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## DYNAMICS AND STRUCTURE OF OCCUPATIONAL INJURIES IN KAZAKHSTAN AND ENGINEERING MEASURES TO REDUCE THEM

### ҚАЗАҚСТАНДАҒЫ ӨНДІРІСТІК ЖАРАҚАТТАНУ ДЫҢ ДИНАМИКАСЫ МЕН ҚҰРЫЛЫМЫ ЖӘНЕ ОНЫ ТӨМЕНДЕТУДІҢ ИНЖЕНЕРЛІК ШАРАЛАРЫ

### ДИНАМИКА И СТРУКТУРА ПРОИЗВОДСТВЕННОГО ТРАВМАТИЗМА В КАЗАХСТАНЕ И ИНЖЕНЕРНЫЕ МЕРЫ ЕГО СНИЖЕНИЯ

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#### Keywords:

occupational injuries, types  
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#### ABSTRACT

Occupational injuries remain an urgent social and economic problem, especially in the most dangerous industries such as construction, mining and manufacturing. The purpose of this study is to study the engineering and organizational and technical factors that cause a high incidence of occupational injuries in the country's enterprises. To solve the problems, methods of statistical data analysis over the past five years have been applied, as well as current regulatory legal acts, international ILO standards and the requirements of the ISO 45001 occupational safety and health management system have been analyzed. It has been established that the main reasons remain the wear and tear of technological equipment, the low level of automation of production processes, the lack of modern alarms and locking devices, as well as the poor qualifications of workers and the lack of training and motivation systems for staff. Based on the analysis, measures are proposed to reduce the level of injuries and improve the safety culture at enterprises.

#### Түйінді сөздер:

өндірістік жарақаттану,  
қызмет түрлері, зардап  
шеккендер, ауырлық  
дәрежесі, себептері

#### ТҮЙІНДЕМЕ

Өндірістік жарақаттану, әсіресе құрылыс, тау-кен және өңдеу өнеркәсібі сияқты ең қауіпті салаларда өзекті әлеуметтік және экономикалық проблема болып қала береді. Осы зерттеудің мақсаты-ел кәсіпорындарында өндірістік жарақаттардың жоғары жиілігін анықтайтын инженерлік және ұйымдастырушылық-техникалық факторларды зерттеу. Міндеттерді шешу үшін соңғы бес жылдағы деректерді статистикалық талдау әдістері қолданылды, сондай-ақ қолданыстағы нормативтік құқықтық актілер, ХЕҰ халықаралық стандарттары және ISO 45001 жүйесінің еңбек қауіпсіздігі мен еңбекті қорғауды басқару жөніндегі талаптары талданды. Негізгі себептер технологиялық жабдықтардың тозуы,



өндірістік процестерді автоматтандырудың төмен деңгейі, заманауи дабыл мен құлыптау құрылғыларының болмауы, сондай-ақ жұмысшылардың біліктілігінің әлсіздігі және оқыту мен персоналды ынталандыру жүйелерінің жетіспеушілігі болып қала беретіні анықталды. Жүргізілген талдау негізінде кәсіпорындарда жарақат алу деңгейін төмендету және қауіпсіздік мәдениетін арттыру бойынша шаралар ұсынылды.

**Ключевые слова:**

производственный  
травматизм, виды  
деятельности,  
пострадавшие, степень  
тяжести, причины

**АННОТАЦИЯ**

Производственный травматизм остаётся актуальной социальной и экономической проблемой, особенно в наиболее опасных отраслях, таких как строительство, горнодобывающая и обрабатывающая промышленность. Целью настоящего исследования изучение инженерных и организационно-технических факторов, обуславливающих высокую частоту производственных травм на предприятиях страны. Для решения задач были применены методы статистического анализа данных за последние пять лет, а также проанализированы действующие нормативные правовые акты, международные стандарты МОТ и требования системы ISO 45001 по управлению безопасностью и охраной труда. Установлено, что основными причинами остаются износ технологического оборудования, низкий уровень автоматизации производственных процессов, отсутствие современной сигнализации и блокировочных устройств, а также слабая квалификация рабочих и недостаток систем обучения и мотивации персонала. На основе проведённого анализа предложены меры по снижению уровня травматизма и повышению культуры безопасности на предприятиях.

