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Comparative Analysis of Regional Mortality Rates and Causes in the Turkistan and Other Regions of Kazakhstan: Data from Unified National Electronic Healthcare System 2018-2023

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Abstract

Background: Turkistan is the most densely populated region of Kazakhstan, with 75% of its population residing in rural areas. The region holds for a rich historical and cultural background as it was recently named as the spiritual capital of the Turkic world. Despite the importance of the place, it has its own challenges in the healthcare field, especially with mortality rates. This study aimed to discover and analyze the structure of the death rates in Turkistan region in order to provide a reliable data for future research projects.

Methods: Mortality data were obtained from the Unified National Electronic Health System of Kazakhstan for 2018-2023 years. The dataset comprised 1,073,382 individual death records. The classification of causes of death followed the WHO Global Health Estimates methodology. All statistical analyses were performed using the Python 3.11.

Results: Turkistan region had 632 deaths per 100,000 population, which was lower than the national average death rate in 2018, however, during the COVID pandemic the numbers spiked to 882 deaths per 100,000 population. Despite high numbers during COVID, the region has managed this problem and by 2023 remained in the top 3 regions with the lowest death rates. Additionally, the following diseases were identified as the leading causes of death by 2023: other neuropsychiatric disorders, cerebrovascular diseases, chronic obstructive pulmonary disease.

Conclusion: Turkistan region needs to develop targeted health programs against the current top death causing diseases, with the emphasis on enhancing the diagnosis, treatment, coding and registration capabilities.

Keywords: mortality, age-standardized mortality rates, disease trends, Turkistan region, Kazakhstan.

Introduction

Turkistan region, located in the south of the Republic of Kazakhstan, covers approximately 4.3% of the country's total territory. The region is characterized by a sharply continental climate, with hot, arid summers and relatively mild winters [1]. In 2018, the former president of Kazakhstan renamed the South Kazakhstan region to the Turkistan region, causing the shift of administrative center from Shymkent to Turkistan [1]. As of June 1, 2025, the population of Turkistan region totaled 2,151,000 people, of whom 543,500 (25.3%) reside in urban areas and 1,607,500 (74.7%)

in rural areas [2]. With an average population density of over 18 people per square kilometer, the region remains one of the most densely populated in the country, placing increased demands on the healthcare system and its resilience.

In addition to its geographical and demographic characteristics, Turkistan holds significant cultural and historical heritage. The region is regarded as the spiritual center of the Turkic world and is known for its religious, architectural, and archaeological monuments. This cultural uniqueness influences the lifestyle of the local population, health-related attitudes, and the perception of preventive and medical interventions [3].

According to official statistics for 2023, the crude mortality rate in Turkistan region was 4.63 per 1,000 population, which is below the national average. The leading causes of death include circulatory system diseases (approximately 23% of all registered cases), neoplasms (9.3%), external causes including accidents, poisoning, and injuries (9%), as well as diseases of the respiratory and digestive systems (7.2%) [4]. These data reflect the predominance of chronic non-communicable diseases, aligning with broader epidemiological trends observed in Central Asian countries and other middle-income nations.

Despite the availability of aggregated statistics, a comprehensive analysis of the mortality structure at the regional level is still lacking. Most existing studies focus on national or interregional demographic indicators, making it difficult to develop strategies that are locally relevant. As a result, mortality patterns specific to Turkistan region, including territorial disparities, age and sex structures, and cultural-medical aspects, remain insufficiently explored.

The aim of this study is to conduct an in-depth analysis of the main causes of mortality in Turkistan region using the available epidemiological data. The findings are intended to fill a gap in the scientific literature and provide an up-to-date understanding of mortality patterns in the region. This, in turn, can serve as a foundation for evidence-based health policy, the identification of priority areas for medical intervention, and the development of targeted prevention programs that take into account the demographic and cultural characteristics of the local population.

Methods

This study is a retrospective descriptive analysis based on national mortality data from Kazakhstan, specifically focusing on the Turkistan region.

