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RETROSPECTIVE ANALYSIS OF MORTALITY AMONG CHILDREN AGED 0 TO 17 IN THE REPUBLIC OF KAZAKHSTAN FOR THE PERIOD 2015–2024

ANNA TURSUN[1], NURLAN DJAINAKBAEV[2], KARLYGASH ZHUBANYSHEVA[3]*, AIGUL NUGMANOVA[4], DILARA KACHURINA[5], LIDIYA KHITUOVA[6], ABDUGANI MUSAYEV[7]

[1] PHD CANDIDATE IN THE EDUCATIONAL PROGRAM «PUBLIC HEALTH» AT THE KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: a.tursun@medkrmu.kz ORCID: 0009-0003-9264-8823.
[2] DOCTOR OF MEDICAL SCIENCES, PROFESSOR, RECTOR OF THE NON-PROFIT ORGANIZATION KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: rector@medkrmu.kz
[3] DOCTOR OF MEDICAL SCIENCES, HEAD OF THE DEPARTMENT OF THE NEONATOLOGY POSTGRADUATE EDUCATION COURSE AT THE NON-PROFIT EDUCATIONAL ORGANIZATION KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: karlygash77@bk.ru. ORCID: 0000-0002-4222-661X
[4] DOCTOR OF MEDICAL SCIENCES, HEAD OF THE DEPARTMENT OF CHILDREN DISEASES WITH A COURSE IN PEDIATRIC INFECTIOUS DISEASES AT THE NON-PROFIT EDUCATIONAL ORGANIZATION KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: aigulmaratovna@mail.ru. ORCID: 0000-0002-9167-5892.
[5] DOCTOR OF MEDICAL SCIENCES, SENIOR LECTURER OF THE NEONATOLOGY POSTGRADUATE EDUCATION COURSE AT THE NON-PROFIT EDUCATIONAL ORGANIZATION KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: kachurinadilara@gmail.com . ORCID:000900945282316
[6] ASSOCIATE PROFESSOR (DOCENT) OF THE DEPARTMENT OF CHILDREN DISEASES WITH A COURSE ON PEDIATRIC INFECTIOUS DISEASES, AT THE NON-PROFIT EDUCATIONAL ORGANIZATION KAZAKH-RUSSIAN MEDICAL UNIVERSITY, ALMATY, KAZAKHSTAN, E-MAIL: khituovalk@mail.ru ORCID: 0000-0002-0368-4773
[7] DOCTOR OF MEDICAL SCIENCES, PROFESSOR MUSAEV.dr@mail.ru ORCID: HTTPS://ORCID.ORG/0000-0001-7782-6255 DEPARTMENT OF EMERGENCY AND EMERGENCY MEDICAL CARE, ASFENDIYAROV KAZAKH NATIONAL MEDICAL UNIVERSITY, KAZAKHSTAN

Abstract:
The right to health is recognized as one of the fundamental human rights. Universal Health Coverage (UHC) serves as a key instrument in realizing this right and is an integral part of the United Nations 2030 Agenda. Within the Sustainable Development Goals (SDGs), UHC is reflected in Goal 3, “Good Health and Well-being” (target 3.8) [1].
The infant mortality rate (IMR) is one of the most important indicators of healthcare effectiveness and reflects the socio-economic development of a country [2]. According to data from the World Health Organization (WHO), the annual mortality rate among children aged 5–14 years is approximately 7 per 1,000 children [3]. According to the United Nations Children’s Fund (UNICEF), mortality among individuals aged 5 to 24 years has been declining globally; since 1990, the mortality rate in this age group has decreased by 48% [4]. However, the global trend toward reduced child mortality shows significant regional differences. For instance, the survival rate among individuals aged 5 to 24 years in Sub-Saharan Africa is 46%, while South Asian countries report a rate of 22% [4]. Mortality among children under the age of five exceeds that of the 5–24 age group: in 2023, global under-five mortality reached 4.8 million, meaning that approximately 13 thousand children under five die every day worldwide [5]. Studies show that the level of education of both parents plays an important role in the survival of young children [6].

INTRODUCTION:

Mortality among school-aged children (5–19 years) in 2019, according to Dr. Li Liu et al., amounted to approximately 1.48 million deaths worldwide. The main causes of mortality in this age group include death due to road traffic accidents, oncological diseases, malaria, drowning, and diarrhea. Thus, the authors concluded in their results that the main causes of mortality among school-aged children are preventable [7].

School age is of crucial importance because it is during this period that neurocognitive, functional, and behavioral skills are formed [8]. Improved survival of newborns with complicated obstetric histories, particularly newborns with very low birth weight (VLBW, <1500 g) and extremely low birth weight (ELBW, <1000 g) [9], children under 5 years with hypoxic-ischemic encephalopathy [10], as well as reduced mortality due to neonatal therapy, subsequently forms a risk group among school-aged children with a likelihood of neurodevelopmental disorders such as delays in psycho-speech development and childhood disability [11].Complications in the neonatal period affect both early childhood and school age: atypical social development, emotional regulation disorders, problems

of internalization, and long-term psychopathology of personality [8], attention deficit hyperactivity disorder [12], autism spectrum disorders (ASD), and anxiety [13]. Concerning the causes of ASD, a study conducted in Australia in 2020 found that significant roles in the development of ASD belong to factors such as preterm birth and low birth weight [14]. The results of the study by Li-Wen Chen et al. also support the hypothesis of an association between preterm birth and the development of ASD in children [15].Preterm children throughout their subsequent life are exposed to a range of pathological conditions [8], which affect the physical and mental health of children and may also be causes of mortality already at school age, thus making the assessment of the condition of school-aged children an indicator of the effectiveness of neonatal interventions [8].

During the coronavirus (SARS-CoV-2) pandemic, the UNICEF COVerAGE database recorded, as of January 2023, 4.1 million deaths caused by coronavirus infection, of which children and young people under 20 years of age accounted for 0.4% [16, 17]. In addition, the coronavirus pandemic had negative effects on the nutrition of children and adolescents: during the first year of the pandemic, 370 million children in 150 countries missed school meals [18]. The restrictive measures during the COVID-19 lockdown had a major impact on school health systems worldwide, including the loss of education for schoolchildren, the disruption of efforts to protect their health particularly monitoring of students' mental health and negative effects on school nutrition, with the impact being especially severe for children from disadvantaged families [19]. Medical care for children and adolescents also suffered as a result of the COVID-19 pandemic, as diagnosis, treatment, and psychosocial support–especially for children with chronic diseases and cancer became fully or partially inaccessible [20, 21].

Child mortality, including that of school-aged children, is not only an indicator of public health and the socio-economic status of a country, but also a measure of the political organization of society [22]. According to Ansell and Samuels (2015), in the democratization of society, where the fair distribution of rights is a fundamental principle, a reduction in child mortality is observed due to expanded access to medical care, education, and social services [22, 23]. One of the key factors explaining the relationship between the protection of human rights, and primarily the protection of women's rights, with child mortality, including the mortality of school-aged children, can be called the role of women's socio-economic and legal autonomy; women's access to education, protection from early marriage, the right to reproductive health, the quality of childcare, nutritional status, and the ability to seek timely medical care directly influence child and adolescent mortality rates [24]. The gender issue, specifically the issue of early marriages among girls in the Republic of Kazakhstan, was addressed in the article by Eva Batyra et al. (2021), which conducted a cohort analysis and found that changes in legislation on the minimum marriage age did not show a significant difference in the country [25]. According to UNICEF data, the proportion of girls under 18 years old who are married in the Republic of Kazakhstan is currently 7%. Overall, the level of child marriages in the Republic of Kazakhstan has remained between 6–13% since 1990, which is lower than in countries in Africa and South Asia (over 9%), but still indicates the presence of the problem of child marriages [26]. The issue of child mortality, including mortality among school-aged children, is closely related to the problem of child marriages and, consequently, childbearing, which requires special attention from the healthcare system and social policy.

School-aged children are an essential part of the world's population; they represent the future labor and intellectual potential of global society. Therefore, the study of mortality in this age group becomes especially relevant, since this indicator serves as a measure of public health and the effectiveness of preventive and medical interventions within a country's healthcare system.

