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Sh. Abikenova [1] , R. Marcelloni [2] , Sh. Aitimova [3]

[1] *National Confederation of Employers "PARYZ", al-Farabi ave., 77/8, Almaty, Kazakhstan*
[2] *National Institute for Insurance against Accidents at Work (INAIL), P. le Pastore, 6, Roma, Italy*
[3] *Republican Research Institute of Labor Protection of the Ministry of Labor and Social Protection of the Population of the Republic of Kazakhstan, Kravtsova str., 18, Astana, Kazakhstan*
(E-mail: shabik_29@mail.ru, rafmarce@libero.it, aitimova_80@mail.ru)

Mathematical aspects of occupational risk and its classification considering statistical indicators

Abstract: Occupational risk emerges as a comparatively novel concept within the regulation of social and labor relations in the Republic of Kazakhstan, serving as an indicator of the risk for loss of work capacity or the death of an employee during the execution of their work-related (official) duties due to an occupational accident. This article elucidates the statistical aspects of occupational risk content, affirming the mathematical ubiquity and the validity of the scientific framework employed. The methodological foundation for assessing occupational risk incorporates universally accepted statistical methods for comparison, grouping, and systematisation through the juxtaposition of credible statistical data.

The purpose of the study is to employ one of the mathematical approaches to categorise types of economic activity into classes of occupational risk within the mandatory insurance system against accidents for workers fulfilling their occupational duties. The application of machine learning theory with big data across 132 types of economic activities (two-digit, including some five-digit codes) facilitated the execution of a classification procedure, resulting in the segmentation into 22 classes of occupational risk. It revealed the necessity for introducing a five-digit classification and further detailing the types economic activities as the class of occupational risk increases, such as including the five-digit codes 07101 "Underground mining of iron ores" and 43991 "Mine construction" into class 22 (the highest), delineating from the two-digit codes of the mining and construction industry accordingly. The scientific results were obtained within the framework of program-targeted funding by the Ministry of Labor and Social Protection of the Population of the Republic of Kazakhstan (scientific and technical program No. BR11965728 "Economic problems of safe work and institutional transformations of the insurance mechanism in the Republic of Kazakhstan").

Keywords: occupational risk, labor statistics, frequency of accidents, level of industrial injury, risk relevance sorting (ranks), variability range.

2000 Mathematics Subject Classification: 62P05

1. INTRODUCTION

In accordance with the Labor Code of 23 November 2015 No. 414-V ZRC [1], the employer is obliged to insure the employee against accidents in the performance of his/her labor (service) duties. This type of insurance is based on the attribution of types of economic activities (TEA) to classes of occupational risk according to the Regulations of attribution of types of economic

activities to classes of occupational risk approved by the Minister of Labor and Social Protection of the Republic of Kazakhstan dated 5 March 2022 No. 86 [2].

In connection with the introduction in December 2007 of a new classification of TEA (OKED NK RK 03-2019 five-digit), on the basis of the Order of the Committee for Technical Regulation and Metrology of the Ministry of Industry and New Technologies of Republic of Kazakhstan в„– 683-od from 14.12.2007 [3] in the application of the Regulations of attribution of types of economic activities to classes of occupational risk there were difficulties. It should be recalled that these rules were approved in 2005 as part of the introduction of a new type of insurance - compulsory insurance of workers civil liability for harm caused to the life and health of an workers while performing their work (official) duties [4]. Incidentally, the name of the insurance type was changed in 2010 to compulsory insurance against accidents for workers in the performance of their work (official) duties. While the name of the insurance changed, the model essentially remained unchanged. A comparative analysis of TEA established that the existing classification contains verbal descriptions without specifying numerical codes, and that out of 996 codes in the new classification, only 97 (i.e., only 10%) have verbal descriptions that match the formulations contained in the Regulations for classifying TEA. A significant number of activity types in the new classification are not listed in the rules, and conversely, several verbal descriptions contained in these rules are absent in the new classification.