Data Sources

Mortality data were obtained from the Unified National Electronic Health System (UNEHS) of Kazakhstan for the period of 2018-2023 years [5, 6]. The dataset comprised 1,073,382 individual death records, of which 70 187 cases were attributed to Turkistan, and included the date of death, age at death, place of death, sex assigned at birth, ICD-10 coded cause of death, and the region. After excluding 39 duplicate entries, the final sample included 1,073,343 death records. This dataset reflects deaths registered within the public healthcare system and does not account for deaths in penitentiary or military systems. Consequently, annual totals are approximately 5-8% lower than those reported by the World Health Organization (WHO) and the Bureau of National Statistics of Kazakhstan (BNSK) [7, 8].

Cause-of-death coding was conducted by certified medical professionals. For deaths outside medical institutions, a physician performed an external examination and determined the cause based on available medical history and, where applicable, autopsy findings. In-hospital deaths were documented by attending physicians.

Population data were sourced from the BNSK and included yearly totals (2018-2023), disaggregated by age (single-year groups), sex, and region.

Data Analysis

All statistical analyses were performed using the Python 3.11. The following libraries were used: pandas (v2.2.2) for data wrangling, statsmodels (v0.14.2) and scipy (v1.13.1) for statistical inference, matplotlib (v3.9.1) and seaborn (v0.13.2) for data visualization, geopandas (v1.0.1) for geospatial analysis, and scikit-learn (v1.5.0) for model implementation.

Mortality rates were computed using standard epidemiological formulas. Age-standardized mortality rates (ASMR) were calculated using the direct method with the total Kazakhstan population as the reference. Age was grouped by single-year intervals from 0 to 84 years, with 85+ as the final category.

Temporal dynamics of mortality were visualized using daily-level calendar heatmaps, where deviations from expected death frequencies were assessed with Chi-squared tests and visualized through standardized residuals. Seasonal decomposition was applied to monthly aggregates to extract trend, seasonal, and residual components.

Linear regression models were fitted for each region to evaluate ASMR trends from 2018 to 2023. The year was used as the independent variable, and ASMR as the dependent variable. Slopes indicated annual changes; significance was evaluated at $\alpha=0.05$. Models were re-run excluding 2020 and 2021 to account for pandemic-related distortions.

Cause of Death Classification

The classification of causes of death followed the WHO Global Health Estimates (GHE) methodology [9]. ICD-10 codes were mapped to standardized cause categories as per WHO guidelines. Two modifications were introduced:

1. ICD-10 codes absent in the WHO GHE mapping were categorized based on clinical review.
2. Codes G93.4, G93.6, and G93.8, which inflated the 'Other neurological diseases' category, were grouped into a new category termed 'Other disorders of the brain'.

More detailed information on the redistributions of the categories can be found in the study published earlier [10].

Results

General ASMR Trends (2018-2023)

The tables below present data on the age-standardized mortality rate (ASMR) in various regions of Kazakhstan from 2018 to 2023.

The table 1 presents raw ASMR values across all regions of Kazakhstan without the trend analysis. However, the data structure allows for the observation of mortality levels and the comparison of Turkistan with other regions for specific years.

In 2020 and 2021, Turkistan region experienced two pronounced mortality peaks, likely associated with the impact of the COVID-19 pandemic. In subsequent years, the indicators decline: by 2023, the ASMR level even falls below that of 2018.

In terms of interregional comparison, Turkistan showed a higher-than-average national mortality rate during the pandemic years but did not fall into the group of regions with the most severe

Table 1 Overall age-standardized mortality rate trends (per 100,000) and statistical significance of the trend over six-year period

Region	2018	2019	2020	2021	2022	2023	slope	p-value
Turkistan	632,01	639,93	860,86	882,23	603,81	596,71	-7,53	0,84
Zhambyl	659,79	658,49	816,29	1015,87	619,99	618,90	-3,44	0,94
North Kazakhstan	751,64	777,65	889,92	990,30	756,13	734,23	-1,46	0,96
West Kazakhstan	718,02	701,99	873,15	991,80	691,60	690,57	-1,42	0,97
Pavlodar	743,11	743,92	880,50	1027,00	753,82	703,40	-0,64	0,99
Akmola	704,99	693,30	846,33	985,19	699,08	677,95	0,60	0,99
Kostanay	677,64	688,93	819,01	961,77	748,36	703,59	12,88	0,67
Mangystau	574,38	575,84	804,13	888,94	633,34	628,74	15,12	0,68
Atyrau	621,71	513,37	866,91	1004,15	688,56	633,49	20,62	0,68
Kazakhstan	580,80	583,48	757,94	937,92	678,38	655,56	23,96	0,52
Shymkent	537,93	534,95	845,08	1035,30	680,34	672,82	37,17	0,48
Kyzylorda	450,89	506,94	765,21	839,23	640,26	638,01	40,28	0,30
Aktobe	459,60	559,26	736,03	923,91	666,23	674,31	45,21	0,28
Astana	430,10	388,18	660,47	897,41	608,22	588,38	48,24	0,32
Almaty Region	382,07	360,89	446,50	519,23	77,45	576,16	48,37	0,00
Almaty	394,49	379,18	526,39	947,97	692,99	643,97	74,58	0,16
East Kazakhstan	416,65	398,68	468,17	588,69	775,96	728,03	80,26	0,01
Karaganda	415,98	454,55	634,76	864,51	796,47	749,06	83,45	0,03
Abai	-	-	-	-	685,20	698,73	-	-
Ulytau	-	-	-	-	800,08	778,42	-	-
Zhetysu	-	-	-	-	640,88	630,32	-	-

situations, such as Karaganda, Pavlodar, and North Kazakhstan regions. In 2022-2023, the ASMR levels in Turkistan became comparable to those in other southern regions – Shymkent, Kyzylorda, and Zhambyl – and by 2023 even dropped below their levels.

In terms of ASMR, the region is positioned between the so-called 'high-burden' areas with persistently elevated mortality and large metropolitan cities such as Almaty and Astana, where the rates are lower.

Thus, even without calculating trend indicators, it can be concluded that Turkistan region demonstrated a high level of post-COVID recovery in terms of mortality rate, which allowed to stay in top 3 regions with the least deaths.

The table 1 also contains the calculated parameters of the linear trend: slope and p-value (statistical significance of the trend). This allows for the assessment of both absolute indicators and their changes over the six-year period.

Mortality in the region increased sharply in 2020-2021, most likely due to the COVID-19 pandemic, and then returned to a level below the pre-COVID baseline (in 2023, it was lower than in 2018) [11]. However, the p-value greater than 0.05 indicates that the overall trend is not statistically significant, meaning these fluctuations may be random and do not reflect a stable increase or decrease in mortality.

