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CORRELATION ANALYSIS OF KEY HEALTH INDICATORS IN KAZAKHSTAN (2015-2024) IN THE CONTEXT OF STRATEGIC MANAGEMENT AND ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT GOALS

Modern healthcare in Kazakhstan is characterized by a high dynamism of socio-demographic and epidemiological processes, a significant increase in chronic diseases, regional disparities in access to medical services, as well as limited financial and human resources. Under these conditions, traditional management methods become insufficiently effective, which threatens the sustainable functioning of the system and the achievement of national and global health goals. Considering the integration of the Sustainable Development Goals (SDGs) into the state strategy, there arises a need to develop scientifically grounded models of strategic management capable of ensuring comprehensive, long-term planning and forecasting of the sector's development.

The relevance of this study is determined by the necessity for quantitative identification of inter-dependencies among key healthcare indicators to form tools for evaluating and optimizing managerial decisions. This creates a foundation for enhancing system resilience and minimizing risks associated with internal and external shocks.

The purpose of this study is to develop a methodological and analytical toolkit for the quantitative identification of relationships among key healthcare indicators and for the formalization of a multilevel management model for the sector based on the principles of sustainable development and the strategic orientations of the SDGs.

The methodological framework is based on a system-structural approach, methods of correlation and regression analysis, as well as scenario modeling. The empirical base was formed from the official statistics of the Ministry of Health of the Republic of Kazakhstan for 2010–2024, integrated with data from the WHO and the World Bank. A multilevel analytical framework was applied to identify cause-and-effect relationships and to construct predictive models, allowing for a quantitative assessment of the system's resilience and its adaptability to external shocks.

The results reveal statistically significant relationships between demographic, epidemiological, and socio-economic indicators, which made it possible to identify the key drivers of healthcare resilience. A conceptual multilevel model of strategic management has been developed, including strategic, institutional, and operational levels, ensuring the integration of planning, resource allocation, and performance evaluation of managerial decisions.

The uniqueness of the study lies in its comprehensive and interdisciplinary approach. For the first time within the national context, a quantitative analysis of inter-indicator dependencies is combined with multilevel strategic healthcare management. The developed model provides a tool for scientifically grounded forecasting and optimization of systemic processes, enhancing the adaptability and sustainability of the sector to internal and external challenges.

Keywords: healthcare, sustainable development, indicators of sustainable development in healthcare, ecology, social aspect.

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**Стратегиялық басқару және тұрақты даму мақсаттарына
қол жеткізу контекстіндегі Қазақстан денсаулық сақтауының
негізгі көрсеткіштерін корреляциялық талдау (2015-2024 жж.)**

Қазақстанның қазіргі денсаулық сақтау жүйесі әлеуметтік-демографиялық және эпидемиологиялық үдерістердің жоғары қарқынымен, созылмалы аурулардың айтарлықтай өсуімен, медициналық қызметтерге қолжетімділіктегі өңірлік теңсіздікпен, сондай-ақ қаржылық

кадрлық ресурстардың шектеулілігімен сипатталады. Осындай жағдайда басқарудың дәстүрлі тәсілдері жеткіліксіз тиімді болып, жүйенің тұрақты жұмыс істеуіне және денсаулық сақтаудың ұлттық әрі жаһандық мақсаттарына қол жеткізуге қауіп төндіреді.

Тұрақты даму мақсаттарының (ТДМ) мемлекеттік стратегияға интеграциялануын ескере отырып, саланың дамуын кешенді, ұзақ мерзімді жоспарлау мен болжауды қамтамасыз ете алатын ғылыми негізделген стратегиялық басқару үлгілерін әзірлеу қажеттілігі туындап отыр.

Зерттеудің өзектілігі – денсаулық сақтаудың негізгі көрсеткіштерінің өзара тәуелділігін сандық тұрғыда анықтау, басқару шешімдерін бағалау мен оңтайландыру тетіктерін қалыптастыру қажеттілігімен айқындалады. Бұл өз кезегінде жүйенің тұрақтылығын арттыруға және ішкі әрі сыртқы күйзелістерге байланысты тәуекелдерді азайтуға негіз қалайды.

Зерттеудің мақсаты – денсаулық сақтау саласындағы негізгі көрсеткіштердің өзара байланысын сандық анықтауға арналған әдіснамалық және аналитикалық құралдарды әзірлеу, сондай-ақ тұрақты даму қағидаттары мен ТДМ стратегиялық бағдарлары негізінде саланы басқарудың көпдеңгейлі моделін қалыптастыру.

Әдіснамалық негіз жүйелік-құрылымдық тәсілді, корреляциялық және регрессиялық талдау әдістерін, сондай-ақ сценарийлік модельдеуді қамтиды. Эмпирикалық база 2010–2024 жылдар аралығындағы Қазақстан Республикасы Денсаулық сақтау министрлігінің ресми статистикасы негізінде, Дүниежүзілік денсаулық сақтау ұйымы (ДДҰ) мен Дүниежүзілік банк деректерімен біріктіріліп жасалды. Себеп-салдарлық байланыстарды анықтау және болжамдық модельдер құру мақсатында көпдеңгейлі аналитикалық құрылым қолданылды, бұл жүйенің тұрақтылығын және сыртқы күйзелістерге бейімделу қабілетін сандық тұрғыда бағалауға мүмкіндік берді.

Нәтижелер демографиялық, эпидемиологиялық және әлеуметтік-экономикалық көрсеткіштер арасындағы статистикалық тұрғыдан маңызды өзара байланыстарды анықтады. Бұл денсаулық сақтау жүйесінің тұрақтылығының негізгі драйверлерін белгілеуге мүмкіндік берді. Жоспарлауды, ресурстық қамтамасыз етуді және қабылданған шешімдердің тиімділігін бағалауды біріктіретін стратегиялық, институционалдық және операциялық деңгейлерден тұратын стратегиялық басқарудың тұжырымдамалық көпдеңгейлі моделі әзірленді.

Зерттеудің бірегейлігі – оның кешенді және пәнаралық сипатында. Қазақстандық контекст аясында алғаш рет көрсеткіштер арасындағы сандық өзара тәуелділік талдауы денсаулық сақтауды көпдеңгейлі стратегиялық басқару тәсілімен біріктірілді. Ұсынылған модель жүйелік процестерді ғылыми негізделген болжау мен оңтайландыру құралы ретінде қызмет етіп, саланың ішкі және сыртқы сын-қатерлерге бейімделгіштігі мен тұрақтылығын арттыруға мүмкіндік береді.

Түйін сөздер: денсаулық сақтау, тұрақты даму, денсаулық сақтаудағы тұрақты даму көрсеткіштері, экология, әлеуметтік аспектілер.

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Корреляционный анализ ключевых показателей здравоохранения Казахстана (2015–2024 гг.) в контексте стратегического управления и достижения целей устойчивого развития

Современное здравоохранение Казахстана характеризуется высокой динамикой социально-демографических и эпидемиологических процессов, значительным ростом хронических заболеваний, региональной неравномерностью доступа к медицинским услугам, а также ограниченностью финансовых и кадровых ресурсов. В этих условиях традиционные методы управления становятся недостаточно эффективными, что ставит под угрозу устойчивое функционирование системы и достижение национальных и глобальных целей в сфере здравоохранения. Учитывая интеграцию Целей устойчивого развития (ЦУР) в государственную стратегию, появляется потребность в разработке научно обоснованных моделей стратегического управления, способных обеспечить комплексное, долгосрочное планирование и прогнозирование развития отрасли. Особая актуальность исследования обусловлена необходимостью количественной идентификации взаимозависимостей ключевых показателей здравоохранения для формирования инструментов оценки и оптимизации управленческих решений, что создаёт основу для повышения устойчивости системы и минимизации рисков, связанных с внутренними и внешними шоками.

Цель данного исследования – разработать методологический и аналитический инструментарий для количественной идентификации взаимосвязей ключевых показателей здравоохранения и формализации многоуровневой модели управления отраслью на основе принципов устойчивого развития и стратегических ориентиров ЦУР.

