

Brief Research Report

Dynamics of YLL, YLD and DALYs in Spinal Cord Injuries in Kazakhstan

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Abstract

Spinal cord injuries are one of the most significant health problems, leading to a significant increase in morbidity, disability and premature mortality. Current research confirms the need to improve the health care system, given the projected further increase in the number of cases and the global burden of the disease.

The aim of the study was to assess the burden of spinal cord injuries in Kazakhstan.

Methods. The burden of spinal cord injury was estimated by calculating DALYs based on two key indicators - YLL and YLD. Analyzed period: 2018-2022.

Results. Analysis of YLL, YLD, and DALY scores over a five-year period demonstrated a significant burden of spinal cord injury on the health care system and society at large. Cumulative life years lost due to YLL was 5,936.5 years and YLD was 16,402.0 years. The integral DALY indicator reached 22,388.5 years, which indicates the high relevance of the problem and the need to take systemic measures to reduce it.

Conclusions. The dynamics of the integral DALY indicator indicates an increasing burden of the disease and the need to improve the system of medical care and rehabilitation.

Keywords: spinal injuries, YLL, YLD, DALY.

1. Introduction

Injuries and their accompanying diseases have the status of one of the key public health problems, having a significant impact on global morbidity, disability and mortality. Spinal cord injuries occupy a special place, and are the leading cause of premature loss of health, long-term disability, reduced quality of life and the formation of a significant financial burden for national and global health systems [1,2].

In recent decades, health systems in various countries have focused on investigating the burden of disease, focusing on obtaining timely, reliable and

clinically relevant estimates of critical health outcomes. This enables the formation of sound management decisions and the development of effective prevention and treatment strategies [3].

According to Global Burden of Disease Spinal Cord Injuries Collaborators (2023), from 1990 to 2019, there was a significant increase in the incidence of spinal cord injuries - by 81.5%, prevalence - by 52.7%, and the years lived with disability (YLD) - by 65.4% [1]. According to the World Health Organization, in 2021 the number of patients with spinal cord injuries reached

15.5 million people [4]. An analysis conducted in the USA (O. Trent Hall et al., 2019) showed that over a 44-year period, spinal cord injuries caused more than 1 million years of healthy life losses [5].

Current epidemiological studies highlight the continued rise in the global, regional, and national burden of spinal cord injury, predicting that cases will exceed 14.5 million by 2050 [6]. Yubao Lu et al. (2024) revealed significant differences in burden levels between countries and regions, highlighting the need to develop targeted prevention and treatment strategies to reduce burden and improve clinical outcomes [7]. So, according to the calculations of Yongcun Wei et al. (2025), the global YLD value attributable to spinal cord injury was 4,566,237, with China, India, and the Americas contributing the most to the global burden at 16.47%, 13.22%, and 6.79%, respectively [8]. Kim M. et al. (2025) also note an increase in absolute burden in East Asia and low - and middle-income countries [6].

2. Materials and Methods

The assessment was based on spinal cord injury data from 2018-2022.

The burden of spinal cord injury was estimated by calculating the DALY (Disability-Adjusted Life Years) - years of life adjusted for disability. This integral indicator is a universal tool for quantifying the global burden of diseases, injuries and other adverse factors affecting the health of the population, and is widely used in epidemiological and economic studies [3,9]. The application of DALYs allows the comparison of the contribution of different diseases and injuries to the structure of health losses both within one country and internationally.

DALYs are based on two key components: YLL (Years of Life Lost) and YLD (Years Lived with Disability):

$$DALY = YLL + YLD \quad (1)$$

To ensure comparability of data between countries and regions, DALYs are expressed in absolute years, which makes it possible to neutralize differences associated with demographic characteristics of populations.

YLL shows the cumulative loss of life years in the population due to premature mortality from the study condition. It is calculated as the product of the number

The findings clearly indicate the need to develop national public health programs aimed at preventing spinal cord injuries, introducing innovative treatment and rehabilitation strategies, and strengthening international cooperation in this area.

