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ARTICLE

Mortality Rates of Ventricular Septal Defect for Children in Kazakhstan: Spatio-Temporal Epidemiological Appraisal

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ABSTRACT

Objective: The aim is to study the trends in ventricular septal defect (VSD) mortality in children in Kazakhstan. **Methods:** The retrospective study was done for the period 2011–2020. Descriptive and analytical methods of epidemiology were applied. The universally acknowledged methodology used in sanitary statistics is used to calculate the extensive, crude, and age-specific mortality rates. **Results:** Kazakhstan is thought to be seeing an increase in mortality from VSDs in children. As a result, this study for the years 2011 to 2020 was conducted to retrospectively assess data from the central registration of the Bureau of National Statistics that was available throughout the nation. Age-standardized mortality data were obtained and compared between age categories. It was shown that 507 children died from this condition throughout the time period under study. The average annual standardized mortality rate was 1.88 per 100,000 population and tended to decrease over time. The peak of mortality was noted at the age of up to 1 year, namely the neonatal period. Cartogram mortality rates were calculated using standardized indicators. Additionally, age-sex variations were taken into account when performing all calculations. **Conclusion:** In recent years, the death rate from VSD has declined from 1.5 to 0.6 per 100,000 people, with the trend remaining constant (T = 1.4%, R^2 = 0.5825). The analysis of mortality trends related to VSD is crucial in both theoretical and practical aspects, as it enables early detection and treatment of VSDs. The findings of this study will be valuable to public health authorities in developing a strategy to treat VSDs effectively.

KEYWORDS

Ventricular septal defect; children mortality; geographical variation; kazakhstan

1 Introduction

Congenital heart defects (CHDs) are the most prevalent type of all major congenital anomalies in the world, influencing millions of newborns every year [1,2]. Moreover, CHDs are the leading cause of birth defects which are related to morbidity, mortality, and expanded healthcare costs [3]. Also, nine out of ten of the world's babies born with CHD live in locations with little or no care and where mortality remains high [4]. Even though there are a lot of types of CHDs, ventricular septal defects (VSDs) are one-third of

the most commonly diagnosed heart defects [5,6]. Moreover, the detection of VSDs has increased due to the improvement of diagnostic methods in the last few decades [7]. The VSDs occur at a rate of 0.5 per 1000 live births and in 4.5 to 7 of 1000 preterm children [8]. Approximately 20% of the VSDs can exist in isolation and, if one includes VSDs in combination with other abnormalities, the VSDs are diagnosed in 50% of all patients with CHDs [9]. Despite the abovementioned combinations, the cause of the VSDs may be associated with chromosomal disorders, which account for about 5% of cases (such as trisomy 21 and 22q11 deletion) [10].

Ventricular septal defects accounted for (36.77%) of all CHDs between 2000 and 2020, according to statistics provided by the European Commission on CHDs [11]. Also, the prevalence of ventricular septal defect in East Africa was found to be 29.92% [12,13]. According to a meta-analysis by Lui et al. published in 2019, including global data on the prevalence of CHDs from 260 studies (130,758,851 births), it was found that VSDs took the leading position, in particular, rising whole the study period, reflecting progressed detection [14,15].

Based on statistics provided by the Centers for Disease Control and Prevention (CDC) from Atlanta appraisal that 42 of every 10,000 births had a ventricular septal defect [16]. This indicates that 16,800 infants are born in the United States (US) each year with a ventricular septal defect [17]. Alternatively stated, around 1 in every 240 infants born in the US every year have a ventricular septal defect [18]. In the Republic of Kazakhstan, the frequency of congenital heart defects among live births is 8–10 per 1000, and the total number of children born with congenital heart defects is about 3000 per year [19,20].

Currently, treatment options for ventricular septal defects may include regular check-ups, medication, and surgical therapy. Approximately 75% of small VSDs do not require surgery and close spontaneously in the first year of life. The rate of spontaneous closure for medium to large VSDs is between 5% and 10% and in other cases, surgical closure is required. If the VSD hasn't closed by the age of 10, spontaneous closure is likely not to occur at all [21,22]. There are three surgical methods for ventricular septal defect: the traditional method with a heart-lung machine, the interventional method, and the hybrid method without the heart-lung machine [23–26]. Based on most studies that have long-term outcomes in people operated on for surgical closure of the VSDs in infancy, they showed good results. However, if the operation is not done on time, as a result of the persistent left-to-right shunt will occur in pulmonary hypertension and Eisenmenger syndrome [27,28].

The study's objective is to assess the temporal and spatial trends of VSD mortality in Kazakhstan while accounting for administrative-territorial division.

2 Materials and Methods

2.1 Data Sources

According to data from the Bureau of National Statistics (BNS) of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, ventricular septal defect (VSD) was recorded as the primary cause of mortality from 2011 to 2020. Beginning in 2011, records of mortality were kept electronically. Causes of mortality were classified using the International Classification of Diseases (ICD): Q-21.0 in ICD-10. The data of mortalities were collected by year of death along with details on birth year, age at death, and sex. The inclusion criteria for the sample were as follows: patients with isolated VSD (perimembranous, muscular, atrioventricular conal type, and subarterial) from birth to 18 years, as well as those with infectious complications. Exclusion criteria included: the combination of VSD with other CHD. Data were distributed into five age groups—under 1 year (infants), 1 to 2 years (toddlers), 3 to 6 years (preschool), 7 to 11 years (school age), and 12 to 17 years (adolescent) —to prevent disclosure.

2.2 Statistical Analysis

The main method used in the study of mortality was a retrospective study using descriptive and analytical methods of epidemiology. Age-standardized mortality rates (ASRs) were calculated for five different age groups (0–1, 1–2, 3–6, 7–11, and 12–17) and ten calendar periods from 2011 to 2020 (1-year intervals). ASRs standardized to the world population proposed by World Health Organization [29] were calculated for each analyzed year.

The infant mortality rate (IMR) was estimated for 10 years period (2011–2020) for each year. The percentage of death distribution under 1 year was defined by age on a daily basis.

According to the commonly used methodology in sanitary statistics, the extensive, crude rate (CR) and age-specific mortality rates (ASMR) were calculated. Calculations were made using the annual averages (M, P), mean error (m), 95% confidence interval (95% CI), and average annual upward/downward rates (T%) [30]. The least squares method was used for determining the dynamics of mortality rates for 10 years. The average annual growth/decline rates (T%) were calculated using a geometric mean.

When creating cartograms, crude rates, and ASRs were used for 10 years (2011–2020). The process for creating a cartogram, first proposed by S.I. Igisinov in 1974, was employed, and it was based on calculating the standard deviation (σ) from the average (x). The formula used to calculate the scale of steps is as follows: using as an interval, the maximum and minimum mortality levels were calculated using the formula: $x \pm 1.5\ \sigma$, with the minimum indicator being equal to $x - 1.5\ \sigma$ and the highest being equal to $x + 1.5\ \sigma$.

Viewing and analyzing the materials were received using the Microsoft 365 software package, in addition, online statistical calculators were used (https://medstatistic.ru/calculators/calcdynamic.html).

2.3 Ethics Approval

An ethics review board's examination and approval were not necessary because this study only involved the analysis of publicly accessible administrative data and did not involve contacting any participants.

3 Results

During the 10 years (2011–2020), 507 children from birth to 17 years old inclusive died from VSD, of which 251 (49.5%) were boys and 256 (50.5%) were girls. The majority of VSDs observed in the study had a large diameter, but only 95 patients were operated while the remaining children did not receive any surgical treatment. However, all patients received medications for heart failure (including diuretics and ACE inhibitors). In Kazakhstan, a significant share of deaths from VSD was identified for infants and children aged from 1 to 2 years for both sexes −82.6% and 11.5% of all childhood deaths, respectively.

In most cases, a fatal outcome results from a viral or bacterial infection acquired at home, with the possible development of sepsis. Also, accession of nosocomial infection in a hospital due to various reasons, such as prolonged artificial ventilation of the lungs due to severe pulmonary and heart failure. As a result of the already-developed sepsis and multiple organ failure, the patient could not be transferred to a specialized cardiac surgery clinic for surgical treatment. In addition, genetic diseases are rarely diagnosed due to the high cost of research, and the lack of a clear algorithm for compensating the financial costs of additional laboratory tests outside the nosology with which the patient was admitted to the clinic further complicates matters.

The most numerous numbers of deaths from VSD according to the distribution by age was in the group of children under 1 year–419 deaths, or 82.6% of all children deaths (Table 1). The proportion of deaths from VSD by age group among boys and girls was similar within the population.

Table 1: Number and mortality rate of VSD by age in Kazakhstan for the period from 2011 to 2020

Age	All				Boy				Girl			
	Number (%)	Mortality			Number (%)	Mortality			Number (%)	Mortality		
		Per 100,000	T, %	R^2		Per 100,000	T, %	R^2		Per 100,000	T, %	R^2
Under 1	419 (82.6)	10.96 ± 2.35	−7	0.6105	204 (81.3)	10.38 ± 2.63	−9	0.4751	215 (84)	11.59 ± 2.44	−6	0.5313
1–2	58 (11.5)	0.78 ± 0.27	−6	0.1559	36 (14.3)	0.94 ± 0.41	−4	0.0749	22 (8.59)	0.61 ± 0.22	−3	0.8859
3–6	10 (1.97)	0.07 ± 0.04	0	0.0505	4 (1.6)	0.06 ± 0.05	0	0.0454	6 (2.34)	0.09 ± 0.06	0	0.0185
7–11	7 (1.38)	0.06 ± 0.05	−100	0.4107	2 (0.8)	0.03 ± 0.04	−100	0.4848	5 (1.95)	0.08 ± 0.08	−100	0.2056
12–17	13 (2.55)	0.09 ± 0.04	0	0.2727	5 (2)	0.07 ± 0.06	0	0.0815	8 (3.12)	0.11 ± 0.09	0	0.0808
CR	507 (100)	0.96 ± 0.22	−7	0.5825	251 (100)	0.92 ± 0.25	−7	0.4244	256 (100)	0.99 ± 0.22	−6	0.5133
ASMR		0.94 ± 0.34	0.14	0.5826		0.90 ± 0.40	0.14	0.6148		0.92 ± 0.36	0.14	0.5508

Notes: T, average annual upward/downward rates; R^2, the value of the approximation confidence; CR, crude rate; ASMR, age-standardized mortality rate.

Infant mortality rate (IMR) was the highest mortality rate for ten years from 2011 to 2020. Within the period IMR of VSD reduced by 56% from 0.16 per 1000 in 2011 to 0.07 per 1000 in 2020 (Fig. 1).

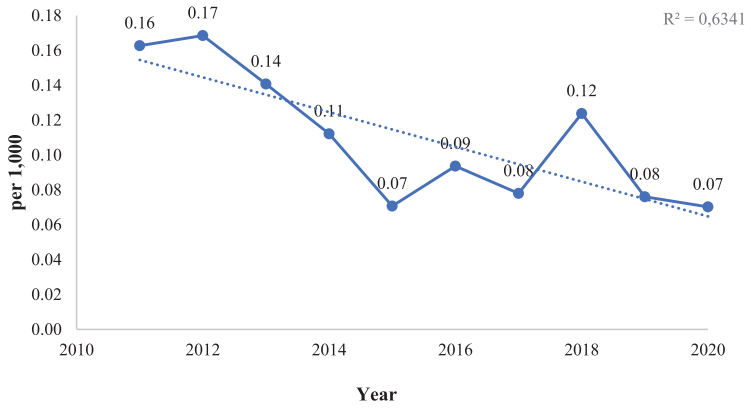

Figure 1: Infant mortality rates in Kazakhstan, for the period from 2011 to 2020

As shown in Fig. 2 the highest mortality was observed in the neonatal period which was the riskiest for children. For the analysed period of ten years 151 deaths, or 36% of overall 419 children's deaths, occurred in the neonatal period.

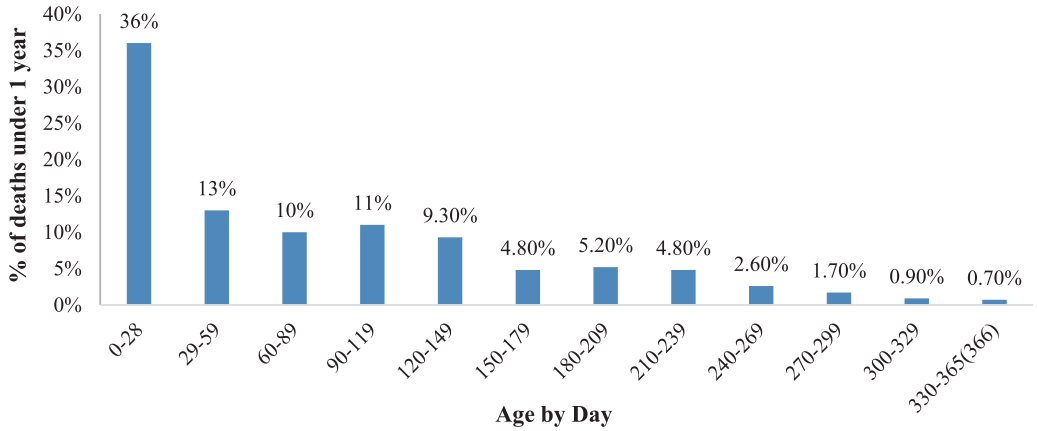

Figure 2: Age-by-day distribution of VSD deaths under 1 year in Kazakhstan, for the period from 2011 to 2020

Table 2 indicates a sharp decrease in infants' deaths after 29 days from birth. Thus, more than 150 deaths were in the neonatal period and around 55 deaths for 29–59 days of children. The downward trend persists during the postneonatal period, and the number of deaths decreases from 54 deaths, or 13% of all infants' death, for 29–50 days infants to 3 deaths, or 0.7% of all infants' death, for 330–365 days infants.

Table 2: Number and percentage of VSD infant deaths by days in Kazakhstan for the period from 2011 to 2020

Under 1 year (age by day)	0–28	29–59	60–89	90–119	120–149	150–179	180–209	210–239	240–269	270–299	300–329	330–365 (366)	Total (2011–2020)
Number (%)	151 (36)	54 (13)	42 (10)	46 (11)	39 (9,3)	20 (4,8)	22 (5,2)	20 (4,8)	11 (2,6)	7 (1,7)	4 (0,9)	3 (0,7)	419 (100)

Fig. 3 provides data about children's mortality by age distribution. The mortality rate decreases steadily from birth to 17 years, from the highest mortality of 10.96 per 100,000 population for the age group under 1 year to 0.09 per 100,000 population for 12 years children.

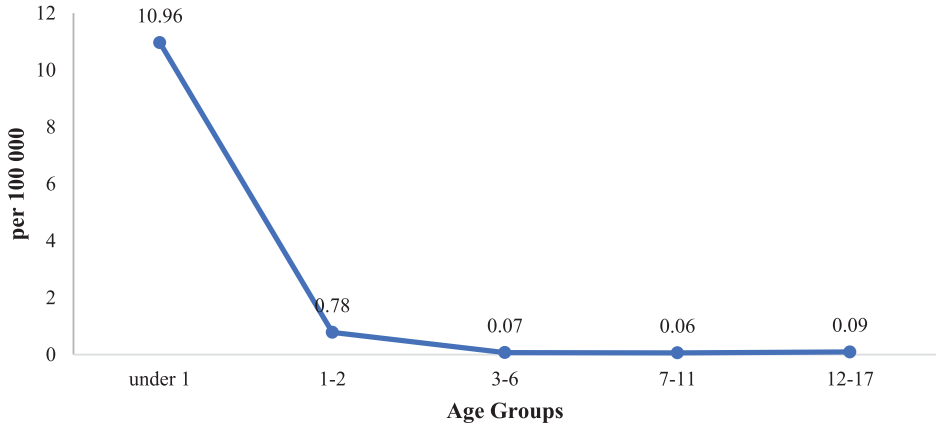

Figure 3: Age distribution of VSD mortality in Kazakhstan, for the period from 2011 to 2020

From 2011 to 2022 the standardized children mortality rate from VSD was 1.88 per 100,000 population in Kazakhstan. For the period the average annual growth rate was T = −2% (R^2 = 0.9971).

According to Fig. 4, crude rates of VSD mortality for children decreased from 1.55 ± 0.2 (95% CI = 1.5–1.6) in 2011 to 0.61 ± 0.2 (95% CI = 0.56–0.66) in 2020 per 100,000, with the average being 0.96 ± 0.22 (95% CI = 0.91–1.0).

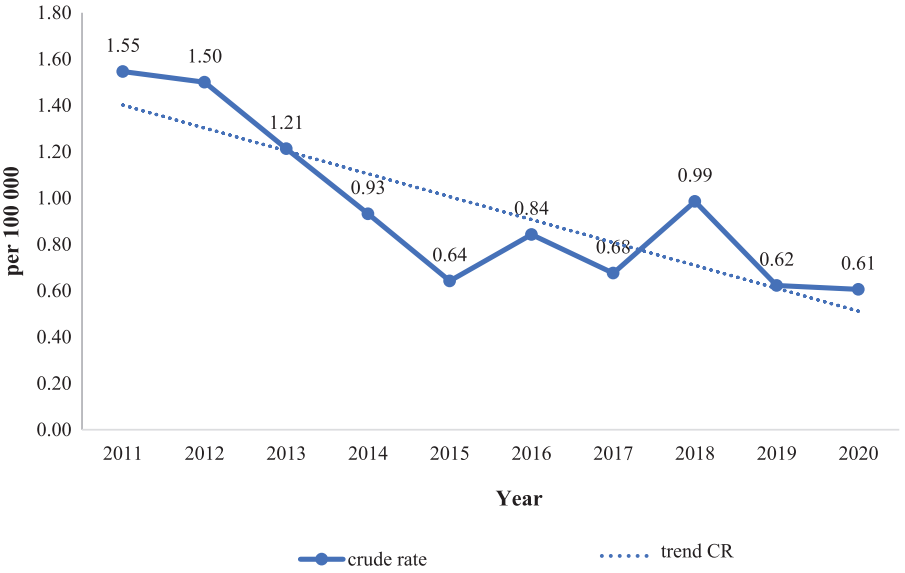

Figure 4: Dynamics of VSD mortality in Kazakhstan, for the period from 2011 to 2020

The 95% CI of the indicators do not overlap with one another, suggesting that these indicators are influenced by different factors, and the average annual rate of mortality decline by VSD was significant (T = −7%), demonstrating a real decline in mortality from this type of congenital heart defect in Kazakhstan. Additionally, the moderate degree of approximation reliability (R^2 = 0.5825) supports this conclusion.

This, as reported by Fig. 5A, spatial assessment of mortality from VSD in the entire population shows that the following regions, including North Kazakhstan, Akmola, Astana City (capital city), Atyrau, and South Kazakhstan were among the regions with the lowest mortality rate. This applies to both boys and girls, as can be seen in Figs. 5B and 5C, respectively. For boys regions (Fig. 5B) with the lowest mortality rate also include Aktobe and Pavlodar, for the Atyrau region mortality rate for boys is moderate. Overall, the lowest mortality rate for boys was in North Kazakhstan. For girls (Fig. 5C), the lowest mortality rate was in Astana. According to the cartogram from VSD mortality in Fig. 5A the southern regions (Kyzylorda, Zhambyl), Kostanay, and Mangystau had the highest mortality rates for the entire population. The highest mortality rate for boys (Fig. 5B) was in Kostanay, and for girls (Fig. 5C) in Mangystau. In the remaining regions, including Almaty, West Kazakhstan, Aktobe, Pavlodar, East Kazakhstan, and Karaganda the mortality rate from VSD was moderate.

More detailed information about geographical variation in VSD mortality in Kazakhstan is provided in Table 3.

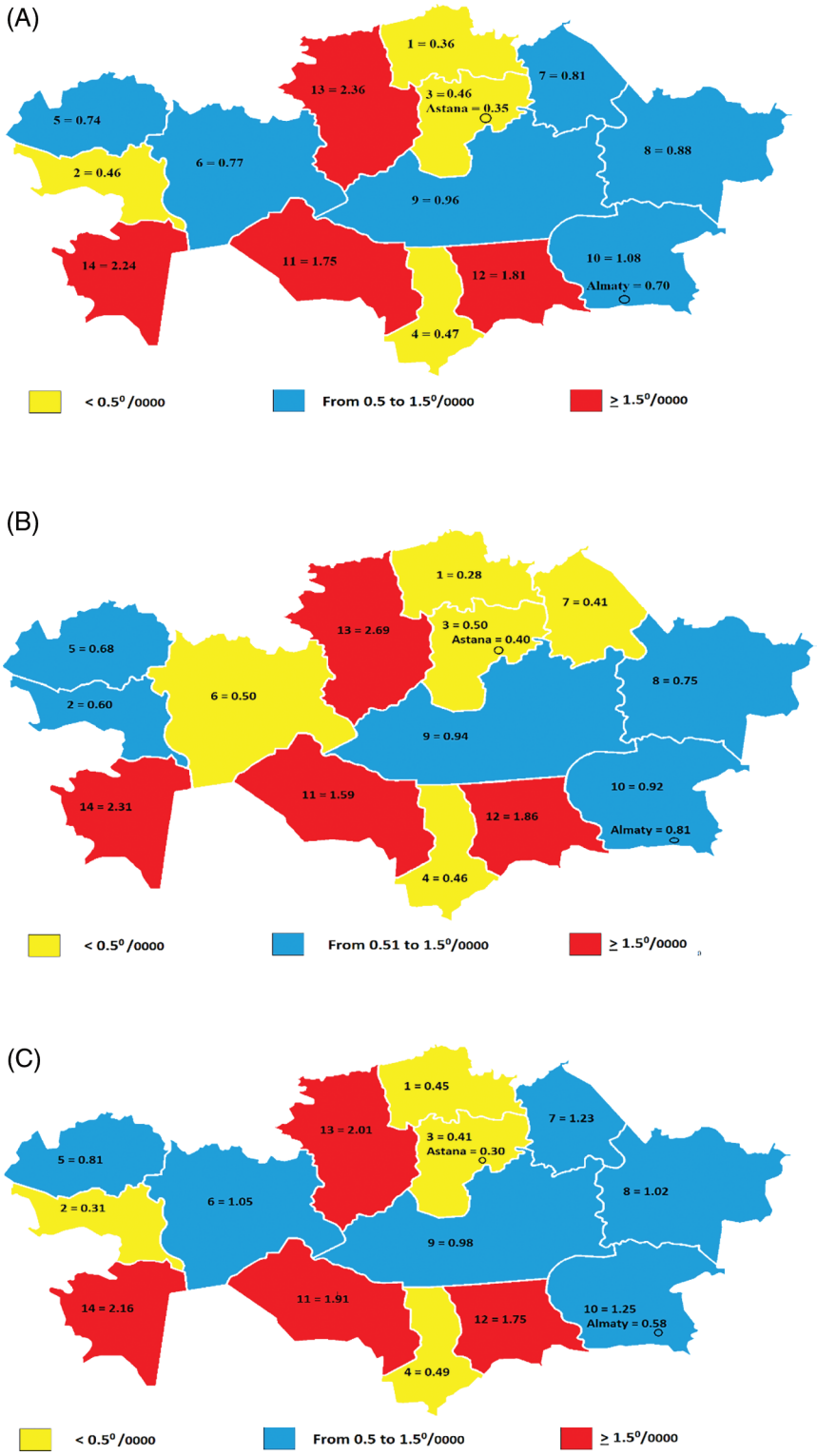

Figure 5: Cartogram of VSD mortality in Kazakhstan, for the period from 2011 to 2020 (A-both sexes, B-boys, C-girls)

Regions: 1. North Kazakhstan, 2. Atyrau, 3. Akmola, 4. South Kazakhstan, 5. West Kazakhstan, 6. Aktobe, 7. Pavlodar, 8. East Kazakhstan, 9. Karaganda, 10. Almaty, 11. Kyzylorda, 12. Zhambyl, 13. Kostanay, 14. Mangystau

Table 3: Number and mortality rate of VSD in the Regional Aspect, for the period from 2011 to 2020

Region	All				Male				Female			
	Number (%)	Mortality			Number (%)	Mortality			Number (%)	Mortality		
		Per 100 000	T, %	R^2		Per 100 000	T, %	R^2		Per 100 000	T, %	R^2
Astana city	8 (1.58)	0.35 ± 0.23	−100	0.1385	5 (1.99)	0.40 ± 0.34	−100	0.0061	3 (1.17)	0.30 ± 0.30	−100	0.2439
North Kazakhstan	5 (0.99)	0.36 ± 0.32	−7	0.0061	2 (0.80)	0.28 ± 0.37	−100	0.0303	3 (1.17)	0.45 ± 0.45	0	0.0014
Atyrau	9 (1.78)	0.46 ± 0.41	−100	0.1483	6 (2.39)	0.60 ± 0.59	−100	0.1443	3 (1.17)	0.31 ± 0.31	0	0.0707
Akmola	9 (1.78)	0.46 ± 0.28	0	0.0742	5 (1.99)	0.50 ± 0.44	−100	0.1946	4 (1.56)	0.41 ± 0.33	0	0.0202
South Kazakhstan	56 (11.05)	0.47 ± 0.39	4	0.3537	28 (11.16)	0.46 ± 0.46	15	0.3109	28 (10.94)	0.49 ± 0.34	−4	0.3697
Almaty city	25 (4.93)	0.70 ± 0.47	−9	0.3025	15 (5.98)	0.81 ± 0.49	−4	0.2861	10 (3.91)	0.58 ± 0.63	−15	0.1592
West Kazakhstan	13 (2.56)	0.74 ± 0.34	−7	0.1351	6 (2.39)	0.68 ± 0.59	−100	0.1894	7 (2.73)	0.81 ± 0.50	0	0.0007
Aktobe	18 (3.55)	0.77 ± 0.45	−100	0.7812	6 (2.39)	0.50 ± 0.36	−100	0.5399	12 (4.69)	1.05 ± 0.69	−100	0.5570
Pavlodar	15 (2.96)	0.81 ± 0.41	−7	0.2640	4 (1.59)	0.41 ± 0.33	0	0.0051	11 (4.30)	1.23 ± 0.71	−7	0.4171
East Kazakhstan	30 (5.92)	0.88 ± 0.41	−15	0.7165	13 (5.18)	0.75 ± 0.54	−100	0.4235	17 (6.64)	1.02 ± 0.44	−13	0.6013
Karaganda	34 (6.71)	0.96 ± 0.54	−5	0.2659	17 (6.77)	0.94 ± 0.62	−4	0.2382	17 (6.64)	0.98 ± 0.49	−7	0.2577
Almaty	70 (13.81)	1.08 ± 0.28	21	0.2135	31 (12.35)	0.92 ± 0.38	15	0.2241	39 (15.23)	1.25 ± 0.62	0	0.0154
Kyzylorda	47 (9.27)	1.75 ± 0.84	−12	0.7087	22 (8.76)	1.59 ± 0.80	−9	0.5800	25 (9.77)	1.91 ± 1.08	−100	0.5394
Zhambyl	70 (13.81)	1.81 ± 0.87	−20	0.5061	37 (14.74)	1.86 ± 0.97	−21	0.4682	33 (12.89)	1.75 ± 0.80	−19	0.5207
Mangystau	50 (9.86)	2.24 ± 0.70	−4	0.0818	26 (10.36)	2.31 ± 0.78	−10	0.4453	24 (9.38)	2.16 ± 1.06	0	0.0094
Kostanay	48 (9.47)	2.36 ± 1.04	−8	0.4497	28 (11.16)	2.69 ± 1.19	−10	0.5448	20 (7.81)	2.01 ± 1.29	−4	0.1544
Kazakhstan	507 (100.0)	0.96 ± 0.22	−7	0.5825	251 (100)	0.92 ± 0.25	−7	0.4244	256 (100)	0.99 ± 0.22	−6	0.5133

Notes: T, average annual upward/downward rates; R^2, the value of the approximation confidence;
* The table is built taking into account the sorting from A to Z of the mortality rate.

For all regions, the minimum indicator of average annual growth rates was in North Kazakhstan (T = −7.0%; R^2 = 0.0061), and the maximum in Aktobe (T = −100%; R^2 = 0.7812). By a level of approximation, the highest was East Kazakhstan (R^2 = 0.7165) and Kyzylorda (R^2 = 0.7087) regions.

As a result of analysis of the boys' population average annual growth rate of the standardized indicator by region, the highest was Kyzylorda region (T = −9%; R^2 = 0.7087), the lowest was the City of Astana (T = +2.2%; R^2 = 0.1359). And the girls' indicators were similar to the overall population.

4 Discussion

CHD is the leading cause of death from non-communicable diseases (NCDs) in childhood. Global CHD deaths in 2019 were 217,000 (95% uncertainty interval 177,000–262,000) [31,32]. There were 129 countries with at least 50,000 deaths [33]. Moreover, there has been an increase in the prevalence of CHD over the past decade with improvements in CHD screening and pediatric care [34,35]. Some studies have found evidence that neonatal screening by echocardiography incidences of VSD increased [36]. Also, increased preterm delivery and environmental factors may be responsible for the increase in the reported incidence of VSD [37]. There are a large number of epidemiological studies showing that maternal exposure to air pollution during pregnancy, especially in the first trimester, is associated with a higher chance of CHD in children [38]. For instance, particulate matter <10 microns and the density of traffic may influence the occurrence of ventricular septal defects and pulmonary valve stenosis [39]. In Kazakhstan, the decision to terminate a pregnancy due to a diagnosis of CHD in the fetus is made exclusively by the parents [40].

Several studies have shown from 2017, the incidence rate of CHD was 17.9/1000 worldwide, with 19.1/1000 for males and 16.6/1000 for females [41]. Especially, ventricular septal defect and atrial septal defect were the most common subtype of CHD with an incidence of 5.29/1000 and accounted for about 29.6% of all cases of CHD, of the VSDs, 20% are isolated lesions [42]. According to past statistical analysis, the incidence of isolated VSDs in neonates was 1.5–2.5/1000 [43]. As previously noted, surgical intervention is the typical treatment for the majority of medium and large ventricular septal defects (VSDs). If left untreated over time, VSDs can cause long-term damage that increases the risk of complications such as heart failure, pulmonary hypertension, arrhythmia, or stroke. Furthermore, in cases where Eisenmenger's syndrome develops, which leads to the disability of patients, the addition of infection can be fatal. In conclusion, managing VSDs incurs significant expenses and places a heavy burden on healthcare resources [44,45].

Kazakhstan's mortality rates mirror the general trend. The study's findings demonstrate that, despite a decline in VSD-related deaths in Kazakhstan (Fig. 4), Kazakhstan still falls into the category of countries with high mortality rates. As proof study results depict, the standardized mortality rate of VSD was 1.88 per 100,000 people. According to the Sustainable Development Index, Kazakhstan is low-middle on the socio-demographical Index [SDI] (<0.4 to ≥0.2) [32]. One of the major findings is the highest mortality rates equal to, 39.7% [34] of deaths globally are seen, in the middle SDI (<0.6 to ≥0.4) [32] countries, such as India, China, Pakistan, and Nigeria by studies from 2019 Global Burden of Disease (GBD).

Based on research on GBD about the incidence rate between 1990 and 2017, all SDI regions saw a decrease in the incidence rate of CHD, but the increase in the frequency of VSD during this time period has largely contributed to the increase in the period of CHD in regions with high SDI (from 12.4/1000 to 12.6/1000) [34]. Also, the lowest incidence rates mainly were found in developed countries, such as Qatar (6.2/1000), Portugal (6.7/1000), and France (8.6/1000) [40].

Worldwide, the age-standardized mortality rate (ASMR) of CHD declined by about 38.1%, from 6.3 per 100.000 population in 1990 to 3.9 per 100.000 population in 2017 [40]. Also in Kazakhstan, the ASMR of VSD declined from 1.5 per 100.000 population in 2011 to 0.6 per 100,000 population in 2020 (Table 1; Fig. 4). Another interesting fact, the infant mortality rate (IMR) of VSD decreased (Fig. 1), accompanied

by a steady decline in deaths across the board for children, which may be a sign that neonatal therapies now have a higher ability to extend survival for those with CHDs for the period from 2011 to 2020. The ongoing decline in mortality rates may be due to the growing popularity of primary newborn surgical repair. Kazakhstan is the first nation in the post-Soviet region to have a national screening program, which was established in 2010 [46]. It has been demonstrated that the introduction of screening causes a short-term increase in VSD incidence due to the greater detection of prevalent cases, which is often followed by a long-term decrease in incidence and mortality from VSD [47]. For instance, this may explain why VSD mortality rates have declined in the majority of high-SDI nations like South Korea, the United States, and Japan as well as middle-SDI nations like Brazil, where CHD screening programs have been in place for two to three decades [48]. The implementation of screening measures in Kazakhstan has led to a 20% reduction in mortality rates from VSDs, with the number of deaths decreasing from 2 per 100,000 in 2011 to 1.6 per 100,000 in 2020. Additionally, the prenatal detection of CHD has increased to 70% [49]. Moreover, the treatment of VSDs has been significantly advanced through the use of improved surgical methods, in combination with medical therapy. As a result, 60% of specialized cardiac surgery clinics in the Republic of Kazakhstan now offer surgical treatment to newborns with large VSDs [50].

Geographic variation in mortality rates was also present in Kazakhstan. The northern regions had the lowest indicators, whereas the southwest and Kostanay regions had the highest. This is brought on by changes in the age structure, the population's ethnic makeup, and people's dietary and behavioral habits.

There are limitations to our study. The Republic of Kazakhstan observed very strictly accounting and registration procedures for deaths, and our study examined secondary data derived from administrative data. It is crucial to distinguish mortality from other reasons and from VSD during the course of a patient's life because mortality in VSD can also result from other causes, such as congestive heart failure, complications of infection, and concurrent chronic conditions.

On the other hand, we performed a detailed standardized mortality assessment to identify age and geographic characteristics. The analysis of mortality trends related to VSD is crucial in both theoretical and practical aspects, as it enables early detection and treatment of VSDs. The findings of this study will be valuable to public health authorities in developing a strategy to treat VSDs effectively.

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