Методологическая основа опирается на системно-структурный подход, методы корреляционного и регрессионного анализа, а также сценарного моделирования. Эмпирическая база сформирована из официальной статистики Министерства здравоохранения РК за 2010–2024 гг., интегрированной с данными WHO и World Bank. Применён многоуровневый аналитический фреймворк для выявления причинно-следственных связей и построения прогностических моделей, позволяющий количественно оценить устойчивость системы и её адаптивность к внешним шокам.

Результаты выделяют статистически значимые зависимости между демографическими, эпидемиологическими и социально-экономическими показателями, что позволило определить ключевые драйверы устойчивости здравоохранения. Разработана концептуальная многоуровневая модель стратегического управления, включающая стратегический, институциональный и операционный уровни, обеспечивающая интеграцию планирования, ресурсного обеспечения и оценки эффективности принимаемых решений.

Уникальность исследования заключается в его комплексном и междисциплинарном подходе. Впервые в рамках отечественного контекста объединены количественный анализ межпоказательных взаимозависимостей с многоуровневым стратегическим управлением здравоохранением. Разработанная модель предоставляет инструмент научно обоснованного прогнозирования и оптимизации системных процессов, повышая адаптивность и устойчивость отрасли к внутренним и внешним вызовам.

Ключевые слова: здравоохранение, устойчивое развитие, индикаторы устойчивого развития в здравоохранении, экология, социальный аспект.

Introduction

Sustainable development in the healthcare sector is increasingly recognized as a critical factor in ensuring social stability, national security, and the economic resilience of the state. According to international studies (WHO, 2023; UNDP, 2022; Sachs et al., 2019), population health is directly correlated with human capital, labor productivity, and socio-economic development. Simultaneously, global challenges—including demographic shifts, the rising burden of chronic and non-communicable diseases, epidemiological risks, and the consequences of climate change—necessitate the systematic integration of the Sustainable Development Goals (SDGs) into national healthcare strategies (UN, 2020; WHO, 2021).

In the Republic of Kazakhstan, the integration of SDGs into healthcare policy is shaped by specific national conditions, such as territorial disparities in infrastructure, regional differences in medical workforce availability, financing peculiarities, and the influence of socio-economic factors on population health (Stat.gov.kz, 2024; UN Kazakhstan, 2023). The implementation of a comprehensive monitoring system for key SDG indicators enables the evaluation of the efficiency of state investments and the identification of systemic sectoral challenges.

An analysis of health indicators over the period 2015–2024 demonstrates both significant achievements and persisting challenges. The overall mortality rate decreased from 6.8‰ in 2015 to 6.1‰ in 2024; maternal mortality declined from 21.5 to

14.3 per 100,000 live births; child mortality dropped from 15.7 to 9.8 per 1,000 live births; and life expectancy increased from 71.9 to 74.6 years. At the same time, public healthcare expenditure rose from 3.6% of GDP in 2015 to 4.0% in 2024, with substantial regional differentiation affecting equitable access to quality medical services (Ministry of Health of the Republic of Kazakhstan, 2024; Bureau of National Statistics, 2024).

The methodological framework of this study includes intertemporal statistical analysis, correlation and regression analysis of key indicators, as well as the construction of integrated healthcare sustainability indices. This approach enables the identification of systemic interconnections among economic, demographic, and medical parameters, the assessment of the effectiveness of national and regional strategies, and the formulation of targeted recommendations for achieving SDGs in healthcare (Sachs et al., 2020; WHO, 2023; UNDP, 2022).

The scientific significance of the study lies in formalizing approaches for assessing healthcare sustainability while accounting for complex factors affecting population health, as well as in developing a methodological basis for integrated monitoring and forecasting of key indicators. Its practical relevance is reflected in the potential application of the results for optimizing budget planning, enhancing institutional coordination, and implementing innovative healthcare management models at both national and regional levels.

Visualization of the interconnections among economic, demographic, and medical factors

through graphical models of integrated SDG indices provides a clear demonstration of which healthcare system components are critical for sustainable development and require priority funding and management decisions. For example, correlation analysis indicates that a 1% increase in public investment as a share of GDP is associated with a 0.15-year increase in life expectancy and a 0.7% reduction in child mortality, underscoring the effectiveness of strategic budgetary decisions (Junusbekova et al., 2023; Aimyshev et al., 2025; Ministry of Health of the Republic of Kazakhstan, 2024).

In summary, this research covers the period 2015–2024, combining intertemporal statistical analysis, econometric modeling, and institutional assessment to provide a comprehensive picture of healthcare sustainability in Kazakhstan. The study establishes both a theoretical foundation for future research and practical recommendations for optimizing healthcare management and implementing SDGs at the national and regional levels.

Literature Review

An analysis of the contemporary academic literature demonstrates that the issue of sustainable development in healthcare is gradually moving from declarative discourse toward comprehensive interdisciplinary research aimed at identifying systemic solutions. During the period 2015–2024, the international research landscape has undergone a significant shift in understanding healthcare sustainability—from assessing the efficiency of individual programs to developing a broader concept of institutional and financial resilience based on principles of adaptability, inclusiveness, and ESG-oriented governance (Kruk et al., 2021; Blanchet et al., 2022; WHO, 2023).

Recent studies increasingly interpret healthcare sustainability not as a static condition but as a dynamic capacity of the system to withstand crises and recover with improved governance quality. Kruk et al. (2021) define a resilient health system as one that maintains functionality during external shocks while ensuring equitable access to medical services. Blanchet et al. (2022) extend this concept by emphasizing the roles of civil society engagement, institutional transparency, and effective state regulation. Research by Kim et al. (2023) highlights the growing adoption of ESG indicators and Sustainable Development Goal (SDG) metrics in evaluating healthcare performance, which is particularly relevant for transition economies, including Kazakhstan.

Empirical studies conducted by the World Health Organization (WHO, 2023) and the Global Burden of Disease (GBD, 2023) indicate that financial sustainability in healthcare is closely linked to social and environmental development parameters. In transition economies such as Kazakhstan, increases in public health expenditure correlate with lower mortality rates and higher life expectancy. However, significant regional disparities persist: according to Junusbekova et al. (2023), mortality from cardiovascular diseases in some Kazakhstani regions remains above the national average, reflecting structural imbalances in resource allocation and healthcare accessibility.

In the Kazakhstani academic discourse, sustainability issues in healthcare have primarily been explored within the frameworks of mandatory health insurance reform, public financing efficiency, and the digital transformation of the sector. Studies by Grazhevskaya, Tyngisheva, Kulzhanov, and Akanov provide valuable insights into key reform directions, yet they insufficiently address institutional resilience and do not incorporate international ESG models or SDG-based evaluation methodologies into the national healthcare context.

Official documents—such as the National Health Accounts (2015–2024), statistical bulletins of the Bureau of National Statistics, and reports of the United Nations Development Programme—offer extensive empirical data for analysis. However, they lack comprehensive interpretation through the lens of sustainability. National policy documents tend to emphasize macroeconomic and staffing aspects while underrepresenting sustainability as an integrative category that encompasses social equity, service quality, and institutional coordination.

The conducted literature analysis reveals several key research gaps. First, there is a lack of quantitative and modeling studies examining the relationship between healthcare financing, performance, and resilience. Second, there are no regional sustainability indices that could help identify disparities and evaluate the impact of managerial decisions at the oblast level. Third, the ESG approach as a tool for assessing healthcare sustainability remains virtually unutilized in Kazakhstan, despite international evidence of its effectiveness in integrating environmental, social, and governance factors into a unified analytical framework.

Overall, the literature of 2015–2024 reflects a global transition toward a systemic, interdisciplinary, and data-driven understanding of healthcare sustainability. However, within the national con-

text of Kazakhstan, this issue remains insufficiently studied. This highlights the need to develop methodological foundations and empirical tools for assessing healthcare sustainability, aligned with the Sustainable Development Goals and aimed at enhancing the effectiveness of national healthcare policy.

Methodology

This study aims to systematically analyze the relationships between key indicators of the health status of the population of the Republic of Kazakhstan for 2015–2024 and assess their impact on the sustainability of the national healthcare system in the context of the implementation of SDGs 3, 5, and 10. Official statistical data from the Ministry of Health of the Republic of Kazakhstan and the Bureau of National Statistics, as well as international sources, including World Health Statistics 2023 (WHO, 2023), Human Development Report 2022 (UNDP, 2022), and studies by Kruk et al. (2021) and Blanchet et al. (2022), were used as initial data.

Correlation analysis using Pearson's rho coefficient was used to identify linear relationships between demographic and epidemiological indicators. Statistical significance was assessed at $p < 0.05$. Graphical visualization of correlation structures allowed us to clearly identify both strong positive and negative relationships. The integration of multidisciplinary data provided a comprehensive assessment of the health care situation and the identification of interdependencies that have practical implications for strategic planning and management.

Results and Discussion

The objectives of sustainable development cover a wide range of areas, including ensuring stable economic growth, increasing the population, improving

living standards, access to quality healthcare, education, environmental safety, and other aspects.

Achieving sustainable development requires the adoption and consistent implementation of socio-economic and environmental policies at the state level. In this context, key indicators of public health – including mortality and fertility rates, morbidity levels, deaths from major causes such as cardiovascular and oncological diseases, average life expectancy, as well as maternal and infant mortality – remain under the constant supervision of governmental institutions.

A comprehensive analysis of these indicators enables the identification of pressing medical and social challenges and supports the design of effective strategies for advancing the healthcare system. Despite notable progress achieved globally in the implementation of the Millennium Development Goals, additional efforts are still required to ensure their full realization.

The analysis of the dynamics of the indicators presented in Figures 1–9 provides a comprehensive assessment of Kazakhstan's progress toward achieving Sustainable Development Goal (SDG) 3 – Good Health and Well-Being – and its interlinkages with SDG 1 (No Poverty), SDG 5 (Gender Equality), and SDG 10 (Reduced Inequalities). Unlike a purely descriptive approach, this study seeks to identify not only statistical trends but also the causal relationships among demographic, socio-economic, and healthcare indicators that determine the sustainability and resilience of the national health system.

The World Health Organization (WHO) emphasizes that life expectancy at birth represents one of the most crucial measures of the socio-economic and demographic well-being of a population. This metric serves as an important benchmark not only for evaluating the performance of national healthcare systems but also for understanding the broader developmental dynamics of society (Figure 1).

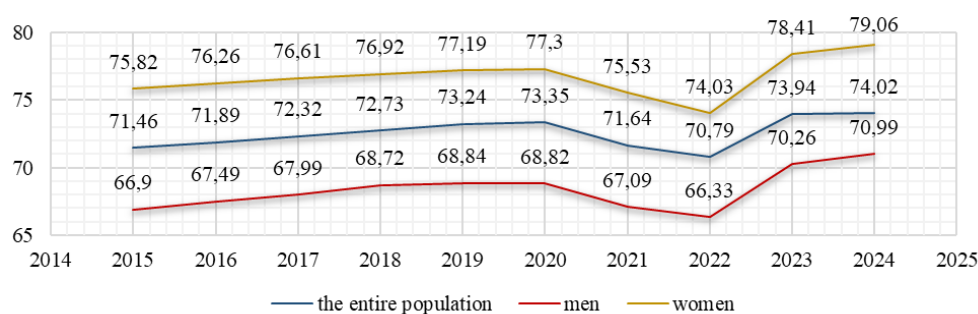


Figure 1 – Life expectancy at birth for 2015–2024

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

As Figure 1 shows, the dynamics of life expectancy in Kazakhstan from 2015 to 2024 are characterized by instability. In 2015–2016, the indicator grew by 1.7%, indicating positive results in healthcare. However, in 2017–2020, the growth rate slowed to 0.6% per year. By 2021, life expectancy had decreased to the 2015 level (75 years), due to the consequences of the COVID-19 pandemic and its socioeconomic impact.

On a positive note, the gender gap in life expectancy is gradually narrowing, indicating a more balanced approach to improving health and social measures.

Despite the overall improvement, the difference in life expectancy between men and women in Kazakhstan remains significant compared to developed countries, reflecting persistent structural health problems and uneven preventive measures. Overall, between 2015 and 2024, the overall mortality rate decreased from 7.98 to 6.77 per 1,000 people, confirming the effectiveness of government programs aimed at increasing access to medical care and in-

roducing modern treatment technologies. However, circulatory diseases remain the leading cause of death (22.7%, or 1.54 cases per 1,000 population), primarily due to ischemic heart disease and cerebrovascular accidents.

Mortality from neoplasms ranks second (10.3%), of which 0.68 per 1,000 are malignant. Respiratory diseases rank third (9.8%). Over the past decade, mortality from circulatory diseases has decreased by 25.6%, and from cancer by 30.9%, reflecting advances in prevention and early diagnosis. Positive results have also been noted in the fight against tuberculosis: the mortality rate decreased from 0.05 to 0.01 per 1,000 population (-75%). However, the COVID-19 pandemic in 2021–2022 disrupted this trend: the overall mortality rate temporarily increased by 19.3%, primarily due to an increase in deaths from respiratory diseases (by 82.8% in 2021 and by a further 62% in 2022), highlighting the need to strengthen public health measures and system preparedness for epidemiological risks (Figure 2).

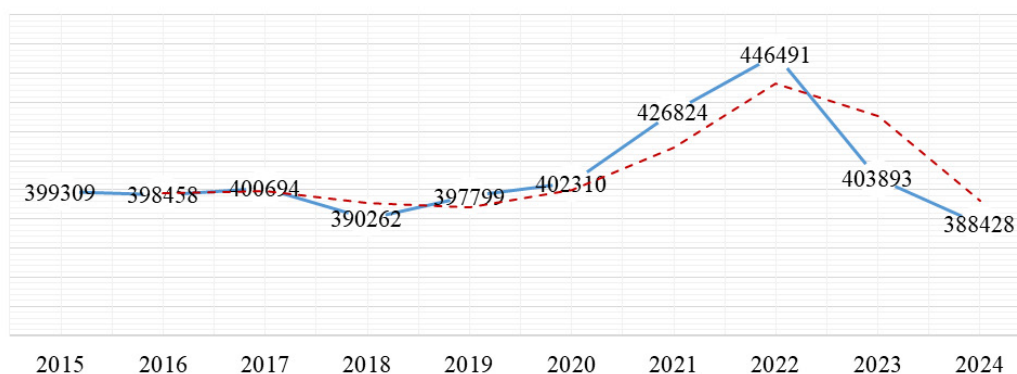


Figure 2 – Birth dynamics by year

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

In 2024, 388,400 births were registered in Kazakhstan, which is 15,400 fewer than in 2023. Of these births, 51.6% were boys and 48.4% were girls. Fifty-nine percent of children were born in urban areas, and 41% in rural areas. The total fertility rate was 19.52 per 1,000 people, a decrease compared to the previous year (20.57). The highest rates were traditionally recorded in the Mangystau (26.74%) and Turkestan (26.18%) regions and in Shymkent (25.70%), reflecting the stable regional concentration of demographic potential in the south of the country. The age structure of fertility shows that

women aged 25–29 (29%) and 30–34 (26%) make the greatest contribution to population reproduction, while the average maternal age has reached 29.7 years. The total fertility rate (TFR) in 2024 was 2.96, compared to 3.05 in 2023. However, differences between urban and rural areas remain: in urban areas, the TFR is 2.63, while in rural areas it is 3.59. The highest values are recorded in the Turkestan (4.39) and Mangystau (3.99) regions, while the lowest are in the North Kazakhstan region (1.82).

Approximately 23% of all children were second in the family (90,700 births), and more than a

thousand cases were eighth children. Multiple births included 4,075 twins, 48 triplets, and one quadruplet. These data reflect a continuing trend toward a gradual decline in fertility, coupled with changes in family behavior patterns.