A few existing codes allow for multiple interpretations, and accordingly, the same OKED (Classification of Economic Activities) can be assigned to different risk classes. This has created a foundation for manipulating risk classes (the possibility of assigning an OKED to the class with the lowest risk and, consequently, with a lower insurance premium among the options), with the aim of attracting a larger number of enterprises. The division of types of activities into risk classes also raises questions when less significant types of activities (for example, the production of ropes, cords, twine, and nets) are given a separate line, while more significant types of activities are "neglected". In this context, the revision of the "Regulations for classifying types of economic activities into Occupational Risk Classes" is a priority task, as is discussed in this article. Scientific results were obtained in accordance with OKED with its verbal description and the indication of the numerical code.

2. METHODS

The materials for the study were based on the results of statistical research on industrial injuries in the Republic of Kazakhstan, conducted during the period from 2018 to 2022, as well as materials from an analytical note on the study of reporting on the number of workers in harmful and other adverse working conditions by specific TEA [5-6].

As a source of statistical information, numerical data collected through Form 7-TPZ "Report on Injuries Related to Occupational Activities and Occupational Diseases" and Form 1-T (working conditions) "Report on the Number of Workers in Harmful and Other Adverse Working Conditions" from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (BNS) were used.

Types of economic activity are classified according to the general classifier of economic activities (OKED NK RK 03-2019 five-digit), which covers the complete nomenclature of 996 types of economic activities according to ISIC-Rev.4, developed by the United Nations for the collection, processing, and storage of information necessary for economic analysis and decision-making at the macroeconomic level [7]. In this study, during the analysis of statistical data, both two-digit and five-digit levels of the OKED were utilized. The methodological basis for the research conducted here was guided by the manual [8-9].

3. RESULTS AND DISCUSSIONS

In accordance with the Regulations for Occupational Risk Management, approved by the order of the Minister of Labor and Social Protection of the Population of the Republic of Kazakhstan dated 11 September 2020, No. 363 [10], occupational risk is understood as the risk of loss of work capacity or death of an employee in the performance of work (official) duties. In turn, the Labor Code of the Republic [1] provides that temporary or permanent loss of work capacity or death is caused by an industrial injury, a sudden deterioration in health, or poisoning of the

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worker, which are the result of exposure to harmful and/or dangerous production factors while performing work (official) duties, i.e., an accident related to labor activities (at the workplace).

Before proceeding to the results of the scientific research, it is also worth recalling that, according to the legislation of the Republic of Kazakhstan, the concept of an occupational risk class is applied - the level of industrial injuries and occupational diseases that has developed according to TEA [4].

As initial data for classifying TEA into occupational risk classes according to the Regulations for Classifying Types of Economic Activities into Occupational Risk Classes [2], the following statistical indicators over the previous five years are used:

– *average annual listed number of workers by type of economic activity.*

– *number of workers employed in harmful and other adverse working conditions by specific TEA.*

– *number of individuals who have suffered accidents related to work activities.*

– *number of fatalities resulting from work-related accidents.*

– *annual accrued number of payments to victims of work-related accidents, including the average amount of compensation per victim of an accident.*

– *annual total of accrued payments in the event of death of workers related to work activities, including the average size of the accrued payments.*

– *annual total of premiums paid to the insurer for accepting the obligation to make an insurance payout to the beneficiary in the amount determined by the compulsory insurance contract against accidents for the employee.*

– *annual wage fund by type of economic activity.*

– *loss of working time – the number of calendar man-days of incapacity that ended in the reporting year among the victims, including the deceased.*

TEA have been classified into occupational risk categories based on the values of the indicators listed below:

– *proportion of workers employed in harmful and other adverse working conditions by TEA, %.*

– *frequency rate of occupational injuries per 1,000 workers.*

– *frequency rate of fatal accidents per 1,000 workers.*

– *ratio of the frequency rate of fatal accidents per 1,000 workers to the frequency rate of all occupational injuries per 1,000 workers.*

– *distribution of the number of victims by TEA, %.*

– *distribution of the number of workers employed in harmful and other adverse working conditions by TEA, %.*

Also, indicators such as the ratio of the annual accrued amount of payments to victims of work-related accidents and the annual amount of accrued payments in the event of the death of workers related to work activities to the annual wage fund by type of economic activity (%), and the ratio of the annual accrued amount of payments to victims of work-related accidents and the annual amount of accrued payments in the event of the death of workers related to work activities to the annual amount of premiums paid to the insurer by type of economic activity (%).

Given the above, the article examines the issues of assessing the risk of accidents related to work activities. Simultaneously, the application of mathematical methods in assessing the risk of accidents is explored in various articles [11-17].

For instance, Jinxian Weng, Xiafan Gan, Zheyu Zhang proposed a mathematical model, QRA (Quantitative Risk Assessment), for assessing the risk of accidents (in the transportation of hazardous materials at work) [11], which combines the frequency of accidents and their consequences. In the work of Iranian scientists Maryam Sadat Hajakbari and Behrouz Minaei-Bidgoli, the results of a comprehensive thematic study utilizing data mining methods based on data from the Ministry of Labor of Iran are presented, aiming at developing a new scoring system for assessing the risk of workplace accidents [12]. The findings of the research indicate that by integrating methods based on the frequency and severity of accidents, used for assessing organizational safety, and data mining models, the proposed accident risk assessment method

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enables the identification and evaluation of critical points with a high level of accuracy. The practical application of the method is demonstrated, identifying the most hazardous workplaces in 2010 and determining the risk level for each category. Subsequently, by repeating the procedure for 2011, critical points are identified based on previous data, and a list of workplaces requiring periodic inspections in 2012 is compiled.

The study [13] is aimed at identifying the most suitable model for predicting the frequency of accidents in the workplace and determining the economic criteria that have the greatest impact. It examines four machine learning algorithms - Random Forest (RF), Support Vector Machine (SVM), Multivariate Adaptive Regression Spline (MARS), and M5 Tree Model (M5), for predicting workplace accidents, considering three economic criteria: Basic Income (BI), Inflation Index (II), and Price Index (PI).

In the work [14], the task of modeling the frequency of losses in insurance through actuarial calculations and the application of Bayesian "Classification and regression trees" (CART) models for accident frequency is addressed. Among many statistical methods, a result presented in [15] is highlighted, which, based on a publicly available database of workplace accidents and assuming that accident statistics information is definitive, ensures its statistical significance.

Scientific results from domestic scientists [16-17] can also be cited. The work [16] presents data on the dynamics of industrial injuries and occupational diseases in the mining industry of the Republic of Kazakhstan. The study [17] applies methods of economic and statistical analysis in the field of occupational safety and provides recommendations for optimizing the system of statistical monitoring of occupational safety. This includes the introduction of new methods for data collection and processing, updating forms of statistical reporting, and implementing proactive approaches to improving working conditions and preventing workplace accidents.

In this study, the object of scientific research is the occupational risk indicator, which is conducted based on the analysis of Kazakhstan statistics on injuries and mortality related to work activities and occupational diseases to assess occupational risk in detailed breakdown by TEA with a non-zero indicator of industrial injuries.

Various approaches are used for classification. Specifically, Hoffmann E, Chamie M. [18] distinguish between different types of classifications, i.e., "reference," "derived," or "related" classifications. Reference classifications result from international agreements approved by the United Nations Statistical Commission or another competent intergovernmental council. ISCO (International Standard Classification of Occupations, ILO) [19] and ISIC (International Standard Industrial Classification of All Economic Activities, UN) [7] are reference classifications and are recognized as such in the family of international economic classifications adopted at the second meeting of the Expert Group on International Classifications [20].

For a more detailed statistical analysis, all economic activities were considered at the five-digit code level (level) according to the OKED (Classification of Economic Activities of the Republic of Kazakhstan) NK RK-2019, the total number of which is 1018 types. Of these, economic activities with a non-zero list number of employees (hereinafter referred to as LNE), including small enterprises acting as a control group for calculating the indicators of industrial injuries on average for the analyzed period, amounted to 944 or 92.6%. Of these 944 types, in 504, there were registered incidents of accidents at work, which constitutes about 55% of the total number of economic activities with a non-zero list number of workers. As of the end of 2022, according to the BNS, the LNE amounted to 5,522.5 thousand people, with the share of workers employed in industry, construction, and the transport sector constituting 28.6%. In these sectors of the economy, the proportion of injured and deceased accounted for approximately 70% of the total number of workers who suffered injuries or died across the country (69.5% and 74.0%, respectively). As of the end of 2022, according to the BNS, the LNE amounted to 5,522.5 thousand people, with the share of workers employed in industry, construction, and the transport sector constituting 28.6%. In these sectors of the economy, the proportion of injured and deceased accounted for approximately 70% of the total number of workers who suffered injuries or died across the country (69.5% and 74.0%, respectively).

For the statistical analysis of industrial injuries, occupational diseases, and mortality due to workplace accidents, the following indicators for the years 2018-2022 were used:

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– list number of workers, including small enterprises.

– number of individuals injured in work-related accidents with a loss of working capacity for 1 working day or more.

– number of fatalities in work-related accidents.

– number of workers employed in harmful and (or) hazardous working conditions (HHWC).

The aggregate values for the LNE and the number of workers who were injured or died in enterprises of the Republic of Kazakhstan for the period from 2018 to 2022, across 19 industries where incidents of workplace accidents are registered, are provided in Table 1.

Table 1 - Aggregate data by sectors of the Republic of Kazakhstan, averaged for 2018-2022.

Code and Name of the Sector	LNE (thous. people)	specific weight, %	number of injured, (people)	specific weight, %	including fatalities (people)	specific weight, %
A - Agriculture, forestry and fishing	144,3	2,6%	323	3,0%	59	6,0%
B - Mining and quarrying	223,5	4,0%	2 197	20,2%	135	13,7%
C - Manufacturing	471,2	8,5%	2 890	26,5%	167	16,9%
D - Electricity, gas, steam and air conditioning supply	114,8	2,1%	399	3,7%	67	6,8%
E - Water supply; sewerage, waste management and remediation activities	60,0	1,1%	272	2,5%	46	4,7%
F - Construction	398,9	7,2%	1 082	9,9%	233	23,6%
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	658,9	11,9%	448	4,1%	39	3,9%
H - Transportation and storage	311,3	5,6%	728	6,7%	84	8,5%
I - Accommodation and food service activities	94,6	1,7%	113	1,0%	5	0,5%
J - Information and communication	134,4	2,4%	74	0,7%	3	0,3%
K - Financial and insurance activities	114,1	2,1%	38	0,3%	1	0,1%
L - Real estate activities	106,6	1,9%	77	0,7%	8	0,8%
M - Professional, scientific and technical activities	209,9	3,8%	142	1,3%	20	2,0%
N - Administrative and support service activities	261,6	4,7%	475	4,4%	33	3,3%
O - Public administration and defence; compulsory social security	410,1	7,4%	255	2,3%	39	3,9%
P - Education	1089,2	19,7%	273	2,5%	12	1,2%
Q - Human health and social work activities	488,8	8,9%	977	9,0%	27	2,7%
R - Arts, entertainment and recreation	116,0	2,1%	75	0,7%	7	0,7%
S - Other service activities	114,3	2,1%	48	0,4%	4	0,4%
TOTAL for the Republic of Kazakhstan	5522,5	100,0	10 886	100	989	100

TEA are classified into occupational risk classes based on the following indicators:

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1. Share of employment in harmful and (or) hazardous working conditions (K_1):

$$K_1 = \frac{N_{hhwc}}{LNE} \times 100\% \tag{1}$$

were,

N_{hhwc} - number of workers employed in harmful and (or) hazardous working conditions (HHWC);

LNE – list number of employees.

2. Total Incident Frequency Rate per 1 000 workers, TIFR (K_2);

$$K_2 = \frac{N_{acc}}{LNE} \times 1000 \tag{2}$$

were,

N_{acc} – number of accidents related to labor activity with loss of working capacity for 1 working day or more.

3. Fatality Incident Frequency Rate per 1 000 workers, FIFR (K_3);

$$K_3 = \frac{N_{fi}}{LNE} \times 1000 \tag{3}$$

were,

N_{fi} – number of deaths in labor-related accidents.

4. K_4 - ratio of K_3 and K_2 coefficients, FIFR /TIFR;

5. Distribution of the number of people affected and works in HHWC by type of economic activity (K_5):

$$K_5 = \frac{N_acc\&hhwc(TEA)}{N_t} \times 100\% \tag{4}$$

were,

$N_{acc\&hhwc(TEA)}$ - number of accidents related and works in HHWC by certain types of economic activity;

N_t – total number of accidents related and works in HHWC.

K_2 (frequency rate of all occupational accidents per 1,000 workers) was used as a key indicator. Based on these indicators, a new approach to classify TEA into 22 classes of occupational risk has been developed.

It should be noted here that to properly assess the injury rate, it is very important to analyse not only the frequency of fatal and non-fatal workplace injuries, but also to assess the ratio between them, which the ILO uses as an indicator of the level of non-fatal workplace injury underreporting. Fatal accidents are difficult to conceal, so data on such accidents are considered statistically reliable, unlike data on non-fatal accidents. Jukka Takala notes in his research paper that because there is no exaggeration of injury rates in reported data, "a low rate indicates underreporting of minor accidents, which are quite common"[21].

The results of the statistical analysis carried out are described below.

The figure below illustrates the values of indicator K_1, i.e. the share of those employed in hazardous labor conditions by certain TEA with the industry code according to ISIC-Rev.4.

The industries with the largest number of workers employed in harmful and other unfavorable working conditions were manufacturing (27.8%), mining and quarrying (23.0%), transport and warehousing, and water supply (13.8% and 13.6% respectively).

Table 2 presents the estimated values of indicators regarding occupational injuries, namely TIFR, FIFR and the ratio of FIFR to TIFR.
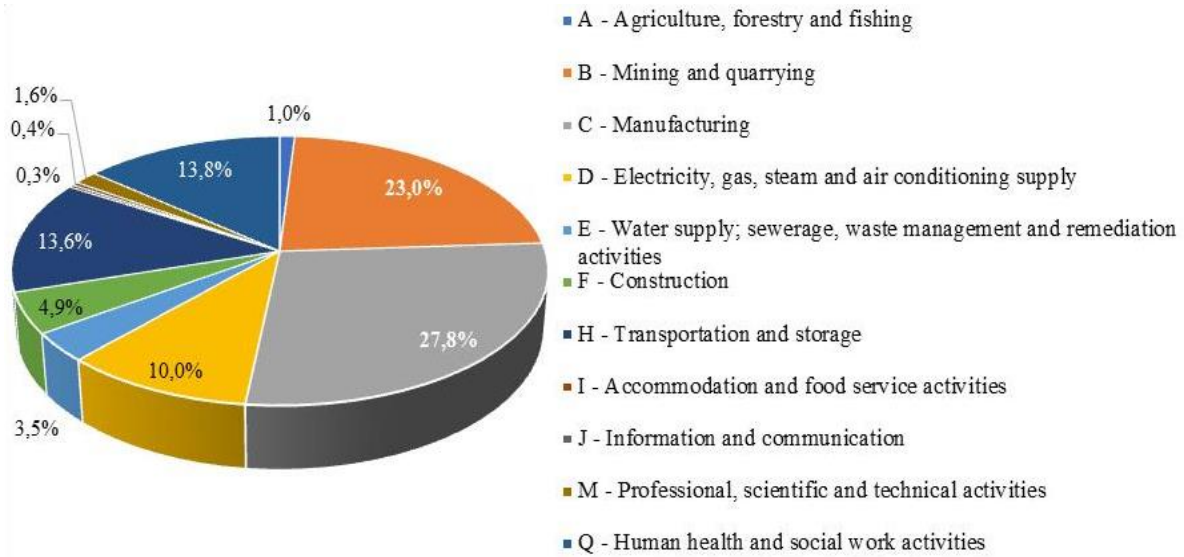
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- A - Agriculture, forestry and fishing
- B - Mining and quarrying
- C - Manufacturing
- D - Electricity, gas, steam and air conditioning supply
- E - Water supply; sewerage, waste management and remediation activities
- F - Construction
- H - Transportation and storage
- I - Accommodation and food service activities
- J - Information and communication
- M - Professional, scientific and technical activities
- Q - Human health and social work activities

FIGURE 1 – Figure 1 - Specific weight of those employed in harmful labor conditions by certain types of economic activity (calculated based on official data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of RK, form 1-T (labor conditions) - Report on the number of workers employed in harmful and other unfavorable working conditions).

Table 2 - Indicators of occupational injuries by individual types of economic activity

Code and name of sectors	Indicators		
	K_2	K_3	K_4
Total for RK	0.40	0.04	0.10
A - Agriculture, forestry and fishing	0.47	0.08	0.18
B - Mining and quarrying	1.84	0.14	0.08
C - Manufacturing	1.19	0.09	0.07
D - Electricity, gas, steam and air conditioning supply	0.68	0.13	0.18
E - Water supply; sewerage, waste management and remediation activities	1.31	0.22	0.16
F - Construction	0.61	0.13	0.22
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	0.15	0.01	0.08
H - Transportation and storage	0.51	0.07	0.14
I - Accommodation and food service activities	0.21	0.01	0.05
J - Information and communication	0.19	0.01	0.04
K - Financial and insurance activities	0.08	0.00	0.02
L - Real estate activities	0.16	0.02	0.14
M - Professional. scientific and technical activities	0.18	0.03	0.15
N - Administrative and support service activities	0.22	0.02	0.10
O - Public administration and defence; compulsory social security	0.14	0.02	0.17
P - Education	0.05	0.00	0.06
Q - Human health and social work activities	0.39	0.01	0.04
R - Arts. entertainment and recreation	0.15	0.01	0.05
S - Other service activities	0.12	0.01	0.08

The level of occupational injuries is significantly differentiated by industries. The top industries in terms of these indicators are as follows:

1. Mining and quarrying (K_2 – 1.84, K_3 – 0.14, K_4 – 0.08).
2. Water supply; sewerage, waste management and remediation activities (K_2 – 1.31, K_3 – 0.22, K_4 – 0.16).
3. Manufacturing (K_2 – 1.19, K_3 – 0.09, K_4 – 0.07);
4. Electricity, gas, steam, and air conditioning supply (K_2 – 0.68, K_3 – 0.13, K_4 – 0.18).
5. Construction (K_2 – 0.61, K_3 – 0.13, K_4 – 0.22).

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The assignment of TEA to occupational risk classes was made in accordance with the following six stages.

At the first step, four indicators were calculated for the five-digit level of classification of economic activities based on the arithmetic mean of statistical indicators for the previous five years.

Thus, 660 numerical values were found for 132 TEA $\{k_i^s\}$, (where $i = 1, \ldots, 5; s = 1, \ldots, 132$) which were then subjected to comparative procedures.

At the second step, the total set of economic activities subject to classification to occupational risk classes is determined on the basis of all sub-activities of economic activities according to the five-digit level of classification, dominating by the specific weight of victims in the related type of economic activity (Indicator K_2 values of which exceed the republican indicator – 0.40), that is $k_2^s > k_2$, (where $i = 1, \ldots, 5; s = 1, \ldots, 132, k_2$ - republican indicator).

At the third step, the indicators for every TEA of the total population were assigned ratings in ascending order of values: the lowest value (zero) has a rate of 1, the highest value - a rate equal to the number of different values of the corresponding indicator for all types of economic activity (equal values were assigned the same rate); for K_1 - 1 to 89; K_2 - 1 to 77; K_3 –1 to 87; K_4 - 1 to 94, $\max k_1^s = 89$, $\max k_2^s = 77$, $\max k_3^s = 87$, $\max k_4^s = 94$.

At the fourth step, weighted average values of ranks and their total value were calculated for every TEA of the total population.

At the fifth step the intervals were determined on the basis of quantitative (ordering the data from the minimum to the maximum, taking into account the average value for the entire population) and qualitative (equal to the total number of occupational risk classes) features of grouping (for indicators K_1, K_2, K_3, K_4 the minimum total value is 0.09 and the maximum is 3.14, respectively for occupational risk classes 1 and 22, for indicators K_1 and K_2 respectively 0.02 and 1.94).

At the sixth step, all TEA are classified by occupational risk classes according to the belonging of their total value of weighted average values of ranks to the corresponding interval value.

The application of this approach to the task of classifying TEA into classes of occupational risk based on a statistical study of indicators of occupational injuries and working conditions allowed 132 types (two-digit, including some five-digit) to be classified into 22 classes. In particular, the first class of occupational risk includes two-digit TEA of such industries as information and communication, financial and insurance activities, activities of households and extraterritorial organisations and bodies. At the same time, with the increase of the occupational risk class, the detailing by TEA increased, so the 22nd class (the highest) includes five-digit types of economic activity 07101 "Underground mining of iron ore" and 43991 "Mine construction", with the allocation of the two-digit code of mining and construction industry, respectively.

All the results obtained in the course of the calculation and analytical work on assigning TEA to classes have been introduced into the domestic labor legislation and are reflected in the Regulations for assigning TEA to classes of occupational risk, approved by Order No. 86 of the Minister of Labor and Social Protection of the Republic of Kazakhstan dated 5 March 2022.

CONCLUSIONS

Identification of risks of production factors for safety and health of workers and their further allocation to individual TEA requires priority attention. Classification of TEA into classes of occupational risk is based on statistical data on working conditions and occupational injuries using methods of mathematical analysis. Classification of occupational risks by individual activities should meet the criteria of similarity of risk characteristics in one group of industry affiliation, the coverage of statistical data should be large enough for data reliability, and the definitions of each class should be sufficiently accurate to exclude the possibility that two identical risks will be classified differently. Therefore, the reliability and transparency of such information will subsequently have a meaningful impact on the outcome of the work undertaken. A scientifically substantiated methodology for classifying TEA into occupational risk classes will serve as a reference point for applying differentiated insurance rates for industrial accident insurance.

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Ш.К. Әбікенова [1] **, Р. Марчеллони** [2] **, Ш.Т.Әйтімова** [3]

[1] *"Paryz" жұмыс берушілер ұлттық конфедерациясы", әл-Фараби даңғ, 77/8, Алматы, Қазақстан*

[2] *Өндірістегі жазатайым оқиғалардан сақтандыру ұлттық институты (INAIL), le Pastore ave., 6, Рим, Италия*

[3] *Еңбек және халықты әлеуметтік қорғау министрлігінің Республикалық еңбекті қорғау бойынша ғылыми-зерттеу институты, Кравцова, 18, Астана, Қазақстан*

Кәсіби тәуекелдің статистикалық көрсеткіштер негізінде жіктелуінің математикалық аспектілері

Аннотация: Кәсіптік тәуекел Қазақстан Республикасындағы әлеуметтік-еңбек қатынастарын реттеудегі салыстырмалы түрде жаңа ұғым болып табылады. Еңбек қызметіне байланысты жазатайым оқиға нәтижесінде еңбек (қызметтік) міндеттерін атқару кезінде еңбекке қабілеттілігінен айырылу не қызметкердің қайтыс болу тәуекелінің көрсеткіші ретінде қолданылады. Экономикалық қызметтің 132 түрінде (екі таңбалы, соның ішінде кейбір бес таңбалы) үлкен деректер бар Машиналық оқыту теориясын қолдану кәсіби тәуекелдің 22 санатына бөлінген жікте процедурасын жүргізуге мүмкіндік берді. Кәсіби тәуекелді бағалаудың әдістемелік негізі сенімді статистикалық деректерді пайдалану арқылы салыстырудың, топтастырудың және жүйелеудің жалпы қабылданған статистикалық әдістері болып табылады.

Зерттеудің мақсаты - қызметкерді еңбек міндеттерін орындау кезінде жазатайым оқиғалардан міндетті сақтандыру жүйесінде кәсіптік тәуекел санаттары бойынша экономикалық қызмет түрлерін жіктеудің математикалық тәсілдерінің бірін қолдану. Бұл тәсілді пайдалану экономикалық қызметтің 132 түрін (екі таңбалы, оның ішінде кейбір бес таңбалы) кәсіптік тәуекелдің 22 санатына жатқызуға мүмкіндік берді. Кәсіби санатты арттыру кезінде экономикалық қызмет түрлерін бес таңбалы жіктеуді және егжей-тегжейлі көрсетуді енгізу қажеттілігі анықталды. Сондықтан 22 (жоғары) сыныпқа тау-кен өнеркәсібі мен құрылыс саласының екі таңбалы кодының 07101 "Темір кендерін жерасты өндіру" және 43991 "Шахта құрылысы" бес таңбалы экономикалық қызмет түрлері кірді. Ғылыми нәтижелер Қазақстан Республикасы Еңбек және халықты әлеуметтік қорғау министрлігінің бағдарламалық-нысаналы қаржыландыру шеңберінде алынды (№ BR11965728 "Қазақстан Республикасында қауіпсіз еңбектің экономикалық проблемалары және сақтандыру механизмінің институционалдық қайта құрулары").

Түйін сөздер: кәсіптік тәуекел, еңбек статистикасы, жазатайым оқиға жиілігі, өндірістік жарақат деңгейі, тәуекелділік (рангтар) бойынша сұрыптау, ауыспалы диапазон.

Ш.К. Абикенова [1] **, Р.Марчеллони** [2] **, Ш.Т. Айтимова** [3]

[1] *Национальная конфедерация работодателей "Paryz", пр. аль-Фараби, 77/8, Алматы, Казахстан*

[2] *Национальный институт страхования от несчастных случаев на производстве (INAIL), le Pastore, 6, Рим, Италия*

[3] *Республиканский научно-исследовательский институт охраны труда Министерства труда и социальной защиты населения Республики Казахстан, Кравцова, 18, Астана, Казахстан*

Математические аспекты профессионального риска и его классификации с учетом статистических показателей

Аннотация: Профессиональный риск является относительно новым понятием в регулировании социально-трудовых отношений в Республике Казахстан и применяется в качестве индикатора риска утраты трудоспособности либо смерти работника при исполнении трудовых (служебных) обязанностей в результате несчастного случая, связанного с трудовой деятельностью. В статье раскрываются статистические аспекты содержания профессионального риска в подтверждении математической вездесущности и обоснованности научного аппарата. Методической основой оценки профессионального риска являются общепринятые статистические методы сравнения, группировки и систематизации посредством сопоставления достоверных статистических данных.

Цель исследования состоит в применении одного из математических подходов к распределению видов экономической деятельности по классам профессионального риска в системе обязательного страхования работника от несчастных случаев при исполнении им трудовых обязанностей. Применение теории Машинного обучения с большими данными в 132 видах экономической деятельности (двухзначные, включая некоторые пятизначные) позволило произвести процедуру классификации с разбивкой на 22 класса профессионального риска. Была выявлена необходимость при повышении класса профессионального введения пятизначной классификации и детализации видов экономической деятельности, так в 22 класс (самый высокий) вошли пятизначные ВЭД 07101 "Добыча железных руд подземным способом" и 43991 "Строительство шахт", с выделением из двухзначного кода горнодобывающей промышленности и строительной отрасли соответственно. Научные результаты получены в рамках программно-целевого финансирования Министерством труда и социальной защиты населения

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Ключевые слова: профессиональный риск, статистика труда, частота несчастных случаев, уровень производственного травматизма, сортировка по релевантности риска (ранги), вариативный диапазон.

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Information about authors:

Әбікенова Шолпан Кәкімжанқызы - байланыс үшін автор, ф.-м.ғ.к., доцент, "PARYZ" жұмыс берушілер ұлттық конфедерациясы" ММ бас директорының орынбасары, әл-Фараби даңғ., 77/8, Алматