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ARTIFICIAL INTELLIGENCE AS A TOOL FOR IMPROVING THE EFFICIENCY OF HEALTHCARE SYSTEM MANAGEMENT IN KAZAKHSTAN

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Abstract. The digital transformation of healthcare and the rapid development of artificial intelligence technologies are creating new opportunities for healthcare delivery and managerial decision-making. This study assesses the prerequisites, application areas, and potential effects of artificial intelligence on the efficiency of healthcare system management in the Republic of Kazakhstan. The empirical base includes official statistical data for Kazakhstan for 2015–2025, materials of the Ministry of Healthcare of the Republic of Kazakhstan, national strategic and regulatory documents, and international research on the application of artificial intelligence in clinical and administrative healthcare processes. The study used dynamic, comparative, and structural analysis, document content analysis, a process-based approach, and systematisation of practical AI implementation cases. The findings show that the number of physicians increased from approximately 69.7 thousand in 2015 to 84.0 thousand in 2025, while the number of hospital organisations changed from 901 to 832. In 2025, more than 215 million healthcare services were provided, of which 190.8 million, or 88.6%, were delivered electronically. The development of the E-Densaulyq ecosystem, integration of fragmented information systems, and creation of a unified medical data repository

establish a technological foundation for moving from digital record-keeping to data-driven, AI-supported management. The greatest managerial potential of AI is identified in patient-flow forecasting, resource planning, pharmaceutical supply management, quality control, clinical decision support, and anomaly detection. The study proposes an original AI-driven healthcare management framework that links digitalisation, data integration, AI applications, managerial processes, measurable efficiency outcomes, risk assessment, and evidence-based scaling. The study also shows that the independent macro-level effect of AI cannot yet be statistically separated from the broader impact of healthcare digitalisation because a sufficiently long and comparable national time series on AI adoption is lacking.

Keywords: artificial intelligence, healthcare, healthcare management, digital transformation, Kazakhstan, efficiency, medical data, E-Densaulыq, decision support

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ЖАСАНДЫ ИНТЕЛЛЕКТ ҚАЗАҚСТАННЫҢ ДЕНСАУЛЫҚ САҚТАУ ЖҮЙЕСІН БАСҚАРУ ТИІМДІЛІГІН АРТТЫРУ ҚҰРАЛЫ РЕТІНДЕ

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Аннотация. Денсаулық сақтау саласының цифрлық трансформациясы және жасанды интеллект технологияларының қарқынды дамуы медициналық көмекті ұйымдастыру мен басқарушылық шешімдер қабылдаудың жаңа мүмкіндіктерін қалыптастырады. Зерттеудің мақсаты – Қазақстан Республикасының денсаулық сақтау жүйесін басқару тиімділігін арттыруда жасанды интеллектті қолданудың алғышарттарын, негізгі бағыттарын және ықтимал нәтижелерін бағалау. Зерттеудің эмпирикалық базасын 2015–2025 жылдардағы Қазақстан Республикасының ресми статистикалық деректері,

Қазақстан Республикасы денсаулық сақтау министрлігінің материалдары, стратегиялық және нормативтік құжаттар, сондай-ақ денсаулық сақтау саласында жасанды интеллектті қолдануға арналған халықаралық ғылыми еңбектер құрады. Динамикалық, салыстырмалы және құрылымдық талдау, контент-талдау, үдерістік тәсіл және практикалық ЖИ-жобаларды жүйелеу әдістері қолданылды. Зерттеу нәтижелері 2015–2025 жылдары дәрігерлер санының 69,7 мыңнан 84,0 мың адамға дейін өскенін көрсетті. 2025 жылы 215 млн-нан астам медициналық қызмет көрсетіліп, олардың 190,8 миллионы немесе 88,6%-ы электрондық форматта ұсынылды. E-Densaulyq экожүйесін қалыптастыру, ақпараттық жүйелерді интеграциялау және бірыңғай медициналық деректер қоймасын құру интеллектуалды басқаруға көшуге негіз қалыптастырады. Жасанды интеллекттің негізгі басқарушылық әлеуеті пациенттер ағынын болжау, ресурстарды бөлу, дәрі-дәрмекпен қамтамасыз ету, медициналық көмектің сапасын бақылау және шешім қабылдауды қолдаумен байланысты екені анықталды. Авторлық AI-driven healthcare management моделі ұсынылды.