Thus, over the past decades, the global child mortality rate, including that of school-aged children, has been decreasing; however, approximately one million children still die worldwide each year, which underscores the seriousness of the problem and calls for the healthcare system of the Republic of Kazakhstan to further study the issue and improve intersectoral programs for protecting the health of the younger generation.

MATERIALS AND METHODS

The study is based on a retrospective analysis of secondary data presented in the official statistical publications of the Republic of Kazakhstan, such as the annual compilations "Health of the Population of the Republic of Kazakhstan and the Activities of Healthcare Organizations" (Form C-13-G, 2015–2024) and the thematic compilations "Children of Kazakhstan" (125 pages, 2024) over a ten-year period from 2015 to 2024. These sources contain information at the national level, demonstrating the state of the healthcare system as well as population health indicators.

The object of the study was child mortality among children aged 0–17 years in the Republic of Kazakhstan.

The study was conducted with the aim of identifying dynamic patterns of child mortality, including that of school-aged children, determining its causes according to nosological characteristics with an assessment of territorial variability, and comparing it with birth rates and natural population growth.

The analysis was conducted along three interrelated directions:

1.Population birth rates.

2.Overall mortality, including the structure and dynamics of mortality among children aged 0–17 years.

3.Natural population growth.

In the Republic of Kazakhstan, dynamic monitoring of child mortality, from the neonatal period to adulthood, is carried out in stages [2]:

1. The first stage is the registration of the event, i.e., the death of a child, with the confirmation of death by a medical professional within medical institutions. A necessary condition is documentary evidence in the form of a completed medical death certificate at an early date, followed by the preparation of medical records and their transfer to the territorial units of the Republican Center for Healthcare Development (hereinafter RCHD).
2. The second stage is the receipt and consolidation of child mortality data by the territorial units of the RCHD, which generate reporting forms that are subsequently submitted to national authorities.
3.The third stage is the centralization of data with final analysis and reporting at the national level.

The collection and processing of statistical information in the Republic of Kazakhstan comply with international standards [27], thereby ensuring the possibility of comparing national data with global indicators and including them in international comparative analyses.

The statistical analysis was conducted using IBM SPSS Statistics 26.0 software. In the statistical analysis, methods of descriptive statistics were applied to child mortality among children aged 0–17 years in the Republic of Kazakhstan for the period 2015–2024, including ranking of regions, analysis of minimum and maximum values, construction of trend lines, and calculation of variation coefficients to assess regional heterogeneity. To evaluate the dynamics of child mortality, including that of school-aged children, the method of linear regression was applied, allowing for the identification of the overall trend, as well as the determination of the rate of change and testing the statistical significance of the observed trend. A limitation of the linear regression method is the assumption of a linear relationship between the time variable and the analyzed indicator, which implies the possibility of nonlinear changes over time. Additionally, the ten-year observation period from 2015 to 2024 imposes limitations on the depth of statistical generalization but is sufficient to identify dynamic patterns and assess the direction of the trend.

For a visual presentation of the research results, graphical and chart-based representations of data were used, which allowed simplifying the perception of statistical information, identifying patterns, and clearly demonstrating temporal trends.

Inclusion criteria:

Included: official statistical data on birth rates, overall mortality, child mortality among children aged 0–17 years in the Republic of Kazakhstan for the period 2015–2024, causes of death, and trends.

Excluded: unsystematized reports, publications without reliable references to official statistical data, and data with incomplete age groups.

Variables and Indicators:

1. Absolute number of deaths by year and disease classes;
2. Absolute increase (difference between the indicators of the years);
3. Growth rate % (ratio of the current year's indicator to the previous year × 100);
4. Rate of increase % (difference between the growth rate and 100%);
5. Visibility coefficient % (ratio of the current year's indicator to the 2015 indicator × 100);
6. Coefficient of variation % (to assess regional heterogeneity);
7. Maximum and minimum values, median, standard deviation;
8. Birth and mortality rates;
9. Natural increase.

Ethical aspects:

The study is based on the analysis of anonymized official statistical data. The statistical information did not contain personal data that could identify specific individuals; therefore, informed consent from study participants was not required. No comparison with individual registries using identifiers was conducted, which eliminates the possibility of reconstructing information about specific individuals.

The study did not involve access to personal data, nor did it include procedures for de-identification, encryption, or the processing and transfer of primary medical documentation.

Ethical approval was obtained from the local ethics committee of the NGO "Kazakhstan-Russian University," meeting protocol No. 27, registration number No. 148 dated October 14, 2024.

RESULTS

Analysis of mortality among children aged 0–17 years in the Republic of Kazakhstan for the period 2015–2024.

The analysis of child mortality dynamics for ages 0–17 was conducted using information obtained from the annual statistical compilations "Health of the Population of the Republic of Kazakhstan and Activities of Healthcare Organizations" (form S-13-G, 2015–2024), which present mortality data for children aged 0–17 and 0–5 years. Unfortunately, data on mortality among school-aged children (6–17 years) are not reflected in the compilations and were not provided upon request by the RCRH.

According to the data presented in the table, the level of child mortality from infectious and parasitic diseases in absolute terms showed significant fluctuations during the analyzed period, reflecting both epidemiological characteristics and the possible impact of changes in the healthcare system.

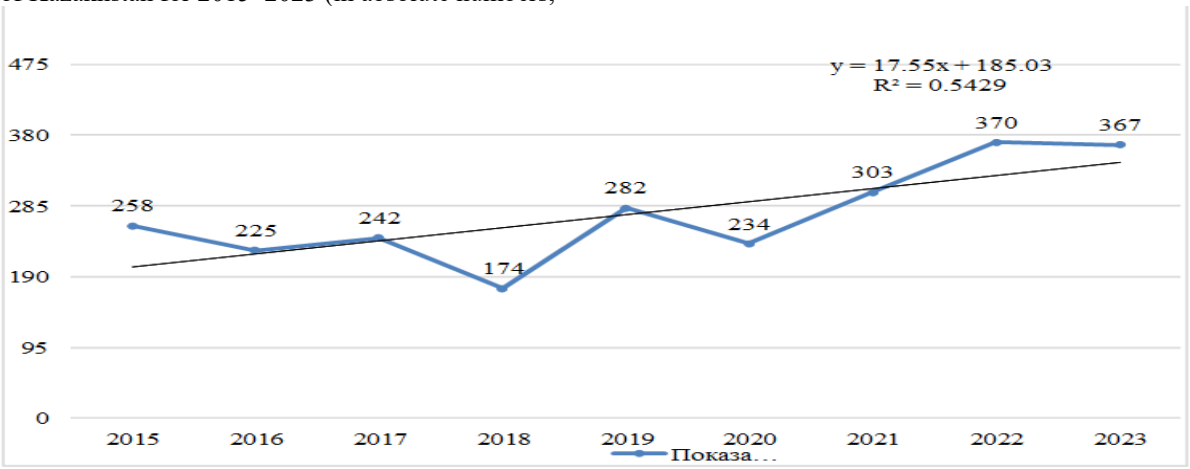
In the baseline year 2015, the number of cases was 258. In 2016, the indicator decreased to 225 (an absolute decrease of 33 cases), corresponding to a growth rate of 87.2% and a rate of increase of −12.8% compared to the previous year. In 2017, a slight increase in mortality was recorded, reaching 242 cases (+17), with a moderate increase of 7.6%, achieving 93.8% of the 2015 level (see Table 1, Fig. 1).

Table №1. Dynamics of absolute indicators of mortality among children aged 0–17 from infectious and parasitic diseases in the Republic of Kazakhstan (2015–2023)

Year	Indicator	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient relative to 2015, %
2015	258				100
2016	225	-33	87,21	-12,79	87,21
2017	242	17	107,56	7,56	93,8
2018	174	-68	71,9	-28,1	67,44
2019	282	108	162,07	62,07	109,3
2020	234	-48	82,98	-17,02	90,7
2021	303	69	129,49	29,49	117,44
2022	370	67	122,11	22,11	143,41
2023	367	-3	99,19	-0,81	142,25
Source: compiled by the authors					

In 2018, a significant decrease to 174 cases was observed, corresponding to a rate of increase of −28.1% and the lowest visibility level for the entire period - 67.4% of the 2015 level. However, in 2019, the number of deaths sharply increased to 282, exceeding the 2015 baseline by 9.3% and showing the highest rate of increase compared to the previous year - + 62.1%.
The graph in Figure 1 reflects the changes in the number of mortality cases among children aged 0–17 from infectious and parasitic diseases in the Republic of Kazakhstan for 2015–2023.