**INTRODUCTION**

Industrial accidents are one of the most pressing socio-economic problems in the Republic of Kazakhstan. The International Labour Organization (ILO) estimates that about 2.78 million people worldwide die from accidents at work each year (International Labor Organization, 2019). This means that every 15 seconds, one person dies as a result of a work-related incident, and another 160 are injured, which underscores the urgency of this problem not only at the national but also at the global level. According to the ILO, workplace injuries are the third leading cause of death among the working-age population (Ospanova, 2012).

The highest levels of injuries and deaths were recorded in industries associated with heavy physical labor, insufficient mechanization and automation, as well as a high degree of occupational risk, such as construction, mining and manufacturing (Statistics on safety and health at work). In particular, in the construction industry, mortality is on average 3-4 times higher than in other sectors of the economy, and in the mining industry, the risks associated with landslides, explosions and exposure to harmful gases lead to serious health consequences and death of workers, such as silicosis and pneumoconiosis. For example, in the United States, total economic losses from occupational injuries and diseases are estimated at about \$250 billion per year, including medical costs, lost productivity, and compensation (Leigh, 2011).

An analysis of occupational injuries in the regions of the Russian Federation shows that there is a relationship between the number of accidents at work and the sectoral specialization of the regional economy (Moskvina, 2024). In countries with well-organized occupational health and safety systems, such as Germany, Canada, and South Korea, the implementation of ISO 45001 standards and the Vision Zero concept has helped significantly reduce injury rates (ISO 45001:2018, Vision Zero 2021). Germany has a mandatory occupational accident insurance system (DGUV), which guarantees insurance for all employees and support for rehabilitation activities

(Deutsche Gesetzliche Unfallversicherung). In Canada, regional authorities are actively involved in the creation and implementation of occupational safety programs, taking into account the specifics of professions and the typical risks of individual industries (Ministry of Labor, Immigration, Training and Skills Development, Ontario, Canada). South Korea is successfully implementing innovative technologies and employee health monitoring systems to ensure the safety of small and medium-sized businesses (South Korea's National Security Strategy).

This problem is also relevant for Kazakhstan. According to official data, there was a steady increase in the number of industrial accidents in 2019-2023, especially in high-risk industries (Bakishiev and Alikhan, 2024). In 2023, 2,670 accidents were registered, of which 246 resulted in the death of victims (National Bureau of Statistics of the Republic of Kazakhstan). The situation remains particularly acute in the West Kazakhstan region, an important industrial zone with large enterprises in the oil and gas sector, mechanical engineering and construction. In 2023, 57 accidents occurred there, resulting in the deaths of nine workers. Despite the current legal framework, including the Constitution of the Republic of Kazakhstan (1995), the Labor Code (2015) and the law "On Compulsory Insurance of employees against Accidents" (2005), the injury rate in the country remains high. The Constitution of the Republic of Kazakhstan guarantees citizens the right to safe work (article 24). The Labor Code of the Republic of Kazakhstan establishes the obligation of employers to ensure safe working conditions, including risk assessment, employee training and the provision of personal protective equipment (Labor Code of the Republic of Kazakhstan, Article 23). Domestic scientists believe that outdated technologies and the lack of modern safety systems are becoming the main factor in occupational injuries, which leads to an increased risk of accidents (Zhaksybekova and Bermagambetova, 2021). International and domestic experience shows the important role of the human factor in ensuring occupational safety, including the behavior, motivation, fatigue and psychophysical state of workers (Lechiev, 2016). Some experts point to possible attempts by employers to conceal incidents, which affects the accuracy of statistics and complicates regulation (Churanova, 2015).

The ILO argues that injury prevention is much cheaper than accident management and compensation (ILO, 2017), making occupational safety an essential component of social and economic policy.

The purpose of this study is to analyze the dynamics and structure of occupational injuries in the Republic of Kazakhstan in 2019-2023, as well as to identify factors influencing the formation of accidents at work, and to substantiate engineering and organizational measures aimed at reducing the level of occupational injuries.

The practical value of our work lies in the possibility of using the results obtained to develop effective injury prevention programs at enterprises, improve the system of state regulation of labor protection, increase the competence of employees in safety issues and reduce socio-economic losses associated with industrial accidents.

To achieve our goals, we have solved the following tasks:

- we conducted an analysis of the dynamics of occurrence and structure of industrial accidents;
- estimated the distribution of injuries by industry, type, cause, and severity;
- we have determined the influence of organizational, technical and human factors on the injury rate;
- we have formulated recommendations for improving the labor protection system.

The object of the study was the level of occupational injuries in the industry of Kazakhstan.

The object of the study is the level and structure of occupational injuries in the industries of the Republic of Kazakhstan.

The subject of the study was the causes and conditions of accidents at work, leading to varying degrees of severity of injuries.

The research methodology included the analysis of statistical data, comparative methods, content analysis of regulatory documents and generalization of the experience of enterprises.

Thus, the need for a comprehensive study of the causes and factors of occupational injuries in Kazakhstan, as well as the development of effective preventive measures, is obvious. Our research is aimed at identifying the key causes and patterns of occupational injuries.

## MATERIALS AND METHODS

This study is devoted to the identification and analysis of occupational injury factors in the Republic of Kazakhstan for the period from 2019 to 2023. The information base of the study was officially published statistical data from the Bureau of National Statistics of the Republic of Kazakhstan, as well as analytical materials from international organizations in the field of occupational safety, containing information on occupational injuries by region and industry. The data analysis was carried out using statistical and comparative analysis methods, which made it possible to identify the main trends and features of the formation of occupational injuries during the study period.

The main indicators used in the study were:

- the total number of victims of industrial accidents in the regions of Kazakhstan;
- the number of dead workers by type of economic activity;
- information about the severity of injuries and the duration of the recovery period;
- dynamics of changes in indicators over a five-year period.

In addition to the official statistical array, regulatory documents defining the procedure for ensuring occupational safety in Kazakhstan were used, including:

- Order of the Minister of Labor and Social Protection of the Population of the Republic of Kazakhstan No. 340 dated August 27, 2020 "On Approval of the Standard Rules of the Occupational Safety and Health Management System";

- Order of the Minister of Labor and Social Protection of the Population of the Republic of Kazakhstan No. 363 dated September 11, 2020 "On approval of the Rules for Occupational Risk Management".

The provisions of international standards such as ISO 45001 were also used to compare them with global occupational safety practices.

Data collection and processing were carried out using quantitative and qualitative analysis methods:

Descriptive statistics. Absolute and relative values, proportions, rates of growth and decline were calculated, as well as annual averages, coefficients of frequency and severity of injuries were determined.

Comparative interregional analysis. The differences in the structure and frequency of injuries between the regions of Kazakhstan were assessed.

Dynamic analysis. The assessment of changes in indicators over time was carried out, trends and cyclicity of changes were considered using time series analysis methods.

Structural analysis. The distribution of accidents by severity, types of economic activity and the main causes of their occurrence was studied.

Content analysis of regulatory documents. Regulatory acts and guidance documents were analyzed to assess the completeness of the legal framework and compliance with modern labor protection requirements.

The results of the study formed the basis for recommendations on reducing occupational injuries, developed specifically for entrepreneurs, government services and occupational safety specialists.

The ChatGPT (OpenAI) generative artificial intelligence system was used as a tool for editorial support and stylistic text correction.

## RESULTS AND DISCUSSION

The compilation of official statistics on industrial accidents in Kazakhstan, including the West Kazakhstan region, for the period from 2019 to 2023 shows a steady and alarming trend of their increase (table 1). A significant number of incidents have been recorded, resulting in serious injuries and, in some cases, deaths (Bureau of National Statistics of the Republic of Kazakhstan, 2025).

**Table 1.** Number of victims of industrial accidents, including fatal accidents

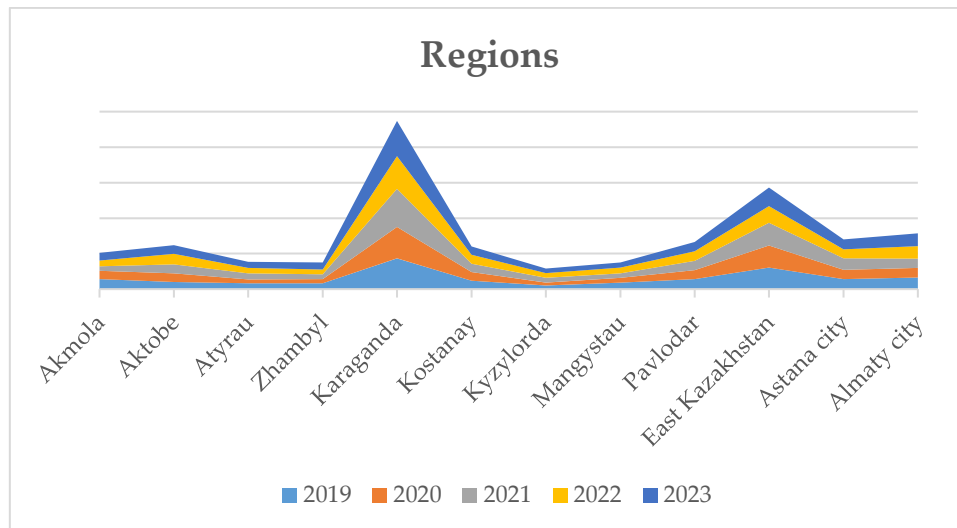
Regions	2019	2020	2021	2022	2023
Abai *	-	-	-	96	125
Akmola	140	118	62	84	107
Aktobe	103	118	129	149	118
Almaty	50	44	43	45	51
Atyrau	81	58	84	77	84
West Kazakhstan	65	77	58	63	57
Zhambyl	83	58	67	67	99
Zhetysu	-	-	-	15	37
Karaganda	433	443	537	460	496
Kostanay	120	122	115	127	118
Kyzylorda	52	41	67	66	62
Mangystau	90	68	65	82	69
Pavlodar	141	128	130	135	129
North Kazakhstan	38	50	43	41	38
Turkestan	58	65	81	54	63
Ulytau*	-	-	-	307	408
East Kazakhstan	302	314	320	233	263
Astana city	142	130	161	128	138
Almaty city	163	134	134	176	181
Shymkent city	50	65	37	44	27
<b>Total</b>	<b>2111</b>	<b>2033</b>	<b>2133</b>	<b>2449</b>	<b>2670</b>

*Note: compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan. The regions marked with "\*" were formed after 2021.*

The analysis of the data presented in Table 1 allowed us to record a steady upward trend in the number of victims at work throughout the country. The total number of victims increased from 2,111 to 2,670 over a five-year period. Such data indicate the low efficiency of the labor protection system at enterprises in the republic, and if this trend continues, the number of victims will increase significantly by 2030, which will lead to significant socio-economic losses.

The largest number of accidents was recorded in the Karaganda region, where 496 people were injured in 2023. The high level of injuries in this region is due to the high concentration of enterprises in the coal and metallurgical industries, which are characterized by outdated equipment, difficult working conditions and a high degree of wear and tear of fixed assets.

Unlike the Karaganda region, Shymkent and the North Kazakhstan region have the lowest injury rates, which is due to less developed industry and more favorable working conditions. However, even in these regions, it is necessary to maintain a high level of control over compliance with occupational safety regulations in order to prevent an increase in the number of accidents.



**Figure 1.** Dynamics of the number of victims of industrial accidents by regions of the Republic of Kazakhstan in 2019-2023

*Note – compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan.*

There are persistently high rates of occupational injuries (Figure 1) in Karaganda, East Kazakhstan and Pavlodar regions, as well as in cities of national significance - Almaty and Astana. In most regions, there is a relative stability of indicators with a moderate upward trend in 2023.

Table 2 shows data on the number of dead workers in production for the same period.

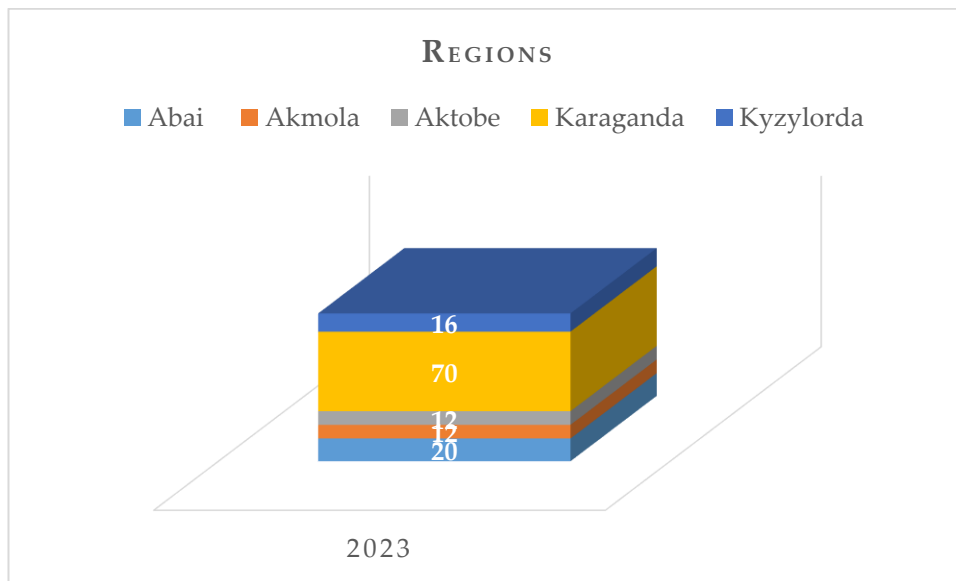
**Table 2.** Number of deaths at work as a result of accidents

Regions	2019	2020	2021	2022	2023
Abai *	-	-	-	6	20
Akmola	4	20	6	11	12
Aktobe	10	20	19	12	12
Almaty	6	2	4	4	1
Atyrau	3	9	4	5	7
West Kazakhstan	4	4	4	13	9
Zhambyl	7	7	16	12	9
Zhetysu	-	-	-	6	8
Karaganda	20	36	32	33	70
Kostanay	11	8	6	17	10
Kyzylorda	3	6	13	12	16
Mangystau	1	5	2	6	9
Pavlodar	6	5	5	6	4
North Kazakhstan	-	11	11	8	11
Turkestan	4	10	8	5	5
Ulytau*	-	-	-	2	8
East Kazakhstan	8	24	20	8	11
Astana city	12	13	17	21	8
Almaty city	6	12	5	12	10
Shymkent city	6	11	4	6	6
<b>Total</b>	<b>111</b>	<b>203</b>	<b>176</b>	<b>205</b>	<b>246</b>

*Note – compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan*

According to the data presented in table 2, the number of deaths as a result of industrial accidents in Kazakhstan increased from 111 to 246 from 2019 to 2023, i.e. an increase of more than 121%, which once again indicates significant shortcomings in various aspects of ensuring safe working conditions for workers in industrial enterprises.. On average, 188 people died annually during this period.

The Karaganda region, which is consistently the leader in the number of industrial accidents, also ranks first in the number of deaths. Between 2019 and 2023, 191 workers died in the region, with the sharp increase in deaths in 2023, when the death toll reached 70, being particularly alarming. Major industrial accidents, in particular the mine accident in the Karaganda region in 2023, had a significant impact on the increase in mortality rates (Sarybayeva, 2024).



**Figure 2.** Top 5 regions affected in 2023

*Note: compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan.*

Table 3 shows data on the number of dead workers by type of economic activity for the period from 2019 to 2023.

**Table 3.** Death toll by type of economic activity

Type of economic activity	2019	2020	2021	2022	2023
Agro-industrial, forestry and fisheries	15	14	7	12	6
Mining and quarrying activities	25	24	31	27	76
Manufacturing industry	32	39	27	33	25
Supply of electricity, gas, steam, hot water, including air conditioning	10	13	15	16	18
Water supply; waste collection, processing, disposal and pollution elimination	10	7	7	11	10
Construction	41	54	34	51	43
Retail and wholesale trade; maintenance, repair of cars and motorcycles	10	6	5	8	6

end of table 3

Transport and equipment	17	17	17	11	17
Provision of accommodation and catering services	1	1	1	2	1
Information and contacts	2	1	1	2	1
Real estate transactions	5	1	2	1	3
Technical, research and professional services	6	5	4	3	4
Work in administration and additional services	7	8	7	8	9
The defense sector, public administration and the compulsory social insurance system	5	6	8	4	19
Education	3	1	2	4	3
Social protection and healthcare system	1	4	8	9	3
Cultural and leisure services	15	1	7	3	1
Provision of other additional services	25	1	31	12	1
<b>Total</b>	<b>190</b>	<b>203</b>	<b>176</b>	<b>205</b>	<b>246</b>

*Note – compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan*

An analysis of the data in table 3 shows that the highest mortality rates are consistently recorded in the construction, mining, and manufacturing industries. This is due to the increased level of danger when performing production operations typical for these industries, insufficient automation of processes and high levels of physical activity. A total of 562 people died in these three industries between 2019 and 2023.

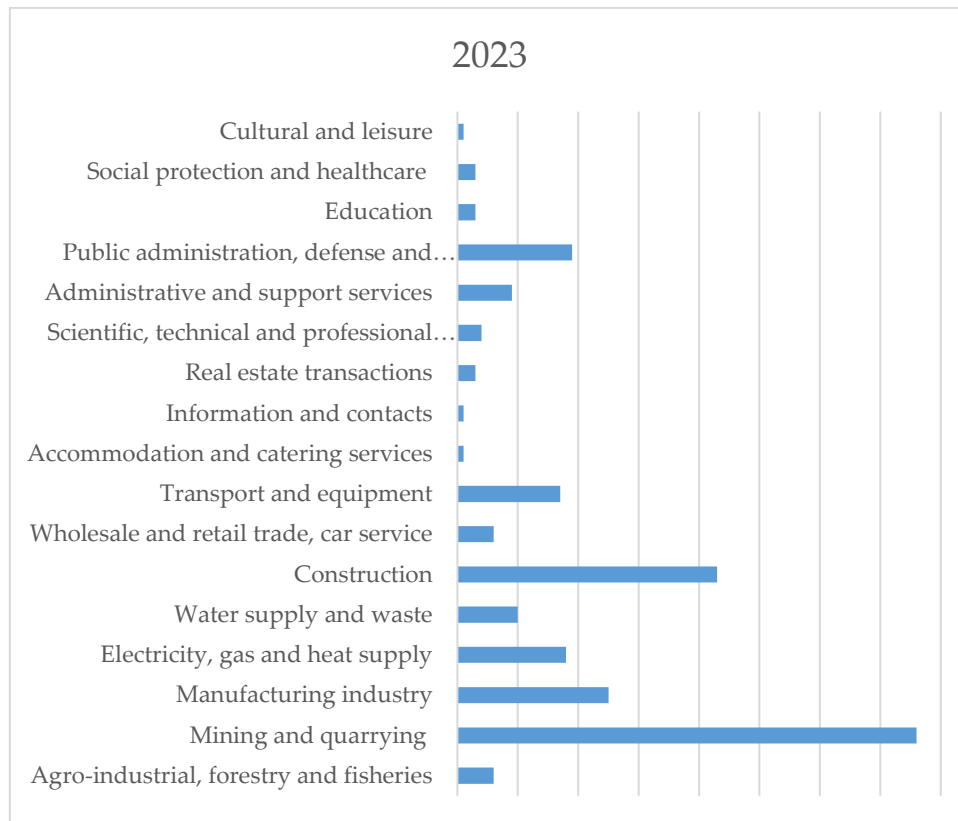
Of particular concern is the sharp increase in deaths during mining and quarrying in 2023, when the death toll increased from 27 to 76 people. This fact may indicate man-made accidents, systemic safety violations, or insufficient effectiveness of control and supervision measures for compliance with safety regulations at mining enterprises. Comparison with statistics from other countries shows that the mortality rate in the mining industry of Kazakhstan significantly exceeds similar indicators in countries with a developed occupational safety and health system.

A relatively positive trend is observed in the agro-industrial sector, where in recent years there has been a decrease in the number of deaths at work. However, this trend may be partly due to changes in the structure of agricultural production and the statistical accounting system. In particular, there is a significant decrease in the proportion of agricultural workers covered by statistical observations, which is associated with an increase in the number of small enterprises, peasant (farmer) and personal subsidiary farms of the population, which do not always fully fall within the scope of official statistical reporting. At the same time, there was a reduction in the number of large agricultural organizations, which were traditionally the main objects of statistical observation (Abikenova, 2023).

Figure 3 shows the distribution of registered industrial accidents by main types of economic activity. The data obtained indicate the need to prioritize preventive and supervisory measures in industries with the highest level of occupational risk.

A comparative analysis shows that the level of fatal occupational injuries in Kazakhstan remains significantly higher than in the countries of the European Union. According to Eurostat, in 2022, the EU average was 1.76 cases per 100,000 employees, while, for example, in the Karaganda region, this figure exceeds 10 cases per 100,000 employees, which is several times higher than the EU average. This difference is explained by a number of factors, including shortcomings in economic development and the state of domestic industry, a low level of safety culture and the effectiveness of state control, etc. In the EU countries, much attention is paid to the prevention of occupational injuries, the introduction of modern technologies and the

formation of a safety culture in which each employee is aware of his responsibility for safety and adheres to safety regulations.



**Figure 3.** Deaths by type of economic activity in 2023

*Note: compiled by the authors on the basis of data from the Bureau of National Statistics of the Republic of Kazakhstan.*

An analysis of domestic statistics also shows that a significant proportion of accidents occur in regions and enterprises with an insufficiently developed safety culture (Takala et al., 2014). In such organizations, there is often a lack of management attention to occupational safety issues, a low level of knowledge and awareness of workers about industrial risks, a lack of motivation to comply with safety requirements, as well as weak control over their implementation. The results obtained indicate the need for a more detailed analysis of the causes of occupational injuries, among which there is an insufficient assessment of occupational risks, the inconsistency of the applied preventive measures with the nature of existing industrial threats and an insufficiently developed occupational safety management system. In conditions where workers are not fully aware of the potential dangers and do not comply with established safety requirements, the likelihood of serious occupational injuries increases significantly.

Industries with a high proportion of manual labor, insufficient mechanization, work in difficult conditions (for example, in underground mines) and direct contact with dangerous equipment and substances are most at risk. During construction and installation work, the risk of falling from a height, injury when working with heavy machinery, and exposure to hazardous materials is particularly high. For example, accidents related to falling from heights prevail in the construction industry of Kazakhstan. In underground mines, where work is often carried out in confined spaces, with poor visibility and the presence of dangerous gases, there is a high probability of rock collapse, gas explosions and coal dust. The operation of heavy machinery used

in construction, mining and other industries is also associated with an increased risk of injury, and the main risks associated with the operation of heavy machinery (Nauka.kz, Liter, 2023). It is necessary to take into account the influence of socio-economic factors, such as low wages and shift work, which can negatively affect the motivation of employees to comply with the rules of OSH.

The analysis of official statistical data shows that the structure of occupational injuries in Kazakhstan is formed under the influence of both organizational and technological factors. According to the Ministry of Labor and Social Protection of the Population of the Republic of Kazakhstan and the Bureau of National Statistics of the Republic of Kazakhstan, among the main causes of industrial accidents in recent years are: violation of occupational safety requirements, insufficient control over production processes and the use of outdated equipment.

Based on the analysis of statistical materials and industry reports, the causes of occupational injuries can be conditionally grouped into three main categories:

1. Organizational reasons. This group includes insufficient management control, non-compliance with occupational safety instructions, and insufficient training for employees in safe working practices. According to the State labor protection reports, it is the violation of safety requirements and industrial discipline that accounts for a significant proportion of reported accidents.

2. Technical and technological reasons. This group is related to the condition of the equipment, the level of mechanization and automation of production processes. In a number of industries in Kazakhstan, a significant proportion of manual operations remain, especially during equipment repairs, loading and unloading operations and maintenance of production facilities. The use of outdated production facilities and insufficient automation of technological processes increase the likelihood of injury to workers.

3. The human factor. This group includes staff errors, non-compliance with technological regulations, employee fatigue, and insufficient professional training. Such factors are widely considered in modern occupational safety research.

According to the International Labor Organization, an effective reduction in occupational injuries is possible only with an integrated approach, including the modernization of equipment, the introduction of automated safety control systems, digital technologies for monitoring hazardous areas and working conditions, as well as the development of a culture of safe behavior in enterprises. Modernization of technological processes and the introduction of engineering solutions, such as automated production lines, robotic complexes and emergency stop systems, play an essential role in this process. Practice shows that the introduction of modern technological solutions can significantly reduce the level of injuries in industrial enterprises.

Analysis of statistical materials and research results shows that the formation of occupational injuries is caused by a combination of organizational, technical and behavioral factors. The most common reasons include poor technical condition of the equipment, insufficient level of mechanization and automation of production processes, violation of technological discipline, as well as insufficient assessment of occupational risks in the workplace. An additional factor is an insufficiently formed occupational safety culture, manifested in non-compliance with the requirements of the instructions and insufficient awareness of workers about possible production risks. Such conditions increase the likelihood of dangerous situations and serious work injuries.

The data obtained indicate the need to implement comprehensive measures to reduce occupational injuries, which requires coordinated actions by the state, employers and employees. The key areas are the improvement of the briefing and production control system, the introduction of digital technologies (motion sensors, video surveillance systems and monitoring the use of personal protective equipment), as well as strengthening state and internal industrial

supervision, including improving the skills of inspectors, the introduction of an internal control system at enterprises and the application of stricter sanctions for violations of safety requirements. An important role is played by the formation of a safety culture at enterprises through the development of corporate standards, holding competitions for the best occupational health and safety management system, involving employees in safety processes, as well as regular training and advanced training of personnel. Of particular importance are engineering solutions aimed at modernizing production processes: the introduction of automated production lines and robotic complexes, the use of sensors and monitoring systems for hazardous areas of equipment, the use of locking devices and emergency stop systems, as well as the introduction of occupational health and safety management systems based on the International Organization for Standardization ISO 45001 standard. Practice shows that upgrading technological processes and increasing the level of automation can significantly reduce the number of injuries associated with manual labor and equipment operation (EU-OSHA, 2022).

### CONCLUSION

Occupational accidents continue to be one of the most acute and urgent problems in the field of OSH both at industrial enterprises and at the state level as a whole. In these conditions, the formation of effective and scientifically based mechanisms for the prevention of occupational injuries, based on the analysis of statistical data, assessment of occupational risks and the introduction of modern engineering and organizational solutions, is of particular importance. An essential role in reducing injury rates is played by improving the occupational safety culture, developing a system for training employees in safe working methods, and developing sustainable skills for safe behavior in the workplace (Zhou, Fang, & Wang, 2008).

The analysis of statistical data for 2019-2023 showed that an unfavorable situation in the field of occupational injuries persists in the Republic of Kazakhstan. Despite the measures taken to improve the occupational safety and health management system, there has been a tendency to increase the total number of accidents at work during the period under review. The situation is particularly difficult in the Karaganda region, where for several years the highest rates have been recorded both in terms of the number of injured workers and the number of deaths. This is largely due to the industrial specialization of the region, which includes large enterprises of the mining and metallurgical industries, related to activities with a high level of occupational risk.

The analysis of the injury structure suggests that technical and organizational factors play a significant role in the formation of emergency situations. Among them, it is possible to single out the deterioration of a part of the production equipment, an insufficient level of automation of technological processes, the absence or insufficient effectiveness of automatic protection systems, as well as insufficient attention to issues of professional risk assessment and management. In some cases, the human factor also has an impact, including insufficient training of employees, non-compliance with the requirements of occupational safety instructions and an insufficiently formed culture of safe behavior at work.

International experience shows that a steady reduction in occupational injuries is achieved through the formation of a systematic approach to occupational safety management based on a combination of organizational, technical and engineering solutions, as well as the active involvement of employees in workplace safety processes (Armstrong, 2020). In modern conditions, the introduction of technological innovations aimed at reducing the impact of hazardous production factors and minimizing human involvement in potentially dangerous operations is of particular importance.

In order to increase the level of industrial safety and minimize occupational risks at enterprises in Kazakhstan, it seems advisable to focus efforts on the implementation of the following priority areas:

- improvement of the industrial safety system, including modernization of technological equipment, introduction of automated control systems, sensor and video surveillance systems, digitalization of monitoring processes in hazardous areas, as well as training and certification of personnel using modern training and simulation technologies;

- development of a comprehensive occupational risk assessment and management system that provides for regular identification of hazards, analysis of the likelihood of accidents, modeling possible industrial incidents and the development of effective response algorithms;

- implementation of modern engineering solutions aimed at improving the safety of equipment operation, including the use of automatic locking systems, sensors for monitoring process parameters, remote control and monitoring systems, as well as robotic complexes for performing the most dangerous production operations;

- the formation of a sustainable occupational safety culture, involving the active involvement of employees in occupational safety management processes, the development of mechanisms for motivating safe behavior, conducting training events and the introduction of corporate safety standards;

- a systematic analysis of the causes of industrial incidents, followed by the use of the results obtained to improve internal regulations and procedures for occupational safety management, including taking into account the requirements of regulatory acts of the Republic of Kazakhstan;

- regular assessment of the effectiveness of implemented measures aimed at determining their effectiveness, adjusting management decisions and adapting applied safety methods to changing production conditions.

Thus, a sustainable reduction in occupational injuries is possible only with the implementation of an integrated and multi-level approach, including the modernization of production equipment, the introduction of modern engineering and digital safety control technologies, the improvement of the occupational risk management system, as well as the formation of a high safety culture among employees. Coordinated actions by the state, employers and employees can create conditions for the formation of a safe and healthy working environment that meets modern industrial safety requirements and international labor protection standards.

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