Түйін сөздер: жасанды интеллект, денсаулық сақтау, басқару, цифрландыру, Қазақстан, тиімділік, медициналық деректер, цифрлық денсаулық сақтау, E-Densaulyq

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ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ КАК ИНСТРУМЕНТ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ УПРАВЛЕНИЯ СИСТЕМОЙ ЗДРАВООХРАНЕНИЯ КАЗАХСТАНА

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Аннотация. Цифровая трансформация здравоохранения и быстрое распространение технологий искусственного интеллекта формируют новые условия для организации медицинской помощи и принятия управленческих решений. Цель исследования заключается в оценке предпосылок, направлений и потенциальных эффектов использования искусственного интеллекта

для повышения эффективности управления системой здравоохранения Республики Казахстан. Эмпирическую основу составили официальные статистические данные Республики Казахстан за 2015–2025 гг., материалы Министерства здравоохранения Республики Казахстан, нормативные и стратегические документы, а также международные научные исследования, посвященные использованию искусственного интеллекта в медицинских и управленческих процессах. Применены методы динамического, сравнительного и структурного анализа, контент-анализ, процессный подход и систематизация практических кейсов внедрения ИИ. Установлено, что численность врачей всех специальностей увеличилась с 69,7 тыс. человек в 2015 г. до 84,0 тыс. человек в 2025 г., тогда как число больничных организаций изменилось с 901 до 832 единиц. В 2025 г. в системе здравоохранения было оказано более 215 млн медицинских услуг, из которых 190,8 млн, или 88,6%, предоставлялись в электронном формате. Создание экосистемы E-Densaulыq, интеграция информационных систем и развитие Единого хранилища медицинских данных формируют информационную основу для перехода от цифрового учета к интеллектуальному управлению. Показано, что наибольший управленческий потенциал ИИ связан с прогнозированием потоков пациентов и потребности в ресурсах, лекарственным обеспечением, управлением качеством, поддержкой клинических решений и выявлением аномалий. Предложена авторская модель перехода к AI-driven healthcare management, предусматривающая обязательную оценку клинической, организационной и экономической эффективности ИИ-решений до их масштабирования. Обосновано, что на современном этапе статистически отделить эффект ИИ от совокупного эффекта цифровизации на макроуровне пока невозможно, что определяет необходимость создания национальной системы КРІ применения искусственного интеллекта в здравоохранении.

Ключевые слова: искусственный интеллект, здравоохранение, управление, цифровая трансформация, Казахстан, эффективность, медицинские данные, E-Densaulыq, цифровое здравоохранение, управленческие решения

Introduction. The modern healthcare system is a complex, multi-level socio-economic system whose effectiveness depends not only on funding levels, the availability of medical infrastructure, and the supply of qualified personnel, but also on the quality of management decisions. Population growth, the increasing prevalence of chronic diseases, the growing complexity of medical technologies, and the increasing volume of information are straining existing mechanisms for planning, monitoring, and allocating resources. At the same time, digital transformation has led to the accumulation of significant volumes of medical data. Electronic medical records, medical organisations' information systems, digital prescriptions, results of laboratory and instrumental studies, and information on hospitalisations, prescriptions, financial flows, and patient movements form a

digital environment that can potentially be used not only to record facts but also to forecast.

Under these conditions, a qualitatively new stage of digital transformation is associated with implementing artificial intelligence. In this study, artificial intelligence is understood as a set of algorithmic technologies capable of analyzing large data sets, identifying hidden patterns, classifying objects, predicting events, and providing information to support management and clinical decisions.

It is important to distinguish between digitalisation and artificial intelligence. Converting medical documentation into an electronic format, online patient registration, or creating an information system are elements of digitalisation. Artificial intelligence предполагает a higher level of data processing, in which an algorithm can predict the likelihood of a certain event, identify an anomaly, classify a medical image, or suggest solution options based on accumulated information. This distinction is of fundamental importance for assessing effectiveness. Improvements in healthcare indicators that occur alongside digital transformation cannot automatically be attributed to the introduction of artificial intelligence. The study's relevance to Kazakhstan stems from the country's simultaneous integration of digital medical platforms and scaling individual AI solutions. The Concept for the Development of Artificial Intelligence for 2024–2029, approved in 2024, provides for the development of data management, infrastructure, human capital, and AI regulation, as well as an increase in the number of AI-based products being implemented in real sectors of the economy (Government of the Republic of Kazakhstan, 2024).

At the same time, the healthcare system is transitioning to the E-Densaulıyq architecture, which envisions integrating previously fragmented information resources. This institutional and technological transformation creates the prerequisites for using artificial intelligence not only for individual diagnostic decisions, but also for managing resources, the quality of medical care, drug supply, and patient flows. In this regard, a research question arises: under what conditions can the implementation of artificial intelligence transform from a separate medical technology into a systemic tool for improving the efficiency of healthcare management in Kazakhstan?

The study aims to assess the prerequisites, main directions, and mechanisms for using artificial intelligence to improve the efficiency of healthcare system management in the Republic of Kazakhstan. To achieve the goal, the following tasks are defined: to analyse changes in the resource and digital base of the healthcare system; to systematise modern approaches to the use of AI; to assess the actual directions of the introduction of artificial intelligence in Kazakhstan; to identify the main channels of its impact on management processes; to propose a model for assessing organisational and economic efficiency and directions for further scaling. The study's scientific hypothesis is that the systemic effect of artificial intelligence is determined not by the number of autonomously implemented algorithms, but by

the degree of their integration with medical data and the core processes of resource management, quality, and organisation of medical care.