Figure 1 - Dynamics of mortality among children aged 0–17 from infectious and parasitic diseases in the Republic of Kazakhstan for 2015–2023 (in absolute numbers,



Source: compiled by the authors

In 2020, against the backdrop of the onset of the COVID-19 pandemic, the indicator decreased to 234 (−17.0%), possibly due to movement restrictions, reduced contacts, and the implementation of anti-epidemic measures. In the following two years, a steady increase was observed: in 2021 – 303 cases, in 2022 – 370, corresponding to a visibility coefficient of 143.4% relative to the 2015 level, reaching the peak for the entire decade. In 2023, the indicator slightly decreased to 367, remaining at a high level.
The average annual mortality among children aged 0–17 from infectious and parasitic diseases in the Republic of Kazakhstan for 2015–2023 was 262 cases. The lowest number was recorded in 2018 (174 cases), and the highest – in 2022 (370 cases). The overall dynamics of the indicator are characterized by moderate fluctuations, with periods of decline followed by subsequent growth.

Thus, the greatest increase was observed in 2019 (+62.1%), and the largest decrease – in 2018 (−28.1%), reflecting the high sensitivity of the indicator to external factors. In the post-COVID period, starting from 2021, a steady rise in mortality was recorded, despite the end of the acute phase of the COVID-19 pandemic. This fact requires further analysis in the context of possible delayed consequences of the pandemic, changes in access to medical care, and the epidemiological situation.

During the period from 2015 to 2023, the mortality rate of children aged 0–17 from neoplasms in the Republic of Kazakhstan ranged from 192 cases (in 2020) to 244 cases (in 2015). The average annual value was 212.33 cases, with a standard deviation of 18.37, indicating moderate variability of the annual indicator (see Table 2, Fig. 2).

The sharpest decrease was recorded in 2016 (−10.7%), and the largest increase – in 2018 (+11.2%). The overall dynamics indicate a wave-like pattern of change without a stable trend toward either decline or growth.

Periods of increase may be associated with improved registration, diagnostics, and access to specialized care, whereas decreases may be linked to early detection measures and treatment within pediatric oncology programs. This indicator requires continuous monitoring within the school health systems and malignant disease prevention.

Table 2. Dynamics of mortality among children aged 0–17 from neoplasms in the Republic of Kazakhstan for 2015–2023 (in absolute numbers)

Year	Indicator	Absolute increase	Growth rate, %	Growth increment, %	Visibility coefficient from 2015, %
2015	244				100
2016	218	-26	89,34	-10,66	89,34
2017	196	-22	89,91	-10,09	80,33
2018	218	22	111,22	11,22	89,34
2019	204	-14	93,58	-6,42	83,61
2020	192	-12	94,12	-5,88	78,69
2021	234	42	121,88	21,88	95,9
2022	213	-21	91,03	-8,97	87,3
2023	192	-21	90,14	-9,86	78,69
Source: compiled by the authors					

Mortality among children aged 0–17 from neoplasms in the Republic of Kazakhstan during 2015–2023 was characterized by a relatively stable level with moderate fluctuations ranging from 192 to 244 cases per year. The average annual value was 212.3 cases, with a standard deviation of 18.4 and a coefficient of variation of 8.7%, indicating low variability of the indicator..

The highest number of fatal outcomes was recorded in 2015 (244 cases), and the lowest in 2020 and 2023 (192 cases each). From 2015 to 2017, a gradual decreasing trend was observed, which was followed by an increase in 2018 to 218 cases. In 2020, the minimum value was recorded, possibly due to limited access to medical care during the pandemic, reduced healthcare visits, and potential underreporting of cases. In 2021, the number rose to 234 cases, likely associated with delayed diagnoses in the preceding period. In 2022, it decreased to 213 cases, and in 2023, the indicator returned to the minimum of 192 cases.

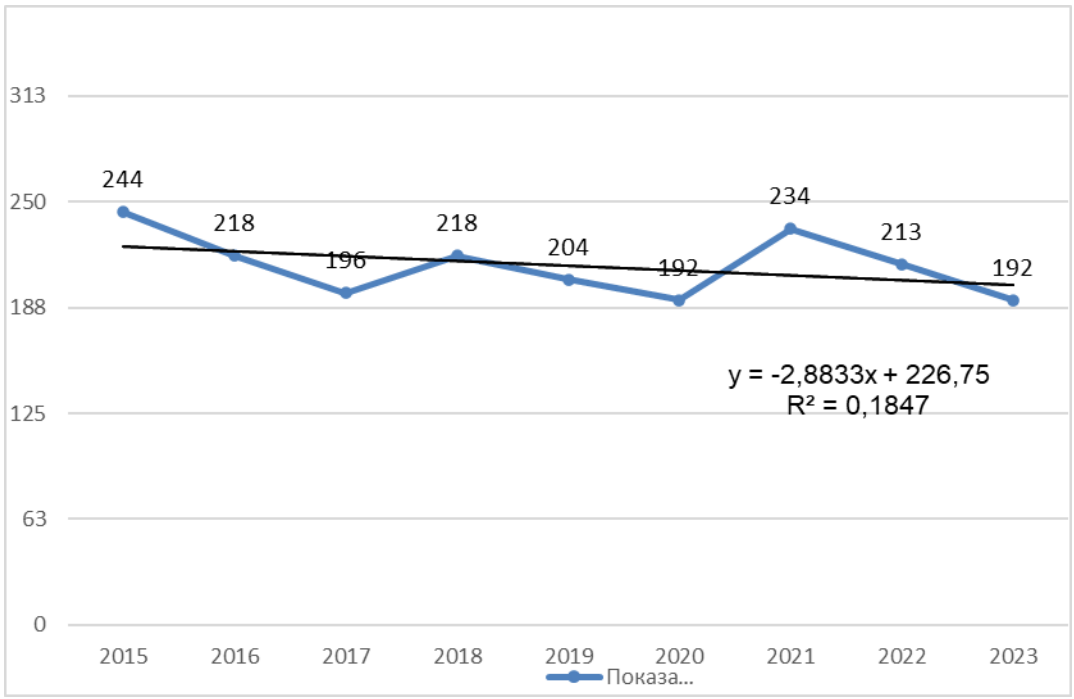


Figure 2 - Dynamics of mortality rates of children aged 0–17 years from neoplasms in the Republic of Kazakhstan for 2015–2023 (cases)
Source: compiled by the authors.

Analysis of mortality from neoplasms revealed that the indicator's dynamics do not show a consistent increase or decrease over the analyzed period. Instead, irregular fluctuations are observed, which may be partially related to systemic factors (availability and quality of diagnostics, organization of oncology care) and external influences (impact of the COVID-19 pandemic, changes in case registration).
Mortality of children aged 0–17 years from diseases of the circulatory system in the Republic of Kazakhstan during 2015–2023 is characterized by irregular dynamics with alternating periods of increase and decrease. In 2015, 185 cases were recorded, taken as the baseline level. In the following two years, a decrease was observed: 154 cases in 2016 (an absolute decrease of 31 cases, growth rate −16.8%) and a moderate increase to 168 in 2017 (+14 cases, +9.1%) (see Table 3, Fig. 3).
From 2018 to 2019, a significant increase in the number of deaths was noted: 214 cases in 2018 (+27.4% compared to the previous year) and a peak in 2019 with 253 cases, which is 37 more than in 2018 (+17.3%). This increase may be associated with improved registration of causes of death or a deterioration in the cardiovascular status among the child population.

Table 3 - Dynamics of mortality of children aged 0–17 years from diseases of the circulatory system in the Republic of Kazakhstan for 2015–2023 (in absolute values)

Year	Indicator	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient from 2015, %
2015	185				100
2016	154	-31	83,243	-16,75	83,24
2017	168	14	109,09	9,09	90,81
2018	214	46	127,38	27,38	115,67
2019	253	39	118,22	18,22	136,75
2020	187	-66	73,91	-26,08	101,08
2021	233	46	124,59	24,59	125,94

2022	207	-26	88,84	-11,15	111,89
2023	220	13	106,28	6,28	118,91
Source: compiled by the authors					

In 2020, the indicator decreased to 187 cases (−26.1%), likely due to the impact of the COVID-19 pandemic and limited access to medical services. In 2021, an increase to 233 cases (+24.6%) was recorded again, followed by a moderate decrease to 207 in 2022 and a subsequent rise to 220 in 2023.

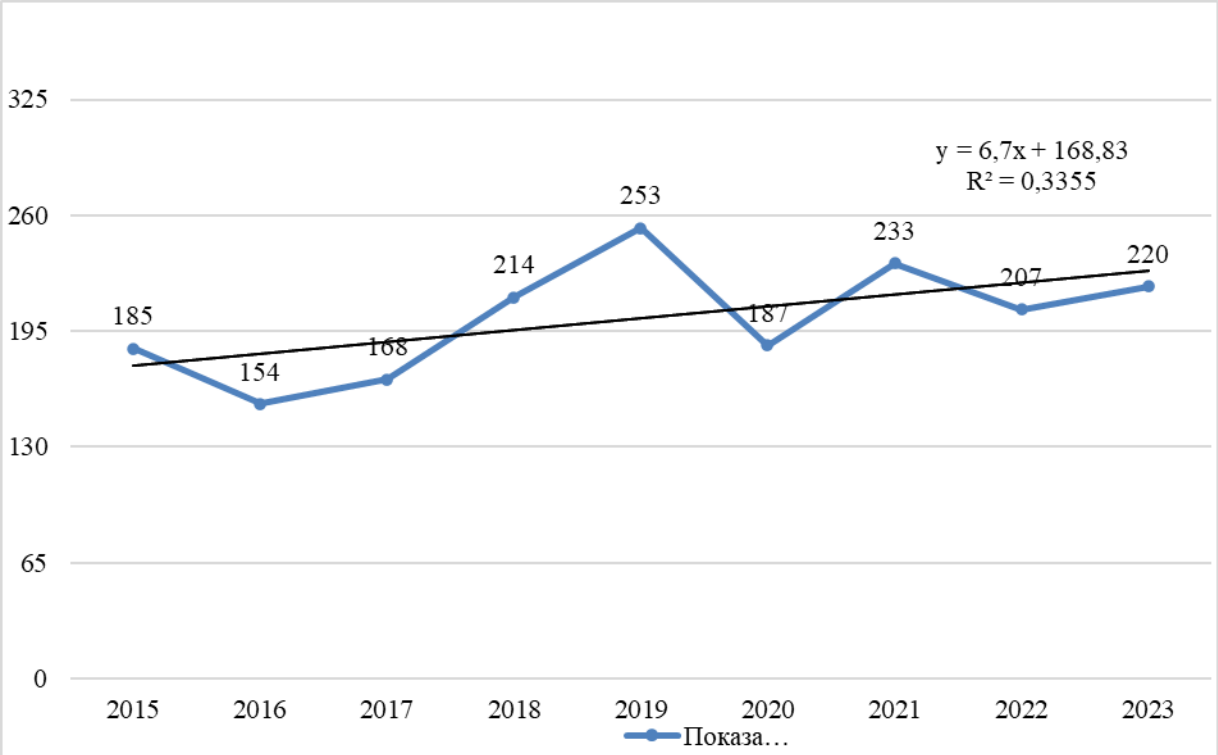


Figure 3 - Mortality of children aged 0–17 years from diseases of the circulatory system in the Republic of Kazakhstan for 2015-2023 (cases)
Source: compiled by the authors

The average annual mortality over the nine-year period was 202.3 cases, with a standard deviation of 32.3 and a coefficient of variation of 15.9%, indicating considerable instability of the indicator. The visibility coefficient relative to the base year (2015) ranged from 83.2% (2016) to 136.8% (2019).
Thus, the observed dynamics of mortality from circulatory system diseases reflect the absence of a stable trend and indicate the influence of various factors, including the availability of cardiological care, quality of diagnostics, epidemiological conditions, and possible delays in medical services during the pandemic. Considering that cardiovascular pathology is not a typical cause of death in childhood, such values require special attention from the school and outpatient healthcare system. An analysis of the quality of specialized care, screenings, and prevention in risk groups is necessary.
Table №4 reflects the dynamics of mortality among children aged 0–17 years from respiratory diseases in the Republic of Kazakhstan for 2015–2023. In the base year 2015, 444 cases were registered. In the following years, pronounced fluctuations are observed without a stable trend, which may indicate the sensitivity of the indicator to external factors, including the epidemiological situation, seasonal variability of infections, and the availability of pediatric care.

Table 4 - Dynamics of mortality among children aged 0-17 years from respiratory diseases in the Republic of Kazakhstan for 2015-2023 (absolute values)

Year	Indicator	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient relative to 2015, %
2015	444				100

2016	337	-107	75,90	-24,09	75,90
2017	322	-15	95,54	-4,45	72,52
2018	339	17	105,27	5,27	76,35
2019	428	89	126,25	26,25	96,39
2020	342	-86	79,90	-20,09	77,02
2021	335	-7	97,95	-2,04	75,45
2022	373	38	111,34	11,34	84,00
2023	415	42	111,26	11,26	93,46
Source: compiled by the authors					

In 2016, mortality decreased by 107 cases (-24.1%) compared to the baseline, reaching 337 cases. The minimum value was recorded in 2017 - 322 cases, which corresponds to 72.5% of the 2015 level. In 2018, the indicator slightly increased to 339 cases (+5.3%). The most significant rise was observed in 2019 - 428 cases (+26.3% compared to the previous year), approaching the baseline level (96.4%). In 2020–2022, the indicator remained relatively stable within the range of 335 - 373 cases. In 2023, an increase to 415 cases was recorded, which corresponds to 93.5% of the 2015 level (see Fig. 4).

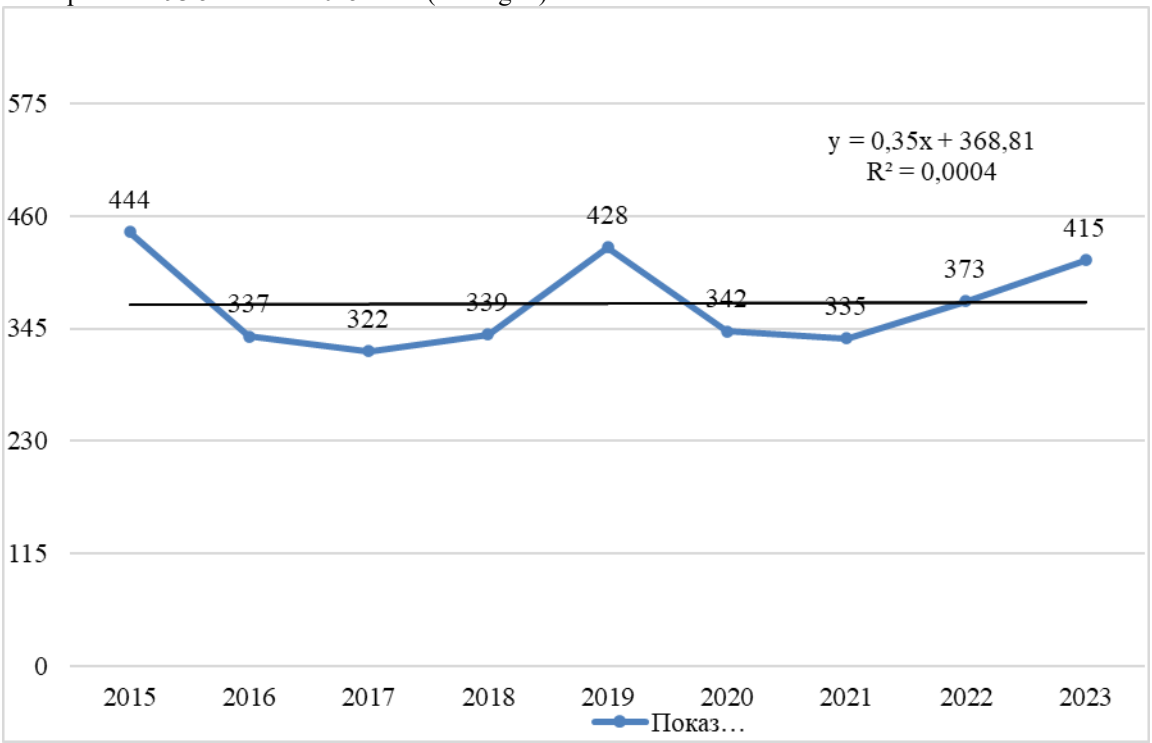


Figure 4 - Trend of mortality among children aged 0-17 from respiratory system diseases in the Republic of Kazakhstan for 2015-2023 (cases)
Source: compiled by the authors

The average value over the period was 370 cases per year. The median was 339 cases. The range of values was 122 cases (from 322 to 444). These data indicate moderate but significant variability, reflecting both epidemiological factors and systemic changes in the provision of medical care to children.
In summary, during 2015–2023, the mortality rate among children from respiratory system diseases in the Republic of Kazakhstan exhibited a wave-like dynamic without signs of a stable decline, but also without significant increases. This may be due to the exclusion of children under 5 years old from this group, who account for the majority of deaths from respiratory diseases. Fluctuations in the indicator were likely influenced by seasonal epidemics, the impact of COVID-19, the quality of primary healthcare, and the coverage of preventive measures within the school health system. The identified features highlight the need to revise strategies for early detection and treatment.

Table 5 illustrates the dynamics of child mortality from digestive system diseases. In the base year 2015, the mortality rate was 92 cases. In 2016, there was a sharp decrease of 33 cases (-35.9%), corresponding to a reduction of the indicator to 64.1% of the base year level.

Table 5 Dynamics of mortality among children aged 0-17 years from digestive system diseases in the Republic of Kazakhstan for 2015–2023 (absolute values)

Year	Indicator	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient relative to 2015, %
2015	92				100
2016	59	-33	64,13043	-35,8696	64,13043
2017	65	6	110,1695	10,16949	70,65217
2018	68	3	104,6154	4,615385	73,91304
2019	67	-1	98,52941	-1,47059	72,82609
2020	62	-5	92,53731	-7,46269	67,3913
2021	76	14	122,5806	22,58065	82,6087
2022	75	-1	98,68421	-1,31579	81,52174
2023	83	8	110,6667	10,66667	90,21739
Source: compiled by the authors					

In the following two years, a moderate increase was observed: in 2017 - by 6 cases (+10.2%), and in 2018 - by 3 cases (+4.6%). However, in 2019 and 2020, a decline was recorded again - down to 67 and 62 cases, respectively, with negative rates of increase of -1.5% and -7.5%. This may be associated with underreporting, reduced healthcare visits, or actual changes in the level of medical care (see Fig. 5).

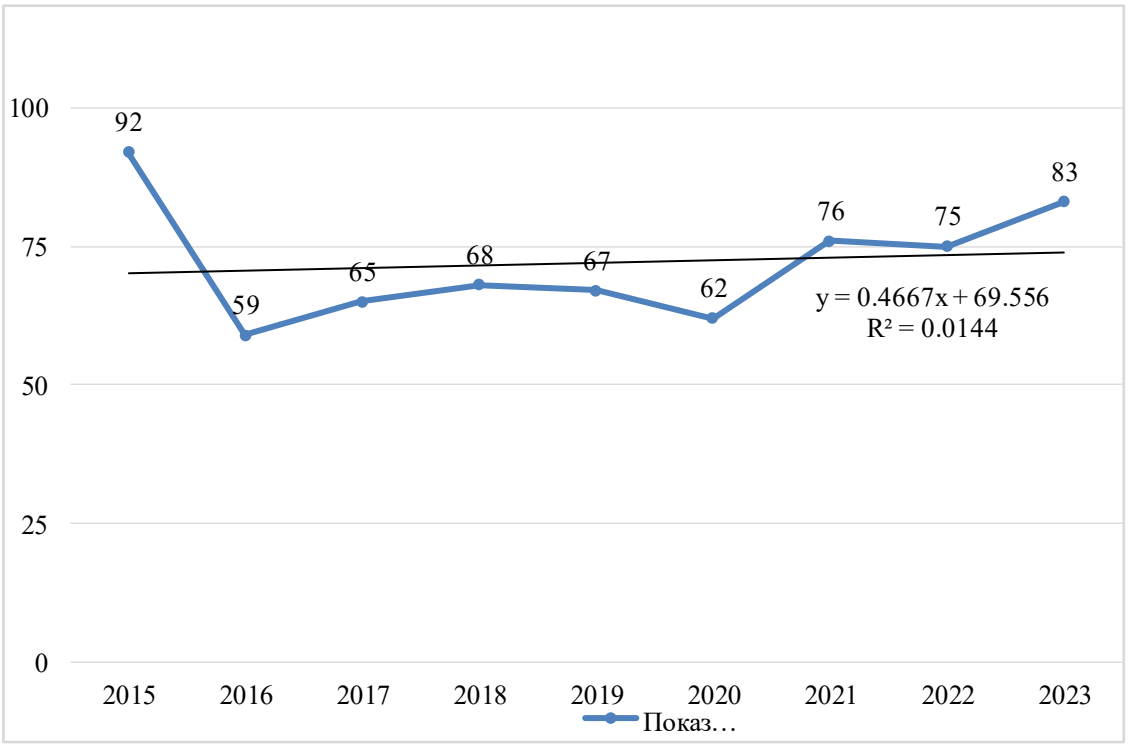


Figure 5 – Dynamics of mortality among children aged 0-17 years from digestive system diseases in the Republic of Kazakhstan for 2015-2023 (absolute values, cases).
Source: compiled by the authors

During the COVID-19 pandemic, a sharp increase in mortality was observed in 2021 - up to 76 cases (+22.6%). This was likely due to disruptions in the provision of specialized medical care. In 2022, the indicator decreased slightly by 1 case (-1.3%), and in 2023 it rose again to 83 cases (+10.7%), which is the highest value in the analyzed period.
Thus, the visibility coefficient relative to 2015 ranged from 64.1% (in 2016) to 90.2% (in 2023), reflecting significant fluctuations. The absence of a stable trend and the pronounced variability of the indicator indicate the need for additional study of mortality factors for this cause, including access to specialized gastroenterological care, the quality of diagnostics, and conditions of inpatient treatment.
Table 6 and Figure 6 show the dynamics of mortality from external causes among children aged 0-17 in the Republic of Kazakhstan for the period 2015-2023. In 2015, this indicator amounted to 1,197 cases and was taken as the baseline (100%). In the following years, a steady decline was observed: in 2016, the number of cases decreased by 90 (-7.5%; 92.5% of the 2015 level), and in 2017-2019 the downward trend continued, amounting to -2.5%, –3.6%, and -3.0%, respectively. By 2019, the visibility coefficient relative to the baseline year reached 84.3% (see Table 6, Fig. 6).

Table № 6 - Dynamics of mortality among children aged 0–17 from external causes in the Republic of Kazakhstan for the period 2015-2023 (absolute values, person)

Year	Indicator	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient relative to 2015, %
2015	1197				100
2016	1107	-90	92,4812	-7,5188	92,4812
2017	1079	-28	97,47064	-2,52936	90,14202
2018	1040	-39	96,38554	-3,61446	86,88388
2019	1009	-31	97,01923	-2,98077	84,29407
2020	855	-154	84,73736	-15,2626	71,42857
2021	916	61	107,1345	7,134503	76,52464
2022	933	17	101,8559	1,855895	77,94486
2023	1093	160	117,149	17,14898	91,31161
Source: compiled by the authors					

The most significant decrease was recorded in 2020 - down to 855 cases, which is 154 fewer than in the previous year (-15.3%), with a visual decline to 71.4% of the 2015 level. This drop may be partially explained by mobility restrictions, remote learning, and reduced social activity during the COVID-19 pandemic.
Beginning in 2021, the trend reversed: the increase amounted to +7.1% in 2021, +1.9% in 2022, and rose sharply to +17.1% in 2023. The total number of fatal outcomes from external causes reached 1,093 cases, corresponding to 91.3% of the baseline level. The absolute increase from 2022 to 2023 was +160 cases - the highest in the entire analyzed period.

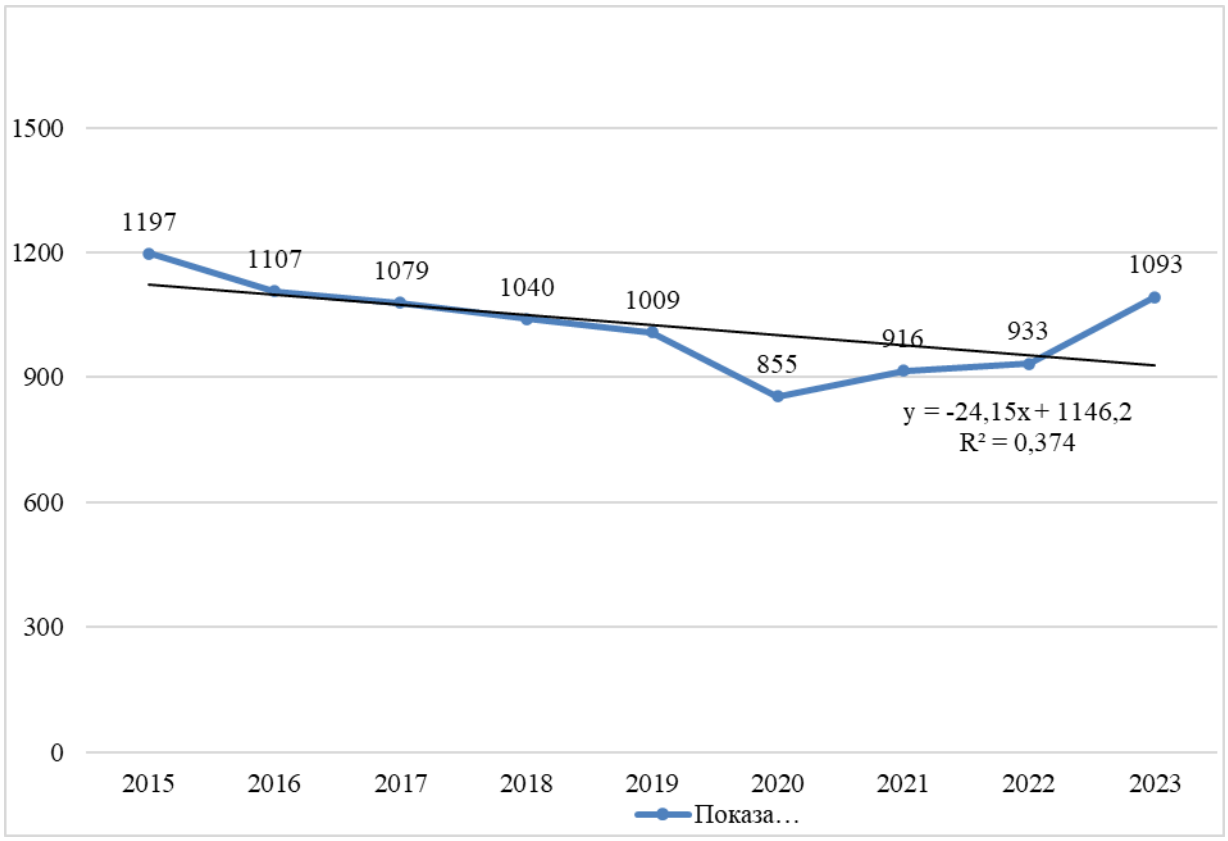


Figure 6 - Changes in the mortality rate of children from external causes in the Republic of Kazakhstan for 2015–2023 (absolute values)

Source: compiled by the authors

The analysis of the dynamics indicates a wave-like trajectory of mortality from external causes. The decline observed up to 2020 can be interpreted as the result of preventive measures and restrictions implemented during the pandemic. The sharp increase after 2020 requires special attention in the context of the restoration of social activity, the psycho-emotional state of children and adolescents, as well as the possible weakening of preventive measures. It is necessary to develop interagency strategies aimed at preventing accidents, injuries, suicides, and other external causes of death among the child population, with a particular focus on the school-age group.

Since birth rates and mortality are key indicators of demographic processes in the development of a country's population, studying the relationship between birth rates and mortality among children aged 0 to 17 years for the period 2015–2024 will make it possible to identify trends in child mortality against the backdrop of overall birth rates, as well as to establish cause-and-effect relationships between the dynamics of natural population reproduction and the health status of the child population.

Analysis of overall birth rates in the Republic of Kazakhstan for the period 2015–2024.

The ten-year period in the country was characterized by alternating phases of growth and decline in overall birth rates. In 2015, the birth rate was 21.49%, and in 2016 a slight increase was observed, with an absolute growth of +0.13 and a growth rate of 0.6%. In 2017, the birth rate in the Republic of Kazakhstan declined (–0.32; –1.48%). However, beginning in 2018, the indicator began to recover (+2.58%), and by 2020 it had reached its peak value of 22.95% (+3.85% compared to the previous year and +6.79% relative to 2015; see Table 7). This dynamic may be explained by changes in population behavioral patterns during COVID-19 restrictions.However, studies of birth rates in high-income countries during the COVID-19 pandemic demonstrated so-called "demographic rollercoasters," meaning a sharp decline in birth rates during the pandemic followed by recovery in the post-pandemic period. For example, Western European countries in 2021 showed an increase in birth rates compared to the pre-pandemic period [49].

In the subsequent years, the Republic of Kazakhstan experienced a moderate decline in the indicator from 21.75% in 2021 to 21.2% in 2024which may be associated with the economic consequences of the pandemic and a decrease in the proportion of women of reproductive age. This assumption has empirical support and is confirmed by the findings of several authors who demonstrate a link between post-pandemic economic instability and birth rates [49, 50, 51, 52].

Overall, the average annual birth rate was approximately 21.8%, which corresponds to a high birth rate according to the WHO classification [53].

Table 7 - Dynamics of the birth rate in the Republic of Kazakhstan for 2015–2024 with calculations of absolute increase, growth rate, rate of increase, and visibility coefficient relative to the baseline year.

Year	Birth rate	Absolute increase	Growth rate, %	Rate of increase, %	Visibility coefficient relative to 2015, %
2015	21,49				100
2016	21,62	0,13	100,6	0,6	100,6
2017	21,3	-0,32	98,52	-1,48	99,12
2018	21,85	0,55	102,58	2,58	101,68
2019	22,1	0,25	101,14	1,14	102,84
2020	22,95	0,85	103,85	3,85	106,79
2021	21,75	-1,2	94,77	-5,23	101,21
2022	21,1	-0,65	97,01	-2,99	98,19
2023	20,8	-0,3	98,58	-1,42	96,79
2024	21,2	0,4	101,92	1,92	98,65
Source: compiled by the authors					

The conducted analysis revealed significant differences between the regions of the country. High birth rates were observed over the ten-year period in the Mangystau Region (average value 29.38), while the lowest rate was recorded in the North Kazakhstan Region (average value 12.2%). Thus, the range of regional differences reaches a 2.4-fold variation, indicating territorial disparities in the natural reproduction of the population of the Republic of Kazakhstan (see Fig. 7).

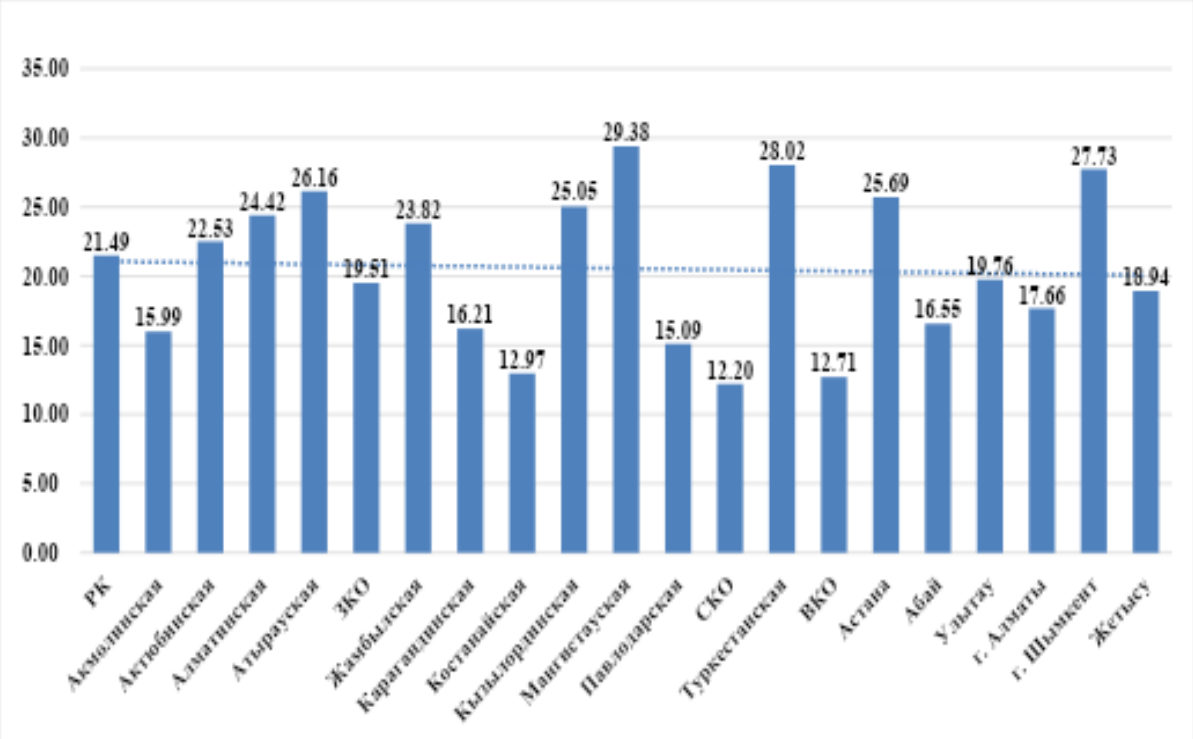


Figure 7 – Range of average birth rates by region in Kazakhstan, 2015–2024/
Source: compiled by the authors.

Analysis of Natural Population Growth in the Republic of Kazakhstan and Its Regions

Natural population growth (hereinafter NPG) – the difference between birth and death rates per 1,000 people – is a key indicator reflecting demographic dynamics, particularly the processes of population renewal. A positive NPG indicates an increase in population through natural reproduction, while a negative value signals depopulation trends and population aging [53].

For the period 2015–2024, the average birth rate was 21.49%, while the overall mortality was 7.44%, which demonstrates a positive natural increase (+14.05%), therefore the population increases annually by 1.4% (see Table 8, Figure 8).

Table 8. Average values of birth rates, death rates, and natural population growth by region of the Republic of Kazakhstan for 2015–2024

Region	Birth Rate	Death Rate	Natural Population Growth (NPG)
Republic of Kazakhstan	21,485	7,438	14,047
Akmola Region	15,989	10,119	5,870
Aktobe Region	22,527	6,757	15,770
Almaty Region	24,423	6,573	17,850
Atyrau Region	26,160	5,912	20,248
West Kazakhstan	19,506	8,833	10,673
Zhambyl Region	23,815	6,782	17,033
Karaganda Region	16,206	10,002	6,204
Kostanay Region	12,969	10,904	2,065
Kyzylorda Region	25,053	5,873	19,180
Mangystau Region	29,383	4,624	24,759
Pavlodar Region	15,091	10,283	4,808
North Kazakhstan	12,204	12,359	-0,155
Turkestan Region	28,019	5,257	22,762
East Kazakhstan	12,705	10,604	2,101
Astana	25,694	4,313	21,381
Abai	16,550	8,930	7,620
Ulytau	19,757	8,620	11,137
Almaty City	17,655	6,448	11,207
Shymkent City	27,726	4,976	22,750
Zhetysu	18,937	7,150	11,787
Source: compiled by the authors.			

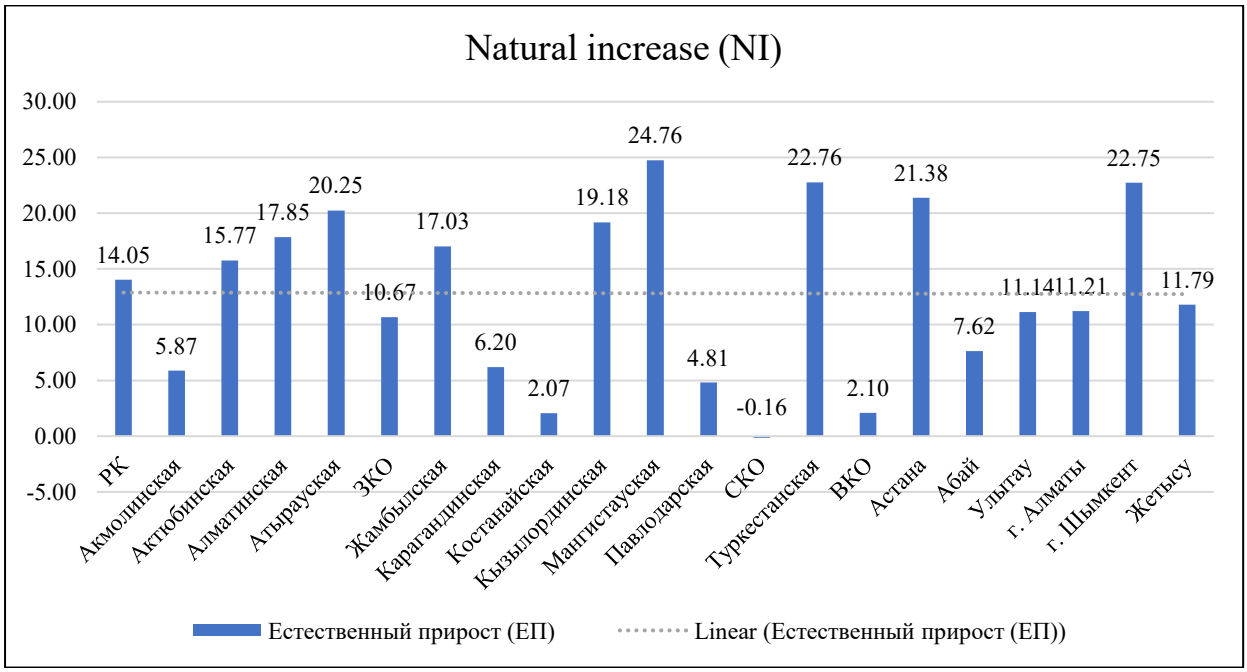


Figure 8. Natural population growth by regions of Kazakhstan, average values for 2015–2024.

Source: compiled by the authors

Overall, the Republic of Kazakhstan demonstrates high rates of population growth, with the maximum natural increase (NI) recorded in Mangystau Region (+24.76%), followed by Turkestan Region (+22.76%), Atyrau

Region (+20.25%), and the city of Shymkent (+22.75%). Average NI values were observed in Akmola Region (+5.87%), Karagandy Region (+6.2%), Pavlodar Region (+4.81%), and other regions, where the natural increase is positive but significantly lower than in the previously mentioned areas. The lowest NI values were recorded in East Kazakhstan Region (+2.1%) and Kostanay Region (+2.06%), indicating a slowdown in population growth rates. This trend is likely associated with population outflows; according to the National Statistics Bureau (2024), negative internal migration balances persisted mainly in the northern and eastern regions of Kazakhstan (Kostanay, North Kazakhstan, East Kazakhstan). Key factors driving internal migration include economic instability, youth and adolescent unemployment, demographic aging, and infrastructural challenges [55].

Thus, the indicators of natural population growth from 2015 to 2024 demonstrate high demographic heterogeneity, where targeted measures of demographic policy aimed at stimulating birth rates and improving the quality of medical care in depopulating regions are necessary to mitigate regional differences.

Returning to the issue of child mortality from ages 0 to 17, the level of natural population growth depends on the ratio of birth rates to death rates, where child mortality from 0 to 17 years represents one of the most important factors affecting the dynamics of population reproduction. An increase in child mortality is reflected in a decrease in natural population growth, while a reduction in child mortality serves as an indicator of the effectiveness of a country's healthcare system.

In conclusion, it is appropriate to cite the words of American demographer Samuel H. Preston: "…Mortality is one of the most important indicators of social inequality, as it shows how successful a group is in providing its members with the most valuable of all goods – life itself…," which most fully articulates the essence of our conclusion regarding the importance of child mortality as an indicator of population health and social justice in any society [29].

DISCUSSION

The conducted retrospective analysis made it possible to identify a general trend of decreasing child mortality in the Republic of Kazakhstan over the ten-year period (from 2015 to 2024), but with pronounced regional and temporal variations. A similar pattern is observed in middle-income countries [7, 30, 31], indicating a complex structural picture of child mortality, where medical factors are intertwined with socio-economic determinants [32].

The results of scientific studies indicate that an increase in the share of healthcare system funding directly affects the reduction of child mortality and the improvement of population health [33, 34, 35], thereby allowing the conclusion about the key role of healthcare financing in the country's demographic well-being. According to data from the World Health Organization (WHO), the share of healthcare expenditures in the total GDP of the Republic of Kazakhstan in 2022 was 3.74% [36]; in comparison, in European Union countries, the average share of healthcare expenditures in 2022 was approximately 10.4% of GDP [37]. Data from the UNFPA report, indicating a growth in per capita income in the Republic of Kazakhstan and an insignificant trend in poverty reduction [38], as well as the results of several studies revealing a direct link between family income levels and child mortality [39, 40, 41], allow us to conclude that the material well-being of families is a critically important factor influencing child mortality alongside the share of healthcare system funding. Therefore, an in-depth study of the population's material well-being in countries contributes to addressing the demographic issue.

Fluctuations in child mortality rates from infectious and parasitic diseases over the ten-year period showed a tendency to increase, with the minimum values observed in 2018. Starting from 2019, an upward trend was noted, despite a short-term decline in the post-pandemic period (2020), which was possibly due to a reduction in the scope of preventive measures and population health monitoring. This assumption is supported by the findings of Howard-Jones AR (2022), which indicate an increase in infectious diseases among children due to the reduction of outpatient and school-based medical-preventive programs during the COVID-19 pandemic [16].

Child mortality rates from diseases of the circulatory system and neoplasms over the period 2015–2024 also reflected a variable trend, which may have been caused by insufficient levels of early detection and uneven access to specialized medical care. The critically important role of access to specialized medical care and its association with child mortality rates is highlighted in the findings of several studies [42, 43, 44].

Particular concern was raised by the data from the study on the oscillatory trend of adolescent mortality in the Republic of Kazakhstan for the period from 2015 to 2024, where the key causes were preventable factors, primarily child mortality due to road traffic accidents and mortality from adolescent suicides, although the coefficient of determination over ten years was $R^2 = 0.374$, which indicates the presence of additional influencing factors, possibly social or organizational, WHO data confirms the key role of preventable causes of mortality among adolescents worldwide [45], therefore, reducing adolescent mortality rates requires strengthening the school healthcare system in the Republic of Kazakhstan.

The study results revealed that pathological conditions of the digestive and respiratory systems are consistently leading causes of child mortality in the country and indicate the need to strengthen outpatient and inpatient pediatric care in the Republic of Kazakhstan. Global practice demonstrates that with an effective model of a comprehensive, multi-level program - including early diagnosis, active monitoring of at-risk groups using standardized protocols, and the active integration of specialized medical care centers into pediatric services - it is possible to reduce child mortality rates [46, 47, 48].

The present study had several limitations, which need to be listed, these are – the absence of data on the role of socio-demographic and medical characteristics of mothers, the infrastructural characteristics of medical

institutions at the regional level were not taken into account, there were no data on the impact of environmental factors on child mortality indicators, which emphasizes the need for an in-depth analysis of the issue of child mortality in the Republic of Kazakhstan.

CONCLUSION

Thus, the analysis of child mortality in the age group 0–17 years for the period 2015–2024 in the Republic of Kazakhstan allowed the following conclusions to be drawn:

1. The neonatal age is the most sensitive, with on averge half of child mortality cases occurring in children under one year of age, thereby emphasizing the need to strengthen the neonatal services in the Republic of Kazakhstan;
2. In adolescence, the main share of mortality causes is attributable to preventable factors, this conclusion indicates the necessity to strengthen the school health system in the Republic of Kazakhstan;
3. Analysis of the dynamics of the indicator revealed an increase in child mortality during the COVID-19 pandemic, which points to the need for the readiness of the healthcare system and immediate response in emergency situations, technological disasters, and natural calamities;
4. The linear regression method confirmed the presence of a statistically significant trend of decreasing child mortality in the Republic of Kazakhstan, but regional and age-specific characteristics require a targeted approach to addressing the problem of child mortality, including among school-age children and children with limited health capacities.

Thus, the results of the study reflect a comprehensive approach to addressing the issue of child mortality, namely the strengthening of neonatal services, as well as the reinforcement and enhancement of the school health system.

Practical Recommendations

According to the conducted analysis of child mortality, including school-age children, for the period 2015–2024, it is necessary to implement a series of comprehensive measures, including: improving the maternal and child healthcare system, particularly in the area of perinatal and neonatal care, which is justified by the mortality rates among children under 1 year of age.

Strengthening the school medicine system in the Republic of Kazakhstan as a key tool for early prevention of preventable causes of mortality among schoolchildren, enhancing psychosocial support for schoolchildren and their families, including families raising children with disabilities, since the analysis included mortality among all children, including school-age children of the Republic of Kazakhstan, as well as children with developmental disabilities.

Strengthening early detection of chronic diseases among schoolchildren, conducting in-depth studies dedicated to the health issues of schoolchildren in the Republic of Kazakhstan. Increasing attention to families raising children with disabilities, as these families face a higher risk of psycho-emotional exhaustion, social tension, and difficulties in accessing medical care, which underscores the role of early intervention within the framework of school medicine.

The need for extensive in-depth studies dedicated to investigating the causes of child mortality, including school-aged children, broken down by specific nosological groups, the results of which will allow the development of targeted preventive measures.

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About the Authors

1. Djainakbaev Nurlan Temirbekovich - Doctor of Medical Sciences, Professor, Rector of the Non-Profit Organization «Kazakh-Russian Medical University»; e-mail: rector@medkrmu.kz. https://orcid.org/0000-0002-0579-8109/.
2. Zhubanysheva Karlygash Birzhanovna - Doctor of Medical Sciences, Professor at the Non-Profit Organization «Kazakh-Russian Medical University»; e-mail: karlygash77@bk.ru ; https://orcid.org/0000-0002-4222-661X.
3 Khituova Lidiya Kikbaevna – Associate Professor (Docent) of the Department of Pediatrics with a course on Pediatric Infectious Diseases, at the Non-Profit Educational Organization «Kazakh-Russian Medical University»; e-mail: khituovalk@mail.ru/ https://orcid.org/0000-0002-0368-4773/.
4. *Tursun Anna Olegovna – PhD candidate in the educational program «Public Health» at the Kazakh-Russian Medical University; e-mail: a.tursun@medkrmu.kz. ORCID: 0009-0003-9264-8823.
5. Nugmanova Aigul Maratovna - Doctor of Medical Sciences, Head of the Department of Children diseases with a course in pediatric Infectious Diseases Non-Governmental Organization «Kazakhstan-Russian Medical University»; e-mail: aigulmaratovna@mail.ru. ORCID: 0000-0002-9167-5892.
6. Kachurina Dilara Radikovna, MD, Doctor of Medical Sciences, Senior Lecturer of the Neonatology Postgraduate Education Course, Non-Governmental Organization «Kazakhstan-Russian Medical University»; e-mail: kachurinadilara@gmail.com . ORCID:000900945282316.

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