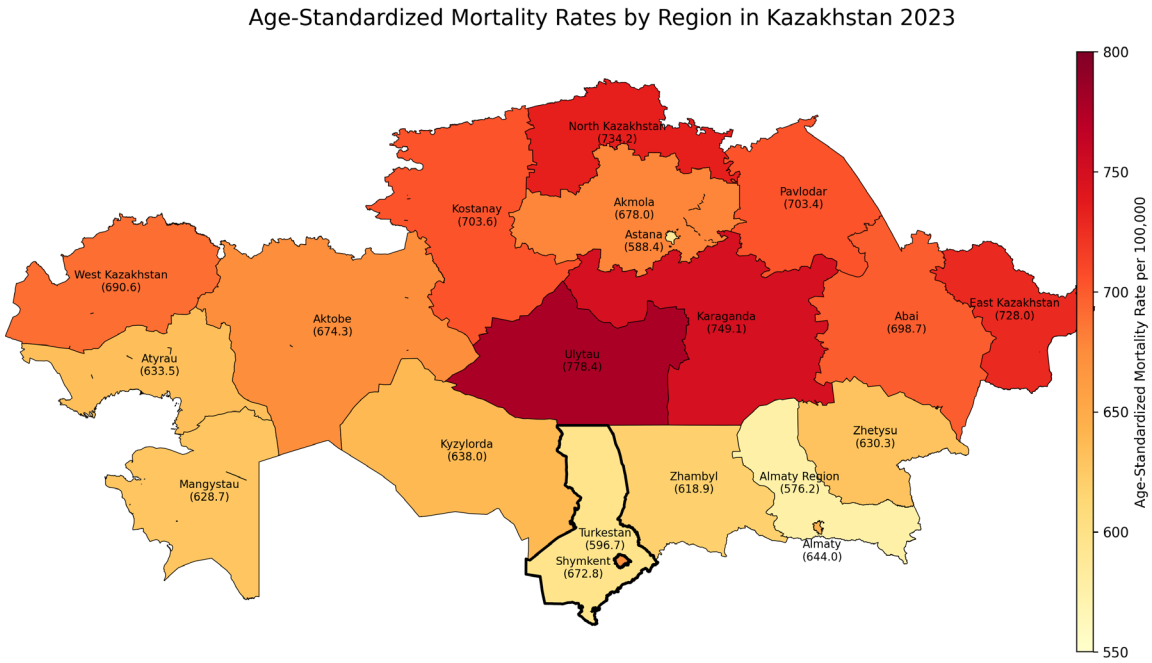
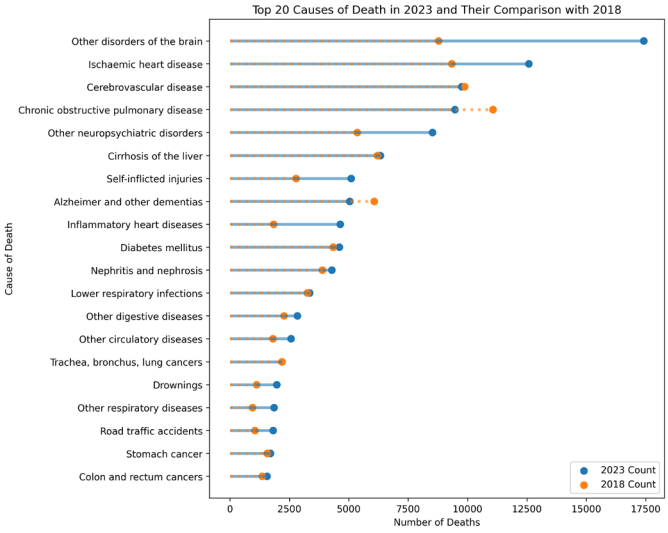
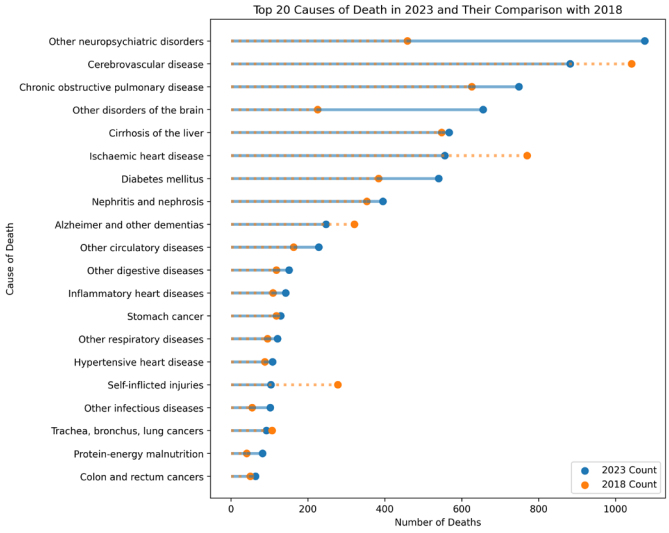


Figure 1 – ASMR by regions in Kazakhstan (2023)



2a



2b

Figure 2 – Comparison of top 20 causes of death in Kazakhstan (2a) and of Turkistan region (2b) for 2018 and 2023 years

Cause of Death	Rank in 2018	Rank in 2019	Rank in 2020	Rank in 2021	Rank in 2022	Rank in 2023
Other disorders of the brain	4	2	1	2	1	1
Ischaemic heart disease	3	4	2	1	2	2
Cerebrovascular disease	2	3	3	4	3	3
Chronic obstructive pulmonary disease	1	1	4	5	4	4
Other neuropsychiatric disorders	7	6	6	6	5	5
Cirrhosis of the liver	5	5	7	7	6	6
Self-inflicted injuries	11	11	12	13	8	7
Alzheimer and other dementias	6	7	8	9	7	8
Inflammatory heart diseases	14	13	13	11	10	9
Diabetes mellitus	8	8	9	8	9	10
Nephritis and nephrosis	9	9	10	12	11	11
Lower respiratory infections	10	10	5	10	12	12
Other digestive diseases	12	12	14	15	13	13
Other circulatory diseases	15	15	15	14	14	14
Trachea, bronchus, lung cancers	13	14	16	17	15	15
Drownings	20	18	21	18	16	16
Other respiratory diseases	22	22	18	16	19	17
Road traffic accidents	21	21	22	19	17	18
Stomach cancer	16	16	19	20	18	19
Colon and rectum cancers	17	17	20	21	20	20

3a

Cause of Death	Rank in 2018	Rank in 2019	Rank in 2020	Rank in 2021	Rank in 2022	Rank in 2023
Other disorders of the brain	4	2	1	2	1	1
Ischaemic heart disease	3	4	2	1	2	2
Cerebrovascular disease	2	3	3	4	3	3
Chronic obstructive pulmonary disease	1	1	4	5	4	4
Other neuropsychiatric disorders	7	6	6	6	5	5
Cirrhosis of the liver	5	5	7	7	6	6
Self-inflicted injuries	11	11	12	13	8	7
Alzheimer and other dementias	6	7	8	9	7	8
Inflammatory heart diseases	14	13	13	11	10	9
Diabetes mellitus	8	8	9	8	9	10
Nephritis and nephrosis	9	9	10	12	11	11
Lower respiratory infections	10	10	5	10	12	12
Other digestive diseases	12	12	14	15	13	13
Other circulatory diseases	15	15	15	14	14	14
Trachea, bronchus, lung cancers	13	14	16	17	15	15
Drownings	20	18	21	18	16	16
Other respiratory diseases	22	22	18	16	19	17
Road traffic accidents	21	21	22	19	17	18
Stomach cancer	16	16	19	20	18	19
Colon and rectum cancers	17	17	20	21	20	20

3b

Figure 3 – Top causes of death for Kazakhstan (3a) and for overall Turkistan region (3b) during the 2018-2023

Turkistan Compared to Other Regions:

- ASMR values in Turkistan were higher than in the urbanized centers such as Almaty, Astana, or Almaty region at the beginning of the period, but lower than in northern and eastern regions like Pavlodar and North Kazakhstan, where mortality is consistently high.
- Some regions (e.g., Karaganda and East Kazakhstan) showed a statistically significant increase in mortality ($p < 0.05$), while no such trend is observed in Turkistan.

The analysis showed no significant trends in the Turkistan region ($p = 0.84$). The overall trend for Kazakhstan was also not statistically significant ($p = 0.518$).

Leading Causes of Mortality in Turkistan Region Compared to Overall Trends in Kazakhstan

For Turkistan region (Figure 2b) the top mortality cause was 'Other neuropsychiatric disorders', which has more than doubled over the 6-year period, together with 'Other disorders of the brain' category. Other diseases were more or less stable over the period, except for 'Cardiovascular diseases', 'Ischemic heart disease', and 'self-inflicted injuries', which showed sharp decline as a cause of death.

By 2023, the top cause of the death in Kazakhstan as a whole (Figure 2a), was the 'Other disorders of the brain'; from 2018 to 2023 the cases of mortality from this disease have doubled. Other deadly diseases that showed continuous growth were 'Ischemic heart disease', 'Other neuropsychiatric disorders', 'self-inflicted injuries' and 'Inflammatory heart disease'. Other diseases showed almost no growth or stability over the period except for 'Chronic obstructive pulmonary disease' and 'Alzheimer and other dementias', which showed slight decline.