Literature review. Scientific studies in recent years demonstrate a significant expansion of the scope of artificial intelligence applications in healthcare. While early studies primarily focused on the diagnostic accuracy of algorithms, modern literature increasingly examines AI from the perspective of changing organizational processes.

Topol (2019) links the development of highly effective medicine to combining human capabilities with artificial intelligence. The author notes that automated processing of large volumes of medical data can free healthcare workers from some routine tasks and improve the quality of information support for decision-making. At the same time, artificial intelligence is not viewed as a complete replacement for a medical specialist, but rather as a complementary technology (Topol, 2019). Davenport and Kalakota (2019) systematize the use of AI in several areas: diagnostics and treatment, patient engagement, and administrative processes. The latter group is of particular interest from a management perspective, as it includes automating routine procedures, processing documents, and analysing information needed for decision-making.

Rajkomar, Dean, and Kohane (2019) emphasise that machine learning algorithms can use electronic medical data to generate predictions, support diagnostics, and assist in treatment. However, this requires high-quality, representative data.

A systematic review by Ali et al. (2022), which included 180 studies, shows that AI affects both medical and administrative functions of the healthcare system. The authors identify diagnostics, treatment, counselling, monitoring, and information processing, while also highlighting problems of confidentiality, data integration, security, and regulation. A separate area of research is directly related to the management of human and organizational resources. Gonzalez-Garcia et al. (2024), in a systematic review, show that artificial intelligence can support resource management, risk assessment, decision-making, and the optimisation of administrative tasks. At the same time, implementation requires special training for managers and interaction between medical personnel and system developers.

The key question is not whether the algorithms produce positive experimental results, but whether the effect can be replicated in a real organisational environment. Wenderott et al. (2024) analyzed 48 studies on the real-world implementation of AI in medical imaging. Among studies that measured task completion time, about two-thirds reported a reduction; however, the authors' meta-analyses did not show a universally statistically significant effect across all process types. This indicates that outcomes depend heavily on the specific algorithm, infrastructure, and workflow organisation.

In studies on the responsible use of AI, the main focus is transparency, security, and the distribution of responsibility. The World Health Organisation considers the preservation of human autonomy, security, transparency, responsibility, inclusivity,

and sustainability as the basic principles of AI governance in healthcare (WHO, 2021).

Consequently, international literature is gradually shifting from the question “can an algorithm perform a medical task?” to “how should an algorithm be integrated into an organizational process so that its use truly enhances efficiency?”

It is this research gap that is most relevant for Kazakhstan. National scientific and analytical literature provides a fairly detailed examination of the digitalisation of healthcare, human resources, and organisational issues; however, a comprehensive assessment of AI specifically as a tool for managing the healthcare system remains significantly underrepresented.

This study proposes to view artificial intelligence as part of an integrated management loop: data → algorithmic analysis → decision support → management action → measurable outcome → risk control. This understanding makes it possible to separate technological effectiveness from organizational and economic efficiency.

Materials and methods. The empirical period of the study covers 2015–2025. The choice of a ten-year interval is обусловлен by the need to compare the state of the healthcare system before the active spread of integrated digital solutions with the stage of forming a modern data infrastructure and the beginning of the practical scaling up of AI.

The information base of the study consists of several groups of sources. The first group comprises official data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, including dynamic indicators of the number of doctors, the network of hospital organizations, and the activities of healthcare organizations.

The second group consists of official materials from the Ministry of Health of the Republic of Kazakhstan on the development of the E-Densaulyq digital ecosystem, electronic medical services, telemedicine, and AI use.

The third group includes strategic documents of the Republic of Kazakhstan, primarily the Concept for the Development of Artificial Intelligence for 2024–2029.

The fourth group includes international scientific publications and World Health Organisation recommendations.

The methodology includes dynamic analysis, which makes it possible to determine changes in the resource indicators of the healthcare system; comparative analysis, used when assessing regional differences; structural analysis of digitalization trends; content analysis of government documents; case analysis of practical AI solutions; and process analysis of the channels through which artificial intelligence influences management.

The following relationship represents the general analytical model of the study:

$$\text{HME} = f(\text{DATA}, \text{AI}, \text{HR}, \text{INFRA}, \text{FIN}, \text{GOV})$$

where
HME is the efficiency of healthcare system management;
DATA is the availability, quality, and integration of medical data;
AI - the degree of application of artificial intelligence;
HR - human resources and digital competencies;
INFRA - medical and digital infrastructure;
FIN - financial support;
GOV - the system of regulation, accountability, and organizational management.
It should be emphasized that the presented relationship is conceptual, not an estimated regression equation.

At the national level, there is no comparable annual indicator of the intensity of AI implementation for the entire period from 2015 to 2025. Building a regression in which changes in macro indicators of healthcare would be explained by artificial intelligence would lead to a methodologically unjustified causal interpretation.

Therefore, this article uses the principle of sequential proof: first, it assesses changes in the basic healthcare system, then the development of digital infrastructure, after which it analyses the AI solutions actually used and the channels of their potential impact on efficiency.

Results. Dynamics of the healthcare system’s resource base. During the period under consideration, there was a noticeable increase in personnel potential. In 2015, Kazakhstan had approximately 69,700 doctors. In 2020, the number of doctors of all specialties reached 76,443; in 2023 - 81,285; in 2024 - 83,379; and in 2025 - 83,994 (Bureau of National Statistics of the Republic of Kazakhstan, 2026).

Thus, over the decade, the number of doctors increased by approximately one-fifth. At the same time, the number of hospital organisations decreased from 901 to 832.

This ratio cannot be interpreted as a simple reduction in infrastructure. The change in the number of legally and organizationally separate hospital organisations may reflect network reorganisation, institutional mergers, the expansion of outpatient care, and shifts in service-delivery structures.

However, these dynamics highlight a change in the management task. As the human and informational scale of activities increases, the need is less for an extensive increase in the number of institutions than for greater productivity of existing infrastructure and higher-quality resource allocation.

Table 1 — Dynamics of the healthcare workforce in Kazakhstan, 2015–2025.

Indicator	2015	2020	2023	2024	2025	Change 2015–2025
Doctors of all specialties, people.	≈69 700	76 443	81 285	83 379	83 994	≈+20,5%
Number of hospital organizations, units	901	-	-	-	832	–7,7%
Note: compiled by the authors based on data from the Bureau of National Statistics of the Republic of Kazakhstan.						

A key factor is the heterogeneity of human resources potential across regions. Table 2 presents data by territory, allowing us to show differences in the scale of the healthcare system.

Official regional data show a significant gap in doctor availability. In 2024, the indicator in Astana was 68.9 doctors per 10,000 population, in Almaty, 64.1, while in the Zhambyl Region it was 29.9, in the Atyrau Region, 31.1, and in the Turkistan Region, 31.6 doctors per 10,000 population (National Statistics Bureau of the Republic of Kazakhstan, 2025).

These differences matter for setting priorities for AI implementation. For large cities, technologies for managing large patient flows, medical imaging, and complex multidisciplinary infrastructure are of particular value. In regions with lower density of medical personnel, telemedicine, remote interpretation of studies, and digital support for doctors may be more valuable. Therefore, the territorial strategy for implementing AI should not be fully standardized. It should account for morbidity patterns, staffing levels, distance to specialised centres, and digital infrastructure.

Table 2 — Dynamics of the number of doctors in selected regions of Kazakhstan, 2020–2024.

Region:	2020, people	2024, people	Change, %	Doctors per 10,000 population, 2024
Astana city	9 048	10 540	+16,5	68,9
Almaty city	13 450	14 681	+9,2	64,1
Aktobe region	4 104	4 522	+10,2	47,6
Atyrau region	2 026	2 211	+9,1	31,1
Zhambyl region	3 287	3 655	+11,2	29,9
Mangystau region	2 424	2 609	+7,6	32,4
North Kazakhstan region	1 694	1 705	+0,6	32,7
Turkistan region	5 883	6 806	+15,7	31,6
Shymkent city	4 600	5 614	+22,0	44,7
Note: the authors calculated the data using information from the Bureau of National Statistics of the Republic of Kazakhstan.				

The most significant change in recent years is related to the scale of digital medical services.

In 2025, Kazakhstan's healthcare system provided more than 215 million medical services, of which 190.8 million, or 88.6%, were delivered electronically. More than 8.5 million electronic medical certificates were issued to citizens, and 5.6 million people used online appointment booking with a doctor (Ministry of Health of the Republic of Kazakhstan, 2026).

Table 3 — Key indicators of the digital transformation of healthcare in Kazakhstan

Indicator	Value	Management significance
Medical services in 2025.	more than 215 million	scale of the operational data array
Services in electronic format	190.8 million	digital base for automated analysis
Share of electronic format	88.6%	high degree of digitalization of interactions
Issued electronic certificates	more than 8.5 million	reduction of paper-based processes
Online appointment users	5.6 million	data on demand and patient flows
Information systems integrated with E-Densaullyq	17	reduction of fragmentation
Target components of E-Densaullyq	6	unified data management architecture
Patients with personalized calculation of medication needs	3.5 million	foundation for predictive planning
Medical organizations in telemedicine pilots	147	expansion of remote forms of assistance
Note: compiled by the authors based on materials from the Ministry of Health of the Republic of Kazakhstan.		