The decline in fertility rates, coupled with persistent regional differences, highlights the need for a comprehensive approach to implementing SDG 3 (“Good health and well-being”), which is closely linked to SDG 1 (“No poverty”), SDG 5 (“Gender equality”), and SDG 10 (“Reduced inequalities”). In regions with high fertility rates, women’s access to education and employment opportunities remains limited, reducing the effectiveness of gender equal-

ity and social inclusion programs. At the same time, in more economically developed regions with lower fertility rates, demographic aging is occurring, requiring adaptation of social and healthcare infrastructure.

Despite the positive trend in ensuring access to reproductive health services, challenges remain, particularly in remote regions. In 2024, the proportion of births attended by skilled health personnel increased by only 0.3 percentage points compared to 2014, indicating the need to accelerate progress towards SDG indicators 3.7 and 3.8 related to reproductive health and universal health coverage (Figure 3).

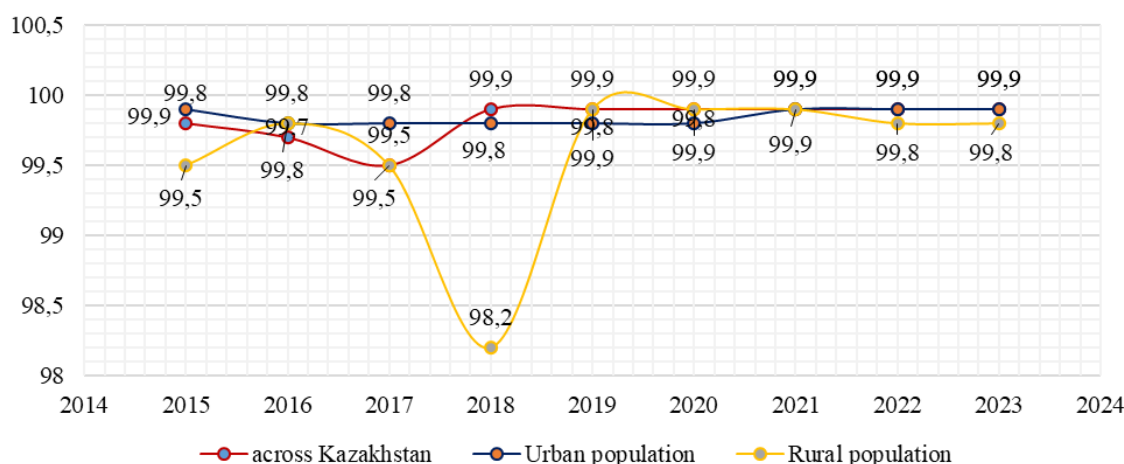


Figure 3 – The proportion of births attended by qualified medical professionals

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

In Kazakhstan, 99.8% of births in 2024 were attended by skilled medical personnel, demonstrating a high level of institutional coverage of obstetric care and meeting SDG target indicator 3.1.2. The overwhelming majority of births occurred in public health facilities, confirming the continued priority role of the public sector in ensuring reproductive health.

Over 90% of births were attended by obstetricians and gynecologists, while 9.8% were attended by mid-level medical personnel—midwives and nurses. This distribution indicates an adequate level of staffing in the obstetric care system but also highlights the need to expand the practice of decentralized forms of obstetric care in rural areas.

Approximately 14.8% of births were completed by cesarean section, with 9.6% of these procedures

performed by prior decision and 5.3% for indications that arose during labor. This structure demonstrates the gradual implementation of personalized approaches to choosing the method of delivery and increases the relevance of monitoring the medical and ethical aspects of surgical interventions in obstetrics.

Despite positive trends in obstetric care, progress in reducing maternal mortality remains limited. A slight decrease in this indicator indicates the need for systemic measures to strengthen primary healthcare, improve the quality of antenatal care, and develop preventive reproductive health programs.

Stability in access to skilled obstetric care is directly linked to the achievement of not only SDG 3 (“Good health and well-being”), but also SDG

5 (“Gender equality”) and SDG 10 (“Reduced inequalities”). Guaranteed access for women to safe childbirth and quality reproductive health services is

a key factor in social justice, contributes to strengthening institutional resilience, and reduces regional disparities in population health (Figure 4).

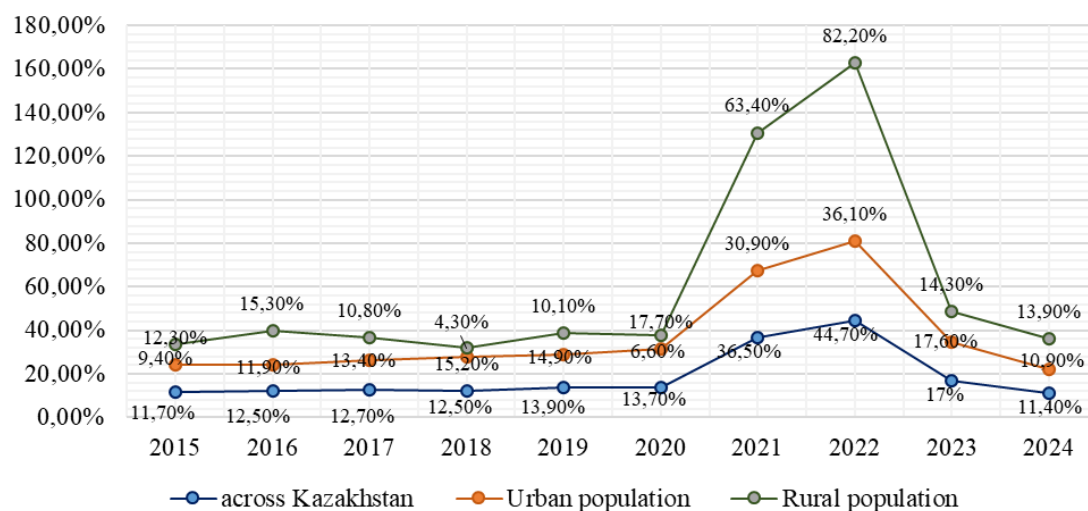


Figure 4 – Maternal mortality rate for 2015-2024

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

The structure of causes of maternal mortality remains relatively stable: complications of pregnancy and childbirth account for over 70% of cases, abortion complications account for approximately 25%, and ectopic pregnancy accounts for approximately 5%. Cardiovascular diseases predominate among extragenital factors, indicating the need to integrate preventive cardiac programs into maternal health policies.

Despite the progress achieved, further reduction in maternal mortality is constrained by a number of factors—organizational, personnel, sociodemographic, and behavioral. Insufficient interagency coordination and low public awareness of risks are observed, which are slowing the achievement of SDG 3 targets. If current trends continue, the rate of decline may be no more than 1.5–2% per year, limiting the possibility of achieving significant results in the short term.

At the same time, in the context of implementing target 3.2 of Sustainable Development Goal 3 (SDG 3), aimed at reducing preventable deaths of newborns and children under five, Kazakhstan is

demonstrating steady improvement. In 2024, the infant mortality rate was 7.67 cases per 1,000 live births, the lowest in the past 15 years and significantly lower than the global average of 28 cases per 1,000 live births.

This progress reflects the state’s systematic efforts to expand access to quality maternal and child health services, implement WHO standards, and strengthen primary healthcare. It is important to emphasize that these achievements contribute not only to progress on SDG 3 but also to strengthening Kazakhstan’s position on SDG 5 (Gender Equality) and SDG 10 (Reduced Inequalities), as improving maternal and child survival is directly linked to social equality, household resilience, and the quality of human capital.

By territorial distribution, infant mortality in Kazakhstan remains higher in rural areas compared to urban settings: 8.37 versus 7.18 per 1,000 live births, respectively. It is noteworthy that in the period from 2008 to 2015, as well as in 2020–2022, the opposite trend was observed, with higher rates recorded in cities.

