitalization of supply chains, sustainable logistics planning, public-private partnership mechanisms in the field of medical education.

5. The necessity of integrating sustainable development approaches into the logistics of medical equipment through the criteria of the equipment life cycle, environmental standards of suppliers and sustainable disposal is substantiated.

By implementing strategies such as localization, digitalization, public-private partnerships, and streamlined customs procedures, KR can significantly enhance the efficiency and sustainability of medical equipment procurement.

The effective application of these measures will result in:

- A reduction in procurement costs and logistical delays.
- Improved accessibility of modern medical equipment in educational institutions.

- Strengthened local production and servicing capabilities.
- Enhanced collaboration between the government, private sector, and international suppliers.
- Greater alignment of national policies with international trade regulations to facilitate seamless medical equipment imports and exports.

In conclusion, optimizing the supply chain of medical equipment is crucial for ensuring high-quality medical education and research in the Kyrgyz Republic. With the proper implementation of these strategies, KR can build a more resilient, cost-effective, and sustainable medical supply chain, ultimately contributing to the growth of its healthcare and education sectors.

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Conclusion

The study of the supply chain of medical equipment for educational institutions in the Kyrgyz Republic has identified key challenges that hinder the effective provision of necessary resources for medical education. Modern medical training requires constant updates and the integration of new technologies, which is

impossible without high-quality equipment. However, the analysis revealed several significant obstacles, including logistical, financial, and administrative barriers.

One of the primary issues is dependence on imports. Most medical equipment used in educational institutions is sourced from abroad, leading to high financial costs. Currency fluctuations, customs duties, and transportation expenses significantly increase procurement expenses. This also makes the supply chain vulnerable to global crises and disruptions in international logistics networks.

Logistical and administrative barriers also contribute to the inefficiency of the system. Government procurement processes are often accompanied by lengthy bureaucratic procedures, resulting in delays in deliveries and the obsolescence of equipment before it is even used. Additionally, the lack of an efficient inventory management system complicates the timely replacement and maintenance of medical equipment.

Another significant problem is the absence of unified standards and regulatory requirements. In Kyrgyzstan, there is no clear regulation defining which medical equipment is necessary for educational institutions or what quality criteria must be met. This leads to an uneven distribution of resources among institutions, with some receiving modern equipment while others are left without essential tools.

Limited government funding is another major challenge. Budgetary resources are often insufficient for timely equipment updates, and private investments in the education sector remain inadequate. This forces educational institutions to seek alternative sources of funding, which is not always feasible.

Unlike developed countries, digital technologies are underutilized in managing the supply chain of medical equipment in Kyrgyzstan. Implementing blockchain, artificial intelligence, and automated procurement systems could significantly enhance the transparency and efficiency of the process.

Recommendations

1. Developing local production of medical equipment to reduce dependence on imports and lower procurement costs.
2. Optimizing government procurement processes by digitizing procedures and reducing bureaucratic delays to speed up supply.
3. Establishing national standards for medical equipment to ensure the fair distribution of resources and quality control.
4. Improving logistics and inventory management by integrating digital solutions to minimize delays and losses.
5. Attracting private investments and international partnerships to create new financial opportunities for the modernization of educational institutions.
6. Implementing digital technologies in supply chain management to enhance transparency and efficiency.

In conclusion, improving the supply chain system for medical equipment in educational institutions in the Kyrgyz Republic requires a comprehensive approach, including the development of local manufacturing, the enhancement of procurement mechanisms, the adoption of digital technologies, and increased funding. Implementing the proposed measures will not only improve access to high-quality medical equipment but also enhance the training standards for future medical professionals. Further research should focus on digitalization and logistics to establish a sustainable and efficient supply system for educational institutions.

A questionnaire for medical students to assess their opinions and experiences related to the educational process and simulation technologies in education:

Questionnaire for medical students

Personal data (optional):

1. Your year of study: _____

2. Your specialization (if applicable): _____

Section 1: Overall satisfaction with the educational process

1. How satisfied are you with the quality of education at your university?

- Very satisfied / Satisfied / Average / Dissatisfied / Not at all satisfied

2. Rate the availability of educational materials and resources.

3. How prepared do you feel for practical work after completing the courses?

4. Do you think that the teachers spend enough time explaining practical skills?

5. How often do you get the opportunity to work with real patients?

Section 2: Evaluation of Simulation Training

6. Have you participated in simulation training?

- Yes / No

7. How would you rate the level of realism of the simulators you have worked with?

8. How often do you participate in simulation training during the academic year?

9. Do you find that simulation training helps you develop practical skills?

10. What types of simulators do you most often work with (mannequins, virtual reality, computer simulations, etc.)?

11. Are you satisfied with the frequency of simulation training?

12. What aspects of simulation training do you find most useful?

Section 3: Practical Training

13. Do you find that practical skills training is adequate for your specialization?

14. What proportion of your time do you spend practicing practical skills compared to theoretical training?

15. Do you feel confident in performing manipulations after simulation training?

16. What types of manipulations or procedures would you like to practice more often?

17. Do you think it is important to use virtual reality in teaching?

Section 4: Interaction with teachers and supervisors

18. How often do teachers provide feedback after simulation sessions?

19. Do teachers sufficiently explain mistakes made on simulation trainers?

20. Rate the competence of teachers in using simulation equipment.

Section 5: Evaluation of conditions and resources

21. Are you satisfied with the state of simulation laboratories and equipment at your university?

22. Are there enough simulators for all students in your course?

23. How often did you have to wait for your turn to work with a simulator?

24. What improvements would you suggest for simulation training at your university?

25. Do you feel that the simulation training prepared you for real practice?