E-Densaullyq envisages consolidating 17 existing information systems into six main components, with a Unified Medical Data Repository serving as the core of the architecture. As part of the digital transformation, 3.5 million patients were covered by personalised calculations of their medication needs, and 147 medical organisations participated in telemedicine pilots (Ministry of Health of the Republic of Kazakhstan, 2025).

This fundamentally changes the potential for using AI. If information is distributed across a large number of incompatible systems, the algorithm does not gain a holistic understanding of the patient or the activities of the medical organization. Data consolidation makes it possible to use not a single medical record, but a sequence of events: an encounter, an examination, a diagnosis, an appointment, medication provision, hospitalization, and the outcome.

From a management perspective, this means a transition from recording to monitoring, from monitoring to forecasting, and from forecasting to decision support. Practical application of artificial intelligence. By the end of the period under consideration, Kazakhstan began transitioning from piloting individual solutions to practical implementation. In the E-Densaullyq architecture, the Ministry of Health indicated the introduction of CEREBRA.AI and WDSOFT for the early detection of stroke and oncological diseases (Ministry of Health of the Republic of Kazakhstan, 2025).

To assess the emerging trend, data from early 2026 are also of interest. They are not included directly in the statistical analysis period of 2015–2025, but are used as a subsequent control point.

Table 4 — The scale of individual AI solutions in healthcare in Kazakhstan

Decision	Direction:	The scale recorded in 2026.	The main management channel:
CEREBRA	CT scan analysis for suspected stroke;	9 stroke centers in 5 regions	accelerated diagnostics and routing;
WDSOFT	analysis of radiological images;	190 medical organizations	standardization and accelerated interpretation;
AIDENTIS	dental imaging;	65 clinics and 3 medical universities	automation of image analysis;
ALIMA	AI assistant for healthcare professionals;	more than 700 polyclinics	information support for staff;
SmartЭКГ	early detection of heart failure.	direction of scaling	risk-based patient identification.

Note: the 2026 data is used as a reference point after the main study period.

In January 2026, the Ministry of Health reported that CEREBRA was used in 9 stroke centers across five regions, WDSOFT - in 190 medical organizations, AIDENTIS - in 65 dental clinics and three medical universities, and ALIMA - in more than 700 polyclinics (Ministry of Health of the Republic of Kazakhstan, 2026).

Later monitoring of specific projects makes it possible to assess individual operational results as well. According to the Ministry of Health, the use of CEREBRA was accompanied by an increase in the use of thrombolytic therapy, and the WDSOFT project reported a reduction in diagnostic time from 40 to 10 minutes. For AIDENTIS, a reduction in the time required to analyze individual dental images was noted. These results reflect the performance of specific projects and should not be automatically extrapolated to the entire healthcare system. It is precisely this caveat that has fundamental methodological significance. The local effectiveness of the algorithm and the effectiveness of the system are different levels of analysis. If the algorithm has reduced the time required to interpret a medical image, the systemic effect only occurs when the freed-up time is actually transformed into increased throughput, reduced waiting times, lower costs, or improved treatment outcomes. Main areas of managerial impact. Based on the analysis, six groups of managerial processes have been identified in which artificial intelligence has the greatest potential.

Table 5 — Channels through which AI affects healthcare management efficiency

Direction	AI functions:	Management outcome:	Recommended KPIs:
Patient flow	- forecasting of referrals and hospitalizations;	- reduced overload;	waiting time; queue; workload;
Human resources	- forecasting of workload and schedules;	- optimized use of personnel;	doctor's workload; overtime work;
Infrastructure	- forecasting of bed and equipment utilization;	- improved asset utilization;	bed turnover; equipment downtime;
Drug supply	- forecasting of demand, detection of anomalies;	- reduced shortages and losses;	availability of medications; write-offs; deviations;

Quality management	- identification of risks and atypical cases;	- early detection of problems;	complications; readmissions;
Decision support	- analysis of clinical and organizational data.	- reduced decision-making time.	turnaround time; route duration.
Note: developed by the authors.			

The presented classification shows that AI can influence efficiency not only through improved diagnostics. A broader organizational effect is potentially generated through the optimization of resource allocation. The author’s model of AI-driven healthcare management. Summarizing the results makes it possible to propose a consistent model for the transition of Kazakhstan’s healthcare system to intelligent management.

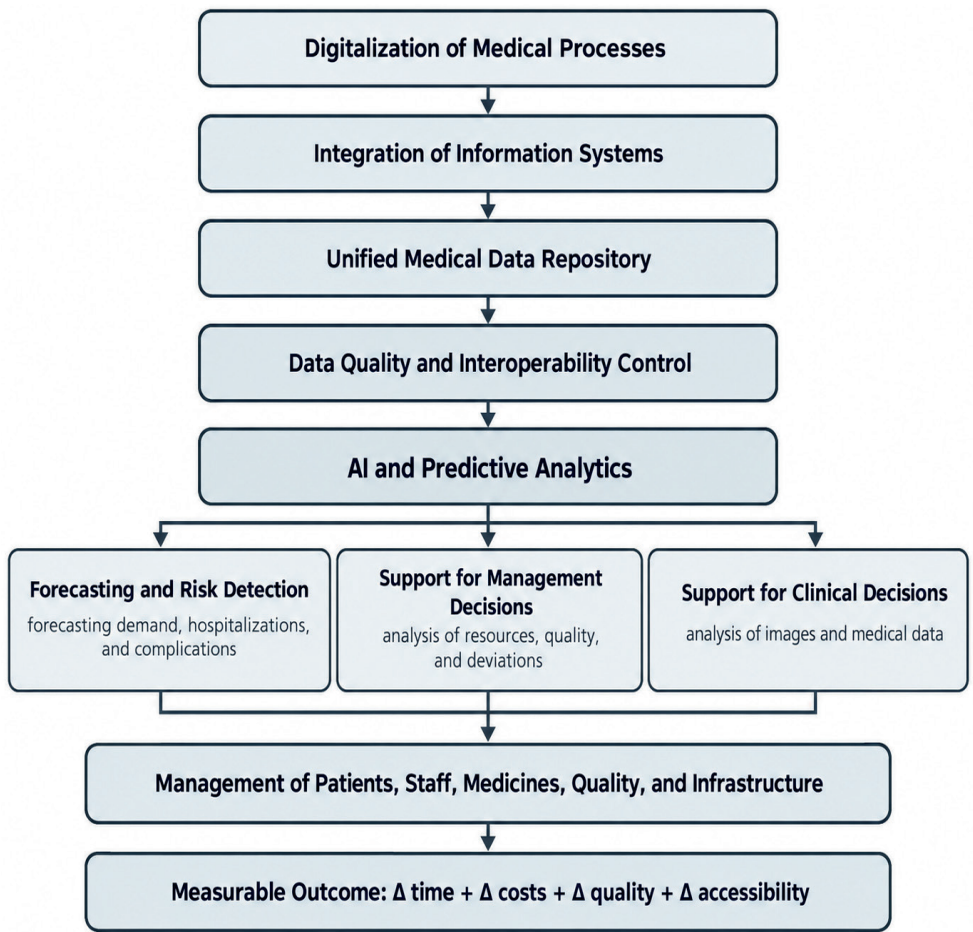


Figure 1 — A mechanism for improving the efficiency of healthcare system management based on artificial intelligence.

Note: developed by the authors.

The model stipulates that scaling should follow, rather than precede, the measurement of the result. For an analytical representation of efficiency, it is proposed to use the following relationship:

$$E_{AI} = f(\Delta T, \Delta C, \Delta Q, \Delta A, R),$$

where

E_{AI} is the integral effect of applying AI;

ΔT is the change in time costs;

ΔC is the change in financial and resource costs;

ΔQ is the change in the quality of medical care;

ΔA is the change in the accessibility of medical care;

R is clinical, informational, legal, and technological risks.

This formula represents the conceptual basis for subsequent empirical assessment. Its application requires the creation of a comparable baseline of indicators before and after the implementation of a specific AI solution.

Discussion. The results obtained confirm that the use of artificial intelligence in healthcare in Kazakhstan should be viewed not as an autonomous technological direction, but as the next stage of the industry's digital transformation. By 2025, the electronic format had covered 88.6% of medical services, and the volume of digital interactions had reached hundreds of millions of operations per year. This trend indicates the formation of a significant body of machine-readable data, without which the use of machine learning methods and predictive analytics across the healthcare system would be significantly limited (Ministry of Health of the Republic of Kazakhstan, 2026). At the same time, the mere increase in the volume of digital data does not guarantee its analytical value. For the use of artificial intelligence, the completeness, reliability, structure, standardization, and technological compatibility of information arrays are of fundamental importance.

In this context, the formation of the digital ecosystem E-Densaulyq and the Unified Medical Data Repository becomes particularly important. The integration of 17 previously fragmented information systems creates the prerequisites for a transition from local digital accounting to end-to-end analysis of medical and management processes (Ministry of Health of the Republic of Kazakhstan, 2025). It is precisely the consolidation of data that allows us to view medical care not as a set of isolated events, but as a sequence of interconnected stages - a patient's consultation, examination, diagnosis, prescription of treatment, provision of medications, hospitalization, and the subsequent outcome. From a management perspective, this forms the basis for moving from recording events to monitoring, forecasting, and decision support.