At the national level, the structure of causes of death is characterized by greater stability compared to the Turkistan region (Figures 3a and 3b). For Turkistan region, the 'other neuropsychiatric disorders' have held the leading position by 2023, rising from fifth place in 2018. The top-5 cause of death by 2023 were cerebrovascular diseases, chronic obstructive pulmonary disease (COPD), other diseases of the brain, and cirrhosis of the liver. All of the other causes of death in Turkistan region stayed more or less in a stable position through 6-year period, except for other infectious diseases, malnutrition issues, cancers of large intestine, which demonstrated a sharp rise from 2018 to 2023.

On the other hand, the data for Kazakhstan as a whole demonstrates a more stable structure of causes of death, dominated by central nervous system and neuropsychiatric diseases. Except for some diseases, there was an absence of sharp fluctuations provided by stable epidemiological environment and a more systematic approach to data recording and diagnosis nationally.

Table 2 presents a quantitative comparison of mortality shares across key disease categories between the Turkistan region and Kazakhstan as a whole. The data allows for an interpretation of differences in the mortality structure at the regional versus national levels based on the presented indicators.

The most pronounced difference is observed in the category of 'other neuropsychiatric disorders' in the Turkistan region, they account for 33.2% of all deaths, whereas the national average was only 17.2%. This nearly twofold gap may result from a combination of factors: differing availability of psychiatric care, possible overdiagnosis in the region, characteristics of an aging population, as well as probable differences in death cause coding practices. It should be noted that such a high share indicates either a structural epidemiological anomaly or a specific or inaccurate diagnostic strategy in the region, warranting further audit.

Table 2 The total share of causes (shown in percentages) for mortality in Turkistan region and Kazakhstan

#	Cause	Turkistan region	Kazakhstan
1	Other neuropsychiatric disorders	33,2%	17,2%
2	COPD	11,9%	7,9%
3	Alzheimer's	10,4%	11,3%
4	IHD	8,4%	9,4%
5	Other disorders of the brain	6,7%	19,5%
6	Cerebrovascular	6,4%	6,1%
7	Nephritis	4,4%	3,9%
8	Cirrhosis	2,8%	1,2%
9	Diabetes	2,8%	2,7%

The COPD and liver cirrhosis are also significantly higher in Turkistan compared to national figures – 11.9% versus 7.9% for COPD and 2.8% versus 1.2% for cirrhosis. These data may reflect deteriorated environmental conditions, high prevalence of risk factors (including smoking and alcohol abuse), as well as possible differences in access to medical care. The high COPD share also correlates with previously presented dynamic data, where this cause periodically rose to the top three causes of death in the region.

At the same time, the category 'Other disorders of the brain' shows a noticeably lower rate in Turkistan – 6.7% versus 19.5% nationwide. This may be due to some conditions coded as neurological disorders in the national statistics being classified as neuropsychiatric disorders in Turkistan, further highlighting potential differences in classification approaches and cause-of-death coding.

Lower rates are also observed for ischemic heart disease (IHD) – 8.4% in Turkistan versus 9.4% nationally. This result confirms the previously noted trend of a declining relative significance of IHD in the region's mortality structure. This may reflect either positive effects from preventive programs and therapies or a shift of death causes toward other categories (e.g., 'other neuropsychiatric disorders').

Alzheimer's disease and diabetes show comparable levels in both regions (approximately 10-11% for Alzheimer's and 2.7-2.8% for diabetes), indicating relative uniformity in the diagnosis of these chronic conditions. However, even here it can be assumed that some dementias may have been included in the broader 'Other neuropsychiatric disorders' category in the regional data, reducing the official Alzheimer's share in Turkistan.

Discussion

This is the first regional retrospective study comparing the mortality trend and top causes of death in Turkistan and other regions of Kazakhstan in large national electronic healthcare cohort. Overall, at the beginning of the 6-year period the Turkistan region showed lower death rates compared to the average national level, however, during the peak of COVID-19 pandemic, it rose up by 40% of the initial number and reached

882 deaths per one hundred thousand population. The analysis of the 6-year mortality trend for Turkistan region has not identified any statistically significant differences.

While Kazakhstan's top leading cause for mortality by far was 'Other disorders of the brain', which can be partially explained by the soaring death rate from stroke [12], the structure of Turkistan region's death rate was predominated by neuropsychiatric disorders, which has shown nearly a twofold excess compared to a national average. Such data may indicate either a true epidemiological burden or differences in coding, diagnostics, and recording practices, which in turn may be associated with a shortage of specialists, especially in psychiatric and neurological services, as well as weak coordination between healthcare institutions and statistical authorities.

Consistently high mortality rates from the COPD and liver cirrhosis also drew attention. Likely causes include a high prevalence of risk factors – smoking, alcohol consumption, environmental pollution [13], combined with limited access to specialized medical care, particularly in rural areas [14, 15]. At the same time, these issues receive insufficient attention in state prevention and treatment programs, worsening the situation. Such conclusions would be impossible without local analysis, as the national data does not reflect these regional peculiarities.

Despite the recorded decline in the ASMR in 2023 compared to peak pandemic values, the results do not indicate a stable positive trend ($p=0.84$). This highlights both the instability of the epidemiological situation and potential limitations of the current death registration and monitoring system. In light of this, it is worth recalling that the 75% of Turkistan region's population reside in rural areas, which in turn makes it significantly harder to change the situation on the ground. To highlight the poor healthcare environment in rural areas of Kazakhstan, in the article done by Syssoyev and colleagues, it is mentioned that countryside residents, with congenital heart disease, had significantly lower chances of survival compared to their counterparts in urban settings [16]. The absence of a full-fledged, systematized regional mortality statistics system verified against primary medical records remains one of the key problems [10]. The establishment of a unified data quality control system, regular retraining of medical and statistical personnel, and expansion of medical expertise infrastructure appear to be necessary steps towards improving the reliability and informativeness of official statistics.

This study is the first to utilize individualized mortality data over a six-year period focusing on the Turkistan region. This allowed for not only to describe the general mortality levels but also to identify the unique regional characteristics of mortality indicators. The application of international methodological standards and modern statistical tools enhanced the reliability of the results.

As for the limitations of the study, the dataset used in this study was obtained from public healthcare facilities, meaning that the deaths within military force systems were omitted. This might explain the difference of up to 8% between the WHO and BNSK reports and the dataset used in this study. Another restriction of this study could be one of the applied cause-of-death coding practices, when physicians had to perform manual searches for possible causes of death in order to fill in the blank spaces. This practice could affect the data accuracy. Last but not least, the general limitations for this kind of articles are the lack of data on socio-economic factors, medical infrastructure, and population behavioral characteristics, as well as possible discrepancies in cause-of-death coding practices between regions and a shortage of qualified personnel in rural areas.

Conclusion

This study represents a first step towards a systematic understanding of the structure and dynamics of mortality in the Turkistan region – one of the most populous and culturally significant regions of Kazakhstan. Unlike national reviews that aggregate data for the entire country, this analysis has, for the first time, identified region-specific patterns that differ in composition and intensity from the national average. The main causes of death for the Turkistan region were neuropsychiatric disorders, the COPD, and liver cirrhosis. These findings underscore the need to reconsider the priorities of regional health policy and to develop locally adapted prevention and care measures.

However, the identified patterns not only reflect epidemiological realities but also result from serious systemic limitations. During the study, it became evident that the Turkistan region suffers from an acute shortage of reliable, comprehensive, and comparable statistical data on causes of death. In many cases, the death classification is made with large assumptions or inaccuracies, which can distort both the actual picture and the decisions based on it. The problem is exacerbated by a lack of qualified personnel in medical examination and statistics, especially in remote and rural areas where the overwhelming majority of the region's population resides.

Given these circumstances, further research should focus not only on deepening epidemiological analyses but also on developing the infrastructure for mortality registration and analysis itself. This includes implementing a unified accounting system, digitizing primary medical documentation, training healthcare workers for accurate ICD-10 coding, and establishing regional centers for monitoring and evaluating statistical quality. Without these changes, any measures to improve population health risk being inadequate or ineffective.

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