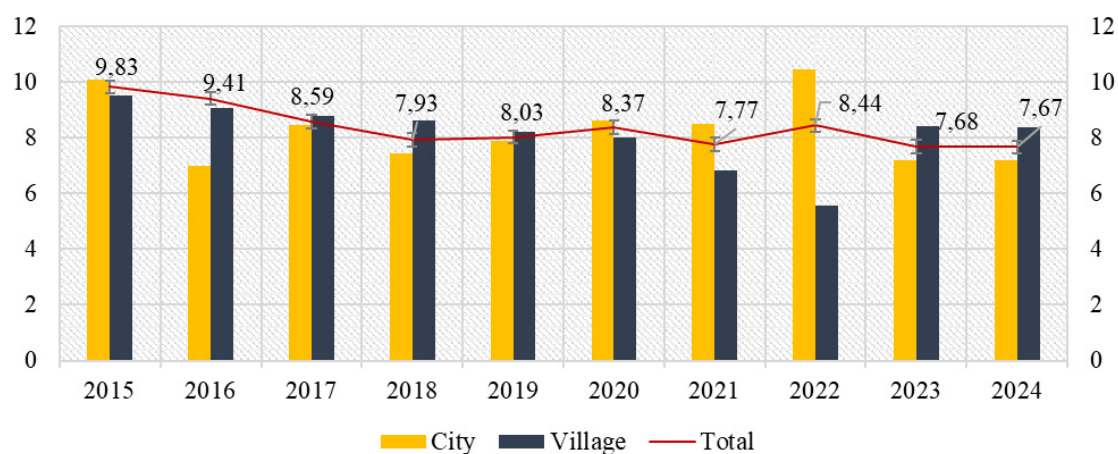


Figure 5 – Infant mortality rates per 1,000 births

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

Gender differences also persist, with mortality consistently higher among boys, a pattern observed since 2008 and consistent with global trends. In 2024, the infant mortality rate among boys was 8.54 per 1,000 live births, while among girls it was 6.74 (Figure 6).

By the close of 2024, Kazakhstan continued to demonstrate steady progress in lowering infant mortality rates, with a decline observed across both genders: 0.78% among boys and 0.76% among girls compared to 2015. The overall structure of infant

mortality has not changed significantly: perinatal conditions remain the leading cause, congenital malformations rank second, infectious diseases occupy third place, while accidental deaths remain in fourth. Over the past three years, the daily mortality rate of infants has been stable, averaging 1.3 per 1,000 live births, which corresponds to 16% of all infant deaths. Deaths occurring at home within the first year of life stand at 0.50 per 1,000 live births, or 6.2% of the total, with no notable variation in recent years.

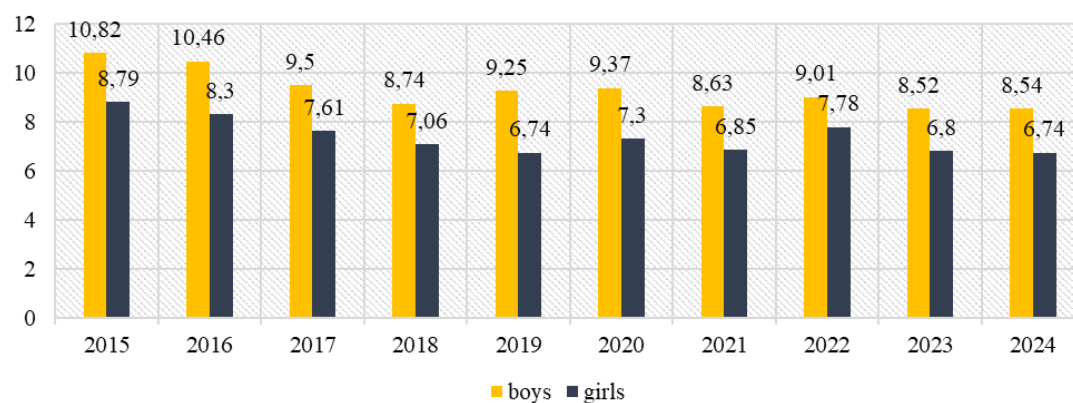


Figure 6 – Infant mortality rates, by gender per 1,000 births

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

An alarming aspect is the continued presence of deaths from preventable causes in the infant mortality structure. This situation highlights insufficient parental awareness of early danger signs in children, delayed medical consultations, and gaps in the performance of primary health care (PHC) services.

For a more accurate assessment of the state of public health and the level of development of the health system, the World Health Organization (WHO) recommends using not only traditional indicators such as total mortality, maternal and infant mortality, but also the mortality rate of children under 5 years of age. This indicator is one of the key indicators of the health status of the population, in-

cluding children's health, and helps identify problems in the healthcare system and the organization of medical care.

As can be seen from the data presented in Figure 7, the mortality rate of children under the age of 5 in 2024 decreased by 72% compared to 2000, amounting to 10.03 per 1,000 live births. This indicates significant progress in the field of health care and improvement of conditions for children in the country.

However, when analyzing the mortality of the child population, it should be noted that the largest part of deaths occurs in infants. This requires increased attention to prevention and improvement of early childhood care.

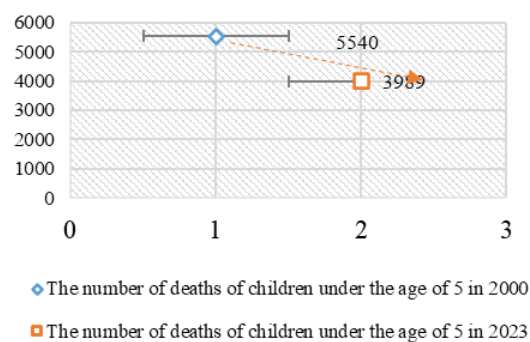
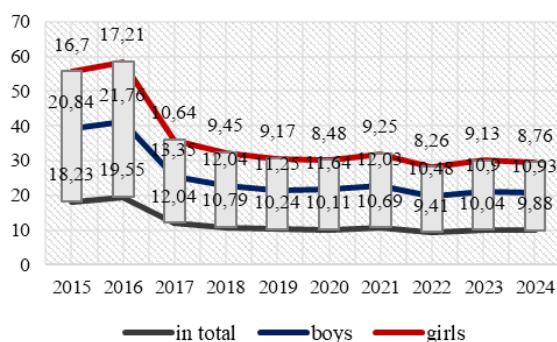


Figure 7 – Mortality rates of children under the age of 5, per 1,000 births

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

Over the past decade, the primary morbidity rate among children under 14 years of age has shown a significant decline of 25%, amounting to 68,943 cases per 100,000 of the respective population in 2024. However, from 2015 to 2024, there has been a noticeable rise in certain categories of childhood diseases:

- congenital anomalies, malformations, and chromosomal disorders – growth of 57.01%;
- neoplasms – growth of 33.4%;
- musculoskeletal and connective tissue diseases – growth of 20.29%.
- At the same time, a substantial reduction was recorded in several other disease categories:
 - mental and behavioral disorders associated with psychoactive substance use – decrease of 92.5%;
 - conditions originating in the perinatal period – decline of 58.97%;
 - blood and hematopoietic diseases, as well as immune system disorders – decline of 57.81%;

- circulatory system diseases – decrease of 55.86%;
- endocrine, nutritional, and metabolic disorders – decline of 43.6%.

These data show both positive trends in decreasing morbidity in a number of areas and an increase in morbidity in others, which highlights the need for healthcare to adapt to changing challenges, especially in the field of disease prevention and early diagnosis.

During the analyzed period, Kazakhstan has made significant progress in reducing infant mortality, which indicates a positive trend in achieving Goal 3.2 within the framework of the Sustainable Development Goals (SDGs). Reducing infant mortality and improving the health of children in the country are important achievements, despite the challenges associated with certain diseases.

Statistical data show that throughout the analyzed period, respiratory diseases consistently occupied the leading position in the structure of primary

morbidity among children aged 0–14 years, making up between 58% and 60% of all registered cases. This predominance is largely explained by the high frequency of acute inflammatory conditions of the respiratory tract in childhood.

The second place in the morbidity profile of children belongs to disorders of the digestive system, which account for 7–9% of total cases. In 2023, this figure reached 6 327 10 per 100,000 people, with a 10-year growth rate of 3%. This may indicate the need to improve the quality of nutrition and physical activity in children, since such diseases can be associated with poor nutrition and a sedentary lifestyle.