The study's results also show a change in the functional role of artificial intelligence. At the initial stage, Kazakhstani projects focused primarily on the analysis of medical images and diagnostic support, which aligns with the international

trajectory of medical AI development. Radiology, computed tomography, and other types of medical imaging are among the most mature areas of machine learning application, as they work with relatively standardized digital data and allow for fairly clear measurement of processing speed and accuracy.

However, modern projects demonstrate a gradual expansion of AI beyond narrow clinical tasks. The use of ALIMA in clinics, the development of intelligent services for detecting abnormalities, and decision-support systems indicate a shift towards administrative and organizational functions (Ministry of Health of the Republic of Kazakhstan, 2026). It is precisely this shift that is of fundamental importance for assessing systemic efficiency. Even a highly accurate diagnostic algorithm may have a limited impact on the overall performance indicators of the sector if it is applied in a single local process. On the contrary, algorithms for predicting patient flow, staff workload, the need for medications, or equipment usage potentially affect several management elements at once and can create a more pronounced organizational and economic effect.

This conclusion is consistent with the research by Davenport and Kalakota (2019), who consider administrative and organizational processes to be one of the key areas for using artificial intelligence in healthcare. Similarly, Gonzalez-Garcia et al. (2024) show that the potential of AI extends not only to clinical decisions but also to human resource management, risk assessment, and the optimization of administrative processes. Consequently, for Kazakhstan, a promising model is one in which artificial intelligence is integrated not into isolated functions but into the broader management framework of a medical organization.

At the same time, the results obtained confirm the need for a cautious interpretation of the claimed effectiveness of AI. The systematic review by Wenderott et al. (2024) shows that a significant portion of medical imaging projects demonstrate a reduction in the time required to complete individual operations; however, the magnitude of this effect varies considerably depending on the algorithm, infrastructure, and workflow organization. This means that technological performance alone is not a sufficient basis for concluding economic or systemic efficiency.

In practical terms, the assessment of each AI solution should include several interrelated questions: what change occurred directly in the workflow; how stable the resulting effect is; what direct and indirect costs are associated with the implementation; whether the result is maintained when scaling up; and whether new clinical, informational, organizational, or legal risks arise. This approach is especially important for healthcare systems, where a technological error can have not only economic but also direct medical consequences.

In this regard, the AI efficiency assessment model proposed in the study should be interpreted as a multi-criteria system that combines time-related, financial, qualitative, and accessibility effects, taking risks into account. In an applied version, the integral efficiency can be represented as follows:

$$E_{AI} = w_Q \Delta Q + w_A \Delta A - w_T \Delta T - w_C \Delta C - w_R R$$

were

E_{AI} is the integral efficiency of using artificial intelligence;

ΔQ is the change in the quality of medical care;

ΔA is the change in accessibility;

ΔT is the change in time costs;

ΔC is the change in financial and resource costs;

R is the total level of clinical, information, legal, and technological risks;

w_i are the weighting coefficients of the corresponding components. At the same time, the sum of the weights must be equal to one. This form allows for a transition from a descriptive assessment of implementation to a formalized comparison of results and costs.

Regional analysis complements this conclusion. Significant differences in the availability of doctors between the largest cities and individual regions of Kazakhstan mean that a single model for implementing AI across all territories may not be sufficiently effective. In regions with lower availability of individual specialists, telemedicine, centralized image interpretation, digital support for doctors, and intelligent patient routing may be of the greatest practical value. In large agglomerations, by contrast, optimizing high-volume flows, managing queues, forecasting equipment utilization, and distributing the workload among medical organizations become more important.

Consequently, the regional strategy for implementing artificial intelligence should be developed in a differentiated manner and take into account not only the availability of technical infrastructure but also staffing levels, the territorial accessibility of specialized care, the structure of morbidity, and the scale of medical flows. In this case, AI should be viewed not as a replacement for medical infrastructure but as a tool for more efficient use of existing resources.

A key condition for effectiveness remains the preservation of the human-in-the-loop principle. In this approach, artificial intelligence forms an additional analytical layer, while the final decision and professional responsibility remain with the medical worker or manager. This principle aligns with the recommendations of the World Health Organization, which emphasizes the need to preserve human autonomy, safety, transparency, accountability, and controllability when using AI in healthcare (WHO, 2021).

For Kazakhstan, this is especially relevant at the stage of scaling up digital solutions. Full automation of clinical or management decisions without a mechanism for professional verification may increase the risk of incorrect data interpretation, algorithmic error, or bias. Therefore, AI governance should include procedures for quality control of the model, periodic validation of results, recording of erroneous decisions, and the possibility of human review.

Organizational competencies require special attention. The introduction of

artificial intelligence changes the requirements not only for a doctor but also for the head of a medical organization. The manager needs to assess the quality of the initial data, select relevant KPIs, compare the cost of the solution with the expected effect, analyze the changes in processes after implementation, take into account the risks of algorithmic errors, and organize staff training. Otherwise, a technically sound system may not translate into a real increase in efficiency.