A deep understanding of the global burden of spinal cord injury is fundamental to shaping effective policies and preventive measures in health care. Given the alarming increase in prevalence and dire consequences for patients and health systems, the results of current research provide valuable insights to optimize future efforts to reduce the incidence of spinal cord injuries, improve the quality of life of those affected, and reduce economic pressures on health systems worldwide

The aim of the study was to assess the burden of spinal cord injuries in Kazakhstan.

$$YLL = N \times L \quad (2)$$

of deaths from a given disease or injury (N) by life expectancy (L) at the time of death:

YLD defines years of life spent with disease or functional limitations due to injury. The following formula is used to estimate YLD:

where, I - the number of new cases (incidence) for a certain period; DW - Disability Weight, taking values

$$YLD = I \times DW \times L \quad (3)$$

from 0 (ideal health) to 1 (state equivalent to death); L is the average duration of the state (in years).

Disability rate is a quantitative measure of the severity of the condition and reflects the decline in quality of life associated with the disease or injury. DW assessments are developed based on expert surveys and data on health perceptions in various populations.

Thus, the DALY score integrates both direct losses from premature mortality and years of life with limited ability to work, which provides a comprehensive assessment of the contribution of spinal cord injuries to the overall disease burden.

This study followed basic ethical standards and used exclusively anonymized aggregated data to calculate DALYs, YLLs, and YLDs.

3. Results

YLL - years of life lost due to early death of patients from spinal cord injuries

YLL reflects the cumulative loss of life years due to premature mortality in patients with spinal cord injury

(SCI). Over the five-year period analyzed, early mortality due to SCI resulted in a loss of 5,936.5 years of life, which corresponds to 191 deaths. The highest YLL values were recorded in 2019 and 2022, which coincides

with an increase in the incidence of SCI during these periods. Annual YLL trend is observed, suggesting an increasing healthcare burden of SCI. The exception is 2020-2021, when there was a hyperbolic decline

associated with the introduction of restrictive measures in the context of the COVID-19 pandemic, as well as a decrease in the number of road accidents and falls from a height (Table 1).

Table 1 - YLL of patients with SCI by study period (2018-2022)

Years	Number of deaths due to condition	Life expectancy (underage years)	YLL
2018	31	29,15	903,65
2019	48	34,68	1 664,64
2020	17	28,77	489,09
2021	28	29,03	812,84
2022	67	30,84	2 066,28
	191		5 936,5

Maximum YLL values occur in patients injured as a result of falls from a height (3,047.8 years) and road accidents (2,183.76 years). These data correlate with a

high proportion of hospitalizations for these causes (up to 90% of all cases) and a significant mortality rate (up to 2/3 of cases) (Table 2).

Table 2 - YLL of patients with SCI by cause, status of clinical and neurological damage, level of damage

Indicator	Number of deaths due to condition	Life expectancy (underage years)	YLL
Causes of SCI			
Road accident	72	30,33	2 183,76
Falls from height	98	31,1	3 047,8
Violence	6	29,6	177,6
Diving	3	27,9	83,7
Sports injury	2	40,8	81,6
Industrial injury	6	35,7	214,2
Other	4	37	148
Clinical and neurological manifestation of SCI (AISA)			
A	87	35,55	3 092,85
B	32	30,6	979,2
C	72	25,9	1 864,8
D	-	-	-
E	-	-	-
Level			
cervical	92	29,9	2 725,6
thoracic	67	32,1	2 150,7
lumbar	32	32,2	1 030,4

A significant contribution to the structure of YLL is made by industrial injuries (214.2 years) and violent actions (177.6 years). High YLL rates for industrial injuries indicate shortcomings in the organization and maintenance of the workplace, non-compliance with equipment safety rules, improper lighting of workplaces, pollution and contamination of the production area, and predetermine the need for the state to strengthen measures and requirements for production organizations of the Republic of Kazakhstan. Also, the growth of YLL due to the causes of violence is largely due to the decriminalization of

violence until 2024, which requires a review of preventive measures.

YLL analysis by clinical and neurological status (AISA/IMSOP) showed a maximum loss of years of life at status «A» (complete loss of function) of 3,092.85 years lost. Significant YLL values are also observed with status «B» (979.2 years) and «C» (1,864.8 years), which is due to the high frequency of combined injuries (the indicator correlates with the presence of combined injuries due to SCI).

In terms of the level of damage, the largest proportion is caused by cases of SCI in the cervical - 2,755.4 years lost, to a lesser extent in the thoracic -

2,150.7 years and the lumbar - 1,030.4 years, which is associated with their high mortality and disability.

YLL analysis demonstrates social and economic losses from high mortality due to SCI. The indicator «lost years of life» increases the significance of those reasons that are inherent in younger age groups, and is explained by behavioral factors and lifestyle, and allows the state to build certain proposals for their prevention and neutralization.

YLD - lost years due to SCI disability

YLD reflects years of life spent with disability due to SCI and takes into account both the severity of the

condition and its duration. Over the past five years, cumulative losses were 16,402.0 years (disability-weighted).

YLDs were highest in 2018, 2019, and 2022, corresponding to periods of increased incidence of SCI. Similarly for YLL, there was a decline in 2020-2021 due to the restrictive measures of the COVID-19 pandemic (Table 3). It is also possible to assume a decrease in the severity of disability from SCI, which may be associated with the introduction of innovative technologies for the treatment of patients with SCI, the transition from a centralized to a decentralized model of medical care, the expansion of rehabilitation services, etc.

Table 3 - YLD of patients with SCI, 2018-2022

Years	Number of incident cases	Severity of disability	Average case duration of event before remission or death (years)	YLD
2018	799	0,104	48,4	4 021,8
2019	803	0,136	50,9	5 558,7
2020	178	0,124	52,5	1 158,8
2021	353	0,095	50,6	1 696,9
2022	971	0,079	51,7	3 965,8
Total				16 402,0

In terms of causes of SCI, the maximum YLD values are for cases of falls from a height (7,943.1 years) and road accidents (5,978.7 years), as well as for other causes (1,074.4 years). These categories are also characterized by the highest values of disability severity

(0.132 for falls from a height, 0.143 for road accidents) (Table 4). The analysis showed a high correlation between the severity of disability due to SCI and the average duration of the condition before remission or death by their causes ($r = 0.895458$).

Table 4 - YLD of patients with SCI by cause, status of clinical and neurological damage, level of damage

Indicator	Number of incident cases	Severity of disability	Average case duration of event before remission or death (years)	YLD
Causes of SCI				
Road accident	903	0,143	46,3	5 978,7
Falls from height	1450	0,132	41,5	7 943,1
Violence	230	0,057	39,8	521,8
Diving	96	0,097	34,8	324,1
Sports injury	133	0,094	29,4	367,6
Industrial injury	53	0,097	37,6	193,3
Other	239	0,085	52,7	1 074,4
Clinical and neurological manifestation of SCI (AISA)				
A	90	0,167	42,7	641,8
B	37	0,142	48,7	255,9
C	158	0,101	56,9	908,0
D	785	0,094	57,7	4 257,7
E	2034	0,088	58,2	10 340,4
Level				
cervical	217	0,142	39,6	1 220,2
thoracic	1 232	0,127	44,9	7 025,2
lumbar	1 655	0,092	53,6	8 161,1

Thus, «other» causes of spinal cord injuries account for 7.7% of all cases, while the severity of disability is 0.085, which causes a fairly high level of YLD — 1 074.4 years. In contrast, for violent injuries, despite a comparable frequency of occurrence, there is a lower YLD value, which is associated with both a lower severity of disability (0.057) and a shorter average duration of the condition before remission or death (39.8 years).

In terms of clinical and neurological manifestation of SCI according to the AISA/IMSOP qualification, the total high indicator was noted for type «E» - 10 340.4 years (for 1 case - 5.1). Highest YLDs per case per AISA type A (7.1 years) associated with maximum neurological impairment.

Lumbar (8,151.1 years) and thoracic (7,025.2 years) injuries contribute the most to YLD among the different levels of injury due to their high prevalence and long duration of disability. When calculating YLD for one case of SCI, the greatest losses are observed with lesions of the thoracic - 5.7 years, as well as the cervical - 5.2 years.

The high rate of disability among patients with SCI is largely due to the insufficient organization of the provision of specialized neurosurgical care, as well as the limited effectiveness of rehabilitation measures in the postoperative period.

DALY (Disability-Adjusted Life Years)

The integral indicator DALY, combining YLL and YLD, allows quantifying the total burden of SCI for a population.

Over the five-year period from 2018 to 2022, the total DALY index due to SCI was 22,388.5 years (table 5). An analysis of the dynamics of this indicator shows a tendency towards its growth, which indicates the high and continuing importance of the problem for the healthcare system. The highest DALY values were recorded in 2019 and 2022 (7,223.34 and 6,032.1, respectively), which correlates with an increase in the number of cases and severity of the consequences of SCI during these periods. The decrease in the indicator in 2020-2021 is associated with restrictive measures introduced in response to the COVID-19 pandemic, which led to a reduction in injuries, including due to a decrease in road accidents and falls from height.

Table 5 - Dynamics of DALYs in patients with SCI (2018-2022)

Years	YLL	YLD	DALY
2018	903,65	4 021,8	4 925,45
2019	1 664,64	5 558,7	7 223,34
2020	489,09	1 158,8	1 647,9
2021	812,84	1 696,9	2 509,74
2022	2 066,28	3 965,8	6 032,1
	5 936,5	16 402,0	22 388,5

A graphical representation of DALY dynamics (Figure 1) clearly illustrates the change in the global burden of SCI by year, as well as its impact on the state of the health care system in the study region. The

growth of this indicator indicates the need to improve preventive strategies, increase the availability of specialized medical care and expand rehabilitation opportunities for patients with SCI.

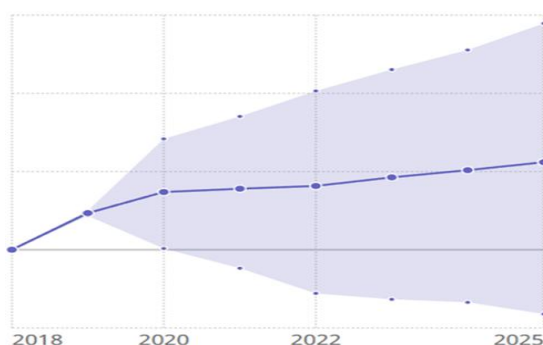


Figure 1 - DALY growth

Thus, a comprehensive analysis of DALYs not only quantifies the scale of the problem, but also serves as a basis for prioritizing health care directions and developing effective measures to reduce mortality and disability associated with spinal cord injuries.

Estimating the loss of life years with the YLL and YLD indicator provides the necessary information to develop specific programs aimed at reducing mortality and disability of the population, to prevent the loss of human and labor potential of the country. Today, the paradigm of the feasibility of injury prevention in terms of increasing life expectancy and improving its quality is generally recognized.

4. Discussion

Analysis of global burden of SCI shows significant socioeconomic impact of both premature mortality and long-term disability. Cumulative YLL over a five-year period was 5,936.5 years with 191 deaths. The highest YLL values were observed in 2019 and 2022, which correlates with an increase in the incidence of SCI in the indicated periods. The hyperbolic decline in 2020-2021 is associated with the introduction of restrictive measures in the context of the COVID-19 pandemic, which led to a decrease in the number of injuries caused by road accidents and falls from a height.

Detailed analysis of the causes of damage showed that road accidents and falls from height are the leading factors that form the structure of YLL, which reflects the high mortality rate and hospitalization rate among patients with SCI. Significant losses are also noted in cases of industrial injuries and violent actions. These data highlight the need to improve safety systems in the workplace, as well as strengthen preventive measures against violence. In particular, the decriminalization of violent actions until 2024 has contributed to an increase in the number of SCI cases associated with victimization, which requires a review of legislative and preventive approaches.

In terms of clinical and neurological status (AISA/IMSOP), the maximum YLL score is observed at status «A», which corresponds to the most severe neurological deficit. However, high YLL values are maintained for types «B» and «C», which is associated with the presence of combined injuries and complications. The greatest losses are observed with damage to the cervical spine, due to the high frequency of such cases and their severe consequences for patients.

The measure of YLD over the period analyzed was 16,402.0 years. YLDs in 2018, 2019, and 2022, reflecting rising rates of SCI and its severe sequelae. At the same time, there is a tendency towards an annual increase in YLD, which indicates the continuing relevance of the

DALY is a universal indicator, and allows you to see not only irretrievable losses or mortality of the population from specific causes, but also to build public health policy that allows you to prevent or slow down the development of fatal diseases, i.e. prolong the life of a particular person or improve its quality. The calculation of the indicator in dynamics makes it possible to assess population effects, both from the use of medical technologies and from the effects of economic, social, environmental, urban and other factors on the population.

problem. However, the decrease in the average severity of disability may be associated with the introduction of modern treatment technologies, increased access to rehabilitation services and the transition to a decentralized model of medical care.

The greatest contribution to YLD is made by falls from height and traffic accidents, which is due to the high severity of disability and a long period before remission or death. The analysis showed a pronounced correlation between the severity of disability and the average duration of the condition, which allows a more accurate assessment of the impact of various causes of damage on the quality of life of patients.

The integral DALY indicator over the past five years amounted to 22,388.5 years, while there is a steady upward trend in this indicator. DALY dynamics reflect not only direct losses from mortality and disability, but also the impact of social, economic, environmental and urban factors on public health. The growth of DALYs indicates the lack of effectiveness of the existing system of medical care and rehabilitation of patients with SCI, as well as the need to introduce comprehensive preventive and organizational measures.

Thus, the results of the YLL, YLD and DALY assessment provide an objective basis for the development of targeted programs aimed at reducing mortality and disability, as well as preventing the loss of human and labor potential. The modern paradigm of injury prevention in order to increase the duration and quality of life of the population requires further development and improvement. The DALY indicator, as a universal metric, allows not only to assess the scale of the problem, but also to form an effective public health policy aimed at preventing and slowing the development of fatal diseases and improving the quality of life of patients.

Dynamic DALY calculation serves as a tool for assessing the effectiveness of medical technologies and social programs, as well as identifying priority areas for intervention in order to minimize the consequences of SCI for society and the economy of the region. The

findings can be used to inform the need to implement innovative therapies, expand rehabilitation services and improve prevention strategies to reduce the global burden of SCI and improve the quality of life of patients.

5. Conclusions

Analysis of YLL, YLD and DALY scores over a five-year period demonstrated a significant burden of SCI on the health care system and society as a whole. The integral indicator DALY reached 22,388.5 years, which indicates the high relevance of the problem and the need to take systemic measures to reduce it. The high rate of disability among patients with SCI is due to insufficient organization of specialized neurosurgical care and limited effectiveness of rehabilitation measures. The findings highlight the importance of developing and implementing comprehensive programs aimed at reducing mortality and disability due to SCI, preventing loss of human and labor potential, and improving the rehabilitation system.