The third place in the structure of morbidity of children is occupied by diseases of the skin and subcutaneous tissue, accounting for 5%. In 10 years, the level of this pathology has decreased by 22%, which is also a positive result.

In addition, according to Target 3.3 of SDG 3, Kazakhstan continues to actively combat epidemics of infectious diseases, including AIDS, tuberculosis, malaria, tropical diseases and waterborne diseases. The HIV Prevention Service is represented by 20 centers, including 17 regional and 3 city HIV prevention centers, which enhances the country's capabilities to combat this problem.

Thus, serious efforts have been made in Kazakhstan in the field of disease prevention and improving children's health, which has a positive impact on achieving the targets under SDG 3.

In accordance with the World Health Organization (WHO) classification, Kazakhstan is currently

experiencing a concentrated stage of the HIV epidemic. This stage is characterized by the fact that the spread of infection is primarily confined to key population groups, including people who inject drugs (PWID), sex workers (SW), men who have sex with men (MSM), as well as individuals in penitentiary institutions.

In 2024, the HIV prevalence rate among the population aged 15–49 in Kazakhstan was 0.3%, which is lower than the global average (0.7%) and the indicator of Eastern Europe and Central Asia (1.1%). This indicates a relatively low prevalence of the disease in the general population, but HIV prevalence is significantly higher in key population groups than in the general population. Thus, the prevalence among women with disabilities is 7.6%, among sex workers – 1.3%, and among men who have sex with men – 6.9%.

The main ways of HIV transmission in Kazakhstan are parenteral (injection) and sexual routes. In 2015, the injection route of transmission was dominant, accounting for 61% of cases, but by 2024, the sexual route of transmission began to prevail (74.7%), while the share of the parenteral route decreased to 20.3%. This reflects a global trend in which the HIV epidemic is moving beyond the limits of the REGN and is spreading to wider segments of the population through various forms of sexual contact.

This situation requires further efforts to prevent HIV, especially in key populations, as well as active efforts to reduce stigma and expand access to health services for people living with HIV.

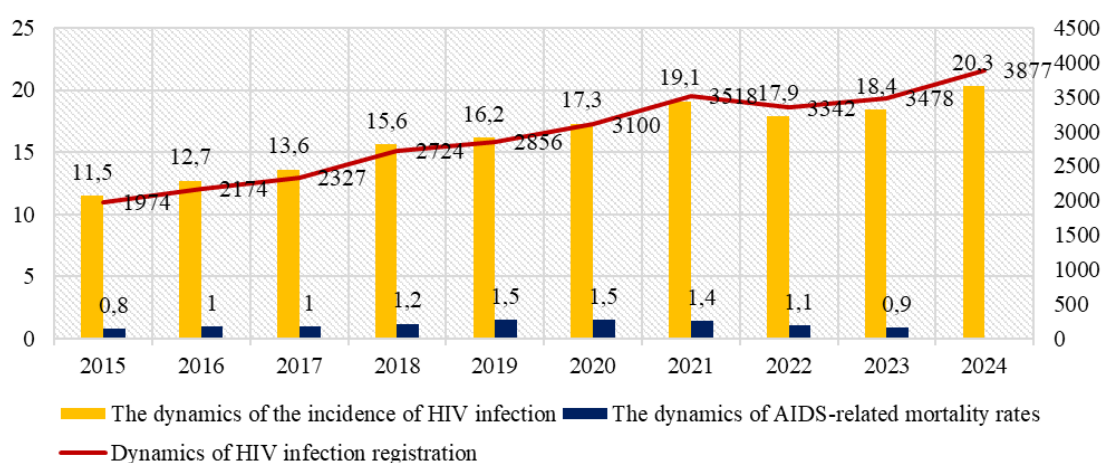


Figure 8 – Dynamics of HIV infection rates

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

The rise in HIV incidence in Kazakhstan in recent years is driven by several key factors. First, expanded HIV testing coverage has facilitated the identification of a greater number of new cases: from 2015 to 2024, the number of people tested increased 1.6-fold, from 2,450,517 to 3,837,896, while the number of new cases identified increased from 2,133 to 7,000. Second, increased screening in primary healthcare and the introduction of rapid testing among key populations (KGP), including people who inject drugs, as well as testing of sexual partners and pregnant women, have significantly increased early diagnosis rates.

Furthermore, expanded access to testing through non-governmental organizations (NGOs) and the introduction of pre-exposure prophylaxis (PrEP) in 2022 have played a significant role. In 2024, 84% of people living with HIV were receiving antiretroviral therapy (ART), which increases treatment effectiveness and reduces mortality. Testing coverage among pregnant women was over 98%, exceeding the WHO recommended level of 95%. These measures help contain the HIV epidemic at a concentrated stage among key populations and reduce the risk of transmission to the general population, reflecting progress toward SDG 3.3 – combating the epidemics of HIV and other infectious diseases.

The situation with tuberculosis is showing similar dynamics. According to 2024 data, the incidence of tuberculosis in Kazakhstan has halved over 10 years – from 73.4 to 36.5 cases per 100,000 population—due to expanded access to treatment, the in-

roduction of highly effective diagnostics, and comprehensive prevention. Significant progress has also been made in the fight against multidrug-resistant tuberculosis (MDR-TB): the cure rate is 81.1%, exceeding the WHO international standard (75%), and treatment is free for all patients, in line with SDG 3.3 recommendations to end the global epidemic by 2030.

Noncommunicable diseases, particularly cardiovascular diseases (CVDs), remain the leading cause of death in Kazakhstan. CVDs account for 22.8% of all deaths, with ischemic heart disease accounting for 33.66% and cerebrovascular diseases accounting for 32.72%. From 2015 to 2023, mortality from CVDs decreased by 61.8%, reflecting the success of national prevention strategies, the introduction of stroke centers (79 operating centers), and improved diagnostics and treatment. Nevertheless, significant challenges remain, requiring continuous improvement of the healthcare system and preventive measures, consistent with SDG target 3.4—reducing premature mortality from NCDs.

Thus, Kazakhstan is demonstrating a comprehensive approach to improving public health: combining expanded access to diagnosis and treatment, implementing modern prevention methods, integrating international standards, and actively targeting key risk groups. These measures not only reduce morbidity and mortality but also contribute to the achievement of related Sustainable Development Goals, including SDGs 3 (health), 5 (gender equality), and 10 (reduced inequalities).

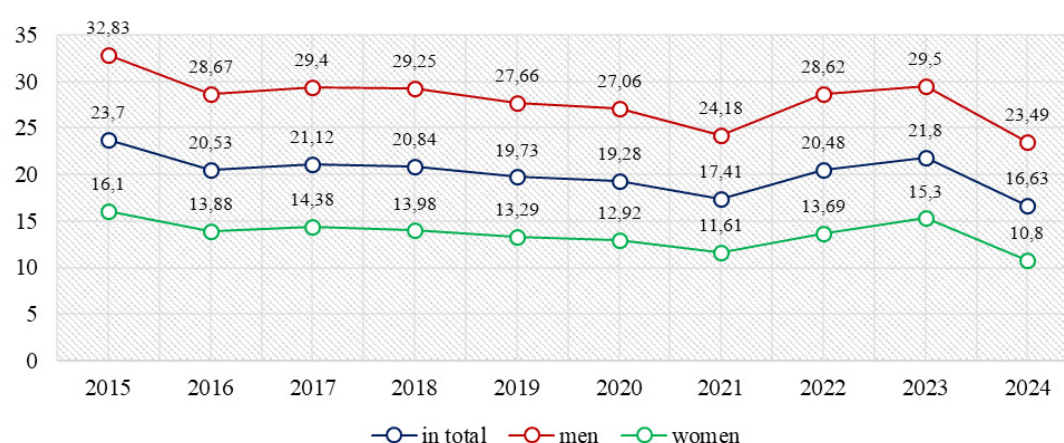


Figure 9 – Mortality from cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases (Target 3.4.1)

Note – compiled by the authors based on the source (Bureau of National Statistics of the Republic of Kazakhstan, 2024)

In Kazakhstan in 2024, the number of people registered for cardiovascular diseases (CVD) varied widely, driven by regional differences in healthcare provision. The highest numbers were registered in major cities and regions: Almaty (257,511), Turkestan Region (244,281), Karaganda Region (216,571), East Kazakhstan Region (148,304), and Almaty City (141,449). The lowest rates were observed in the Ulytau Region (35,798), Atyrau Region (53,508), Mangistau Region (67,278), and Zhetysay Region (83,595). Statistics show a steady decline in CVD mortality: from 207.4 cases per 100,000 population in 2015 to 154.39 in 2024. This trend confirms the effectiveness of national health strategies aimed at reducing the burden of cardiovascular disease. At the same time, Kazakhstan is actively implementing measures to prevent and treat substance abuse, including alcohol and drugs, which aligns with SDG 3 target 3.5.

According to the WHO, the global problem of psychoactive substance use remains pressing: in 2024, approximately 17% of the world's population aged 15–64 used drugs. Between 2015 and 2022, the number of drug addicts increased from 240 million to 296 million people (+23%), partly due to demographic growth. In Kazakhstan, prevention efforts are carried out through 104 NGOs working with vulnerable populations. Alcohol consumption among men is 25 liters of pure alcohol per year, compared to 9 liters among women, ranking the country 100th out of 189 countries.

Particular attention is paid to the health of the working-age population, which at the beginning of 2025 amounted to 10.4 million people (53% of the total population). Over the past ten years, the share of the working-age population has declined from 60% in 2015, increasing the importance of measures to maintain health and reduce premature mortality.

Combating drug addiction, alcoholism, and preventing cardiovascular disease are key public policy areas integrated into the SDG program. In particular, measures aimed at improving the health of the working-age population and reducing the burden of chronic diseases contribute to progress on SDG 3 (health and well-being), SDG 10 (reduced inequalities), and SDG 8 (decent work and economic growth). For strategic planning of healthcare system development, it is important to consider Kazakhstan's position in international SDG rankings and set measurable targets for key indicators. Institutional integration at the international level, consistent with global social policy standards, is critical to the successful implementation of these goals. The overall

global SDG agenda envisages the achievement of 17 key goals by 2030, including reducing inequalities, improving public health, and ensuring sustainable socioeconomic development. Kazakhstan's indicators demonstrate variability in certain areas, reflecting both positive and problematic trends, which requires ongoing monitoring and targeted measures at the national level.

An analysis of key healthcare indicators in Kazakhstan for 2015–2024 demonstrates that the system's effectiveness is determined not only by the availability of medical services but also by the comprehensive integration of socioeconomic and demographic factors. Despite a decline in infant and child mortality and an expansion in skilled obstetric care, significant regional and gender disparities remain, limiting the implementation of SDG 3. Spatial inequalities in healthcare resource availability, the rise in chronic and congenital diseases, and the dynamics of HIV infection reflect the need for a multisectoral approach and strengthened preventive and diagnostic programs.

The inter-target relationship between SDG 3 and SDG 1, SDG 5, and SDG 10 is revealed through a robust correlation between income levels, women's access to reproductive care, and the availability of healthcare resources in certain regions. Socioeconomic constraints directly impact population health, highlighting the critical role of integrated strategies that integrate healthcare, social policy, and regional development. Further sustainable development of the healthcare system requires strengthening primary care, expanding the prevention of chronic and infectious diseases, integrating interregional and sociodemographic indicators into strategic planning, and creating a comprehensive system for monitoring the quality and sustainability of healthcare services. Only a systematic combination of these measures will improve resource efficiency, reduce structural inequalities, strengthen human capital, and ensure the long-term sustainability of the national healthcare system, ensuring the achievement of SDG 3 and related Sustainable Development Goals.

Further, the work plans to analyze correlations between key healthcare indicators and socioeconomic variables to identify the impact of poverty, gender inequality, regional availability of healthcare resources, and the prevalence of chronic and infectious diseases on the sustainability of the healthcare system. This approach will allow for a quantitative assessment of the inter-target relationships among the SDGs, identify key drivers of progress and weak

points in the system, and substantiate priority areas for strategic planning and resource allocation to improve the effectiveness and sustainability of the national healthcare system.

Thus, the achieved results highlight the critical role of a systems-based approach to managing the national healthcare system, which combines strengthening primary care, expanding preventive measures, integrating cross-regional and sociodemographic indicators, and introducing comprehensive monitoring of the quality and sustainability of healthcare services. The practical implementation of these measures not only improves the efficient use of limited resources and reduces structural inequalities, but also strengthens human capital, ensuring the long-term sustainability of the healthcare system and contributing to the achievement of SDG 3 and related Sustainable Development Goals.

Further research, including a correlation analysis between key healthcare indicators and socioeconomic variables, will enable us to quantify the impact of poverty, gender inequality, regional availability of healthcare resources, and the prevalence of chronic and infectious diseases on the system's sustainability. This approach will help identify inter-target relationships among the SDGs, identify key drivers of progress and vulnerable segments of the system, and substantiate priorities for strategic planning and the rational allocation of resources. As a result, a scientifically sound basis for improving the effectiveness and sustainability of the national healthcare system is being developed, which is a key condition for ensuring the country's long-term social and economic stability.

Correlation analysis was conducted to quantitatively assess the relationships between key demographic and epidemiological indicators influencing the achievement of SDG 3 ("Health and Well-being"), as well as to identify potential bottlenecks in Kazakhstan's national healthcare system. The analysis used annual data for the period 2015–2024, including birth rate (%), infant mortality (per 1,000 live births), proportion of births attended by skilled medical personnel (%), all-cause mortality (per 1,000 population), mortality from cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases (per 100,000 population), life expectancy (years), and HIV/AIDS incidence and mortality. The data take into account the dynamics of demographic and institutional factors, including the impact of the COVID-19 pandemic.

Statistical analysis was performed using the Pearson correlation coefficient (r), which allows one to determine the direction and degree of linear relationship between pairs of indicators. The formula for the Pearson correlation coefficient is:

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 \sum_{i=1}^n (Y_i - \bar{Y})^2}} \quad (1)$$

where X_i and Y_i are the values of the studied indicators in the i -th year, $\bar{X}$ and $\bar{Y}$ are their average values, n is the number of observations.

To quantify the relationships between key demographic and epidemiological indicators, a Pearson correlation coefficient was constructed. The correlation matrix is presented in Tables 1 and 2.

Table 1 – Correlation matrix of healthcare indicators in Kazakhstan (2015–2024)

Year	Fertility	Proportion of births attended by skilled personnel	Infant mortality	Maternal mortality	Life expectancy	Mortality from chronic diseases	HIV/AIDS incidence
2015	71,46	381153	99,8	9,83	18,23	23,7	11,5
2016	71,89	398458	99,7	9,41	19,55	20,53	12,7
2017	72,32	400694	99,5	8,59	12,04	21,12	13,6
2018	72,73	390262	99,9	7,93	10,79	20,84	15,6
2019	73,24	397799	99,9	8,03	10,24	19,73	16,2
2020	73,35	402310	99,9	8,37	10,11	19,28	17,3
2021	71,64	426824	99,9	7,77	10,69	17,41	19,1
2022	70,79	446491	99,9	8,44	9,41	20,48	17,9
2023	73,94	403893	99,9	7,68	10,04	21,8	18,4
2024	74,02	388428	99,7	7,67	9,88	16,63	20,3

Note – compiled by authors

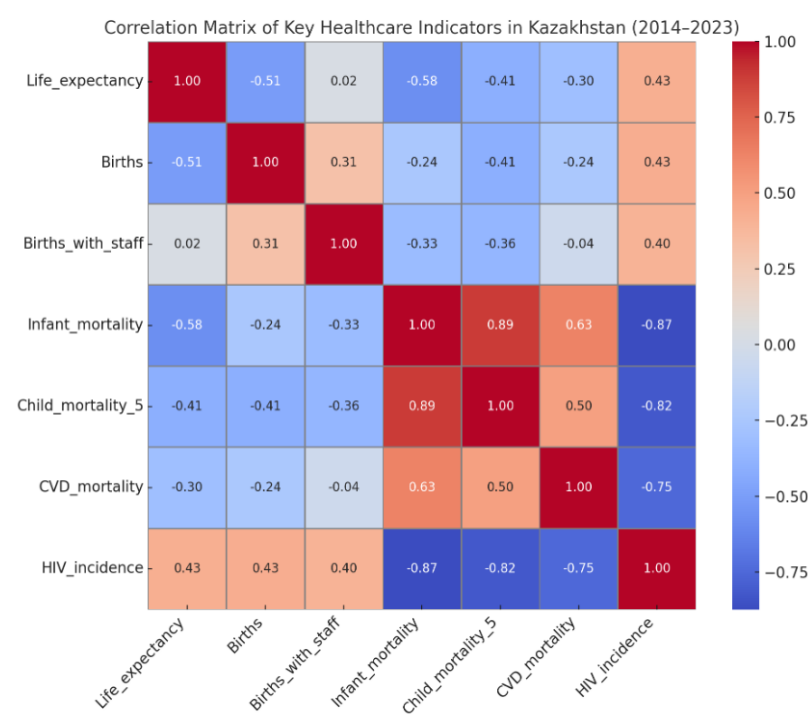
Table 2 – Pearson correlation matrix of key healthcare indicators in Kazakhstan (2015-2024)

Indicator Xi \ Yj	Life expectancy	Births	Births with qualified staff	Infant mortality	Child mortality (<5)	CVD mortality	HIV/AIDS incidence
Life expectancy	1,00	-0,51	0,02	-0,58	-0,41	-0,30	0,43
Births	-0,51	1,00	0,31	-0,24	-0,41	-0,24	0,43
Births with qualified staff	0,02	0,31	1,00	-0,33	-0,36	-0,04	0,40
Infant mortality	-0,58	-0,24	-0,33	1,00	0,89	0,63	-0,87
Child mortality (<5)	-0,41	-0,41	-0,36	0,89	1,00	0,50	-0,82
CVD mortality	-0,30	-0,24	-0,04	0,63	0,50	1,00	-0,75
HIV/AIDS incidence	0,43	0,43	0,40	-0,87	-0,82	-0,75	1,00

Note – complied by authors

To systematically analyze the inter-indicator relationships of key indicators of the state of healthcare of the population of the Republic of Kazakhstan for 2015–2024, a correlation matrix was constructed using the Pearson coefficient, which complies with international standards of statistical analysis and allows for the identification of linear relationships between variables with a high degree of reliability

(Karamagi et al., 2022; Blanchet et al., 2023; WHO, 2023). Despite the presence of numerical correlation values in tabular form, their graphical visualization provides the researcher with a clear understanding of the structure of the relationships, allowing for the intuitive identification of both strong positive and negative correlations between demographic and epidemiological indicators (Figure 10).

**Figure 10** – Correlation matrix of key indicators of healthcare of the population of the Republic of Kazakhstan for 2015-2024.

Note – The correlation matrix was constructed using Pearson's coefficient in IBM SPSS Statistics 29.

The color scale visualizes the strength and direction of the correlation: intense red shades indicate strong positive relationships, intense blue shades indicate strong negative relationships. Coefficient values range from -1 to +1, where 0 reflects the absence of a linear relationship.

A correlation analysis of key healthcare indicators in Kazakhstan for 2015-2024 revealed systemic and logically consistent interdependencies reflecting the complex influence of demographic and epidemiological factors on population health.

Life expectancy demonstrates a moderately strong negative correlation with fertility ($r = -0.51$), a very strong negative correlation with infant mortality ($r = -0.58$), and a moderate negative correlation with under-5 mortality ($r = -0.41$), confirming the direct impact of child mortality and demographic risks on life expectancy.

At the same time, a moderate positive correlation with HIV/AIDS incidence ($r = 0.43$) is observed, which may reflect regional epidemiological characteristics of the adult population. Fertility has a weak positive association with the proportion of births attended by skilled personnel ($r = 0.31$) and moderate negative correlations with infant ($r = -0.24$) and child mortality ($r = -0.41$), highlighting the importance of quality of care in reducing mortality among newborns and young children.

The proportion of births with skilled personnel demonstrates weak and moderate negative correlations with infant ($r = -0.33$) and child mortality ($r = -0.36$) and a moderate positive association with HIV/AIDS incidence ($r = 0.40$), confirming the need for a comprehensive analysis of factors influencing the epidemiological situation.

Infant and child mortality are closely interrelated ($r = 0.89$), positively correlate with cardiovascular mortality ($r = 0.63$ and $r = 0.50$), and have very strong negative correlations with HIV/AIDS incidence ($r = -0.87$ and $r = -0.82$), reflecting the different impact of chronic and infectious factors on child mortality rates.

Cardiovascular disease mortality has a moderately strong negative correlation with HIV/AIDS incidence ($r = -0.75$) and weak negative associations with demographic indicators, indicating the partial independence of chronic diseases from demographic risks.

HIV/AIDS incidence has very strong negative correlations with infant and child mortality ($r = -0.87$ and $r = -0.82$) and a moderately strong negative association with cardiovascular mortality ($r = -0.75$). It also exhibits moderate positive correlations with fertility, the proportion of births with skilled personnel, and life expectancy ($r = 0.43$; $r = 0.40$; $r = 0.43$), reflecting the complex epidemiological interaction of factors.

The structure of the correlation matrix reveals distinct clusters of interrelated demographic and

epidemiological indicators, confirming the systemic nature of the factors determining population health. Identifying indicators with strong and very strong correlations allows us to identify priority areas for strategic planning and scientifically based resource allocation in healthcare, as well as formulate targeted management measures aimed at optimizing demographic and epidemiological processes. The obtained results provide a quantitative basis for developing integrated programs for prevention, early detection, and comprehensive treatment aimed at increasing life expectancy and the quality of healthcare services for the population.

Conculison

Based on the analysis of key healthcare indicators in Kazakhstan, a set of management measures is proposed to improve the efficiency and sustainability of the healthcare system:

- Strengthening primary healthcare is a priority. It is recommended to expand the coverage of healthcare services in rural areas, increase the number of primary care specialists, particularly midwives and therapists, in regions with staff shortages, and introduce mobile medical teams to serve remote areas. These measures will reduce regional disparities and ensure access to basic healthcare for all population groups.

- Prevention and early diagnosis should be strengthened by scaling up screening programs for children and adults, including blood tests and newborn screening for hereditary pathologies. It is necessary to actively implement educational campaigns for the early detection of disease symptoms and strengthen preventive programs for cardiovascular, oncological, and chronic diseases.

- Regarding infectious diseases and HIV/AIDS, it is advisable to continue testing and early detection programs among key populations, expand access to pre-exposure prophylaxis (PrEP) and antiretroviral therapy, and raise public awareness and reduce the stigma associated with these infections.

- To reduce regional and gender disparities, it is necessary to implement programs to equalize access to quality medical care between urban and rural areas, support women and families with children in regions with high birth rates and low medical resources, and utilize a multisectoral approach integrating social, educational, and medical policies. Monitoring and strategic planning should be based on the integration of demographic, socioeconomic, and

health data to support informed decision-making. An important tool is the creation of an early warning system for the risk of epidemics and overload of healthcare facilities, as well as the implementation of mechanisms for assessing the effectiveness of public healthcare programs using SDG correlation indicators.

Strategic development areas include the comprehensive integration of SDGs 3, 5, and 10 to reduce inequalities, improve access to healthcare, and strengthen human capital. Digitalization of the

healthcare system is essential through the introduction of electronic patient records, remote consultations, and telemedicine. Systematic prevention of chronic diseases and infections should include programs for physical activity, healthy nutrition, and psychosocial support. Particular attention should be paid to developing human resources through training, advanced training, and motivational measures, as well as a focus on early childhood and maternal care as a key element of the sustainability of the national healthcare system.

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