In this regard, it is advisable to accompany the introduction of AI with the mandatory formation of an initial database of indicators before the project begins. For medical image analysis systems, such indicators may include the average time required to interpret a study, the duration of waiting for a conclusion, the number of studies per specialist, the frequency of revision of conclusions, the cost of processing a single study, and indicators of diagnostic effectiveness. For patient flow management systems, it is advisable to record the average waiting time, the proportion of no-shows, the workload on the doctor, the occupancy rate of the rooms, and the number of patients served. For drug supply systems, these indicators may include the accuracy of demand forecasting, the number of shortage cases, the volume of write-offs, the level of inventory, and the frequency of unjustified prescriptions. Only by comparing the indicators “before” and “after” the implementation can we separate the real technological effect from the subjective perception of the system’s usefulness.

An important result of the study is also the identification of methodological limitations of the existing statistical base. At the national level, there is no comparable time series on the intensity of artificial intelligence use in healthcare organizations for 2015–2025. Open data on individual projects mainly characterize the scale of implementation and individual operational indicators, but rarely contain a full set of financial, organizational, and clinical parameters. Furthermore, technologies are advancing so rapidly that the level of their adoption in 2026 already differs noticeably from the situation at the end of the main period under study. For this reason, the data from 2026 are reasonably used in this work as a reference point characterizing the direction of further development, rather than as an element of the main dynamic series.

The specified limitations simultaneously determine the future directions of applied policy and research. The primary task is to complete the integration of key medical information datasets and to unify technical standards. The next stage should be the development of a national system of indicators for the use of artificial intelligence, including information about the type of algorithm used, the number of processed cases, time savings, changes in costs, the quality and accessibility of medical care, as well as the level of risks.

Independent clinical and economic assessment of pilot projects prior to their scaling up is of particular importance. The expansion of application should not be based solely on the fact of technological novelty or a local positive result, but on the presence of a reproducible effect in a real organizational environment. In the future,

indicators of AI usage can be integrated into national healthcare monitoring panels, which will make it possible to move from assessing the number of implemented digital solutions to assessing the management effect they create.

Thus, the discussion of the results shows that the strategic value of artificial intelligence for Kazakhstan's healthcare system is determined not by the number of implemented algorithms, but by the depth of their integration into data, organizational processes, and the system of management decisions. The most обоснованным approach is to transition from the "AI as a separate digital product" model to the "AI as an element of the management loop" model, in which the technology is assessed through measurable changes in time, costs, quality, and accessibility of medical care, with mandatory risk control and the preservation of human responsibility.

Conclusion. The conducted study confirms that artificial intelligence can become a significant tool for improving the efficiency of managing Kazakhstan's healthcare system. At the same time, the obtained results show that its role should not be considered in isolation, but as the next stage of digital transformation.

Between 2015 and 2025, the number of doctors in the country increased by approximately 20.5% and reached 83,994 people. In 2025, there were 832 hospital organizations (Bureau of National Statistics of the Republic of Kazakhstan, 2026).

At the same time, the digital component of the industry expanded significantly. More than 215 million medical services were provided in 2025, with 190.8 million of them delivered in electronic format. 8.5 million electronic certificates and 5.6 million online records reflect the transition of digital medical solutions from the experimental stage to everyday practice (Ministry of Health of the Republic of Kazakhstan, 2026).

The formation of E-Densaulyq and the Unified Medical Data Repository is a crucial infrastructure prerequisite for the next stage of development. It is the integration of data that makes it possible to use AI not only for a specific diagnostic task, but also for managing resources and the quality of medical care.

The practice of using CEREBRA, WDSOFT, AIDENTIS, and ALIMA indicates a gradual expansion of the functional scope of AI - from the analysis of medical images to supporting the activities of medical personnel and monitoring processes.

The most promising management areas are patient flow forecasting, planning of human and infrastructure resources, drug supply, quality control, anomaly detection, and decision-support.

At the same time, the study does not confirm the possibility of directly attributing changes in macro indicators of healthcare to the implementation of AI. The duration of the widespread use of technologies is still insufficient, and there is no unified statistical system for measuring the intensity of AI use.

In this regard, a priority area for further research should be the creation of a database at the level of medical organizations, with the recording of indicators before and after the implementation of the technology. Such a database will make

it possible to use quasi-experimental, panel, and econometric methods to assess the causal impact of AI.

The model proposed by the authors предполагает a transition from digitalization to data integration, from integration to analytics, from analytics to artificial intelligence, and from AI to a measurable management outcome.

Thus, the strategic value of artificial intelligence for Kazakhstan lies not in the maximum number of implemented algorithms, but in creating a system in which technologies ensure a measurable improvement in the quality, accessibility, and efficiency of medical care while maintaining human control and a manageable level of risk.

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