Dynamic DALY analysis serves as a tool to assess the impact of health, economic, social and environmental factors on health. The results of the

study can be used to justify the need to introduce innovative treatment methods, expand rehabilitation services and improve preventive strategies, which will reduce the global burden of SCI and improve the quality of life of patients.

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AI Declaration. The authors declare that no generative AI were utilized to create, write, or alter any portion of the submitted work.

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Қазақстандағы жұлын жарақаттары кезіндегі YLL, YLD және DALY көрсеткіштерінің динамикасы

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Түйіндеме

Жұлынның жарақаттары денсаулық сақтаудың маңызды мәселелерінің бірі болып табылады, бұл аурушаңдықтың, мүгедектіктің және мезгілсіз өлімнің айтарлықтай өсуіне әкеледі. Заманауи зерттеулер жағдайлардың одан әрі өсуі мен аурудың жаһандық ауыртпалығын ескере отырып, денсаулық сақтау жүйесін жетілдіру қажеттілігін растайды.

Зерттеудің мақсаты Қазақстандағы жұлын жарақаттарының ауыртпалығын бағалау болды.

Әдістері. Жұлын жарақаттарының ауыртпалығын бағалау екі негізгі көрсеткіш - YLL және YLD негізінде есептелген DALY өлшемін есептеу арқылы жүзеге асырылды. Талданатын кезең: 2018-2022 жылдар.

Нәтижелері. Бес жылдық кезеңдегі YLL, YLD және DALY көрсеткіштерін талдау денсаулық сақтау жүйесі мен жалпы қоғам үшін жұлын жарақаттарының айтарлықтай ауыртпалығын көрсетті. Мерзімінен бұрын болған өлім-жітім (YLL) салдарынан өмір сүрген жылдардың жиынтық шығыны 5 936,5 жасты, ал мүгедектік (YLD) 16 402,0 жасты құрады. DALY интегралдық көрсеткіші 22 388,5 жасқа жетті, бұл мәселенің жоғары өзектілігін және оны төмендету бойынша жүйелі шаралар қабылдау қажеттігін көрсетеді.

Қорытынды. DALY интегралды көрсеткішінің динамикасы аурудың өсіп келе жатқан ауыртпалығын және медициналық көмек пен оңалту жүйесін жетілдіру қажеттілігін көрсетеді.

Түйін сөздер: жұлын жарақаттары, YLL, YLD, аурулардың жаһандық ауыртпалығы.

Динамика показателей YLL, YLD и DALY при травмах спинного мозга в Казахстане

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Резюме

Травмы спинного мозга являются одной из наиболее значимых проблем здравоохранения, приводя к существенному росту заболеваемости, инвалидизации и преждевременной смертности. Современные исследования подтверждают необходимость совершенствования системы здравоохранения, учитывая прогнозируемое дальнейшее увеличение числа случаев и глобального бремени заболевания.

Цель исследования: оценить распространенности травм спинного мозга в Казахстане.

Методы. Оценка бремени травм спинного мозга осуществлялась посредством расчета показателя DALY, рассчитанных на основе двух ключевых показателей - YLL и YLD. Анализируемый период: 2018-2022 годы.

Результаты. Анализ показателей YLL, YLD и DALY за пятилетний период продемонстрировал значительное бремя травм спинного мозга для системы здравоохранения и общества в целом. Совокупные потери лет жизни из-за преждевременной смертности (YLL) составили 5 936,5 лет, а из-за инвалидности (YLD) - 16 402,0 лет. Интегральный показатель DALY достиг 22 388,5 лет, что свидетельствует о высокой актуальности проблемы и необходимости принятия системных мер по ее снижению.

Выводы. Динамика интегрального показателя DALY свидетельствует о возрастающем бремени заболевания и необходимости совершенствования системы медицинской помощи и реабилитации.

Ключевые слова: спинномозговые травмы, YLL, YLD, глобальное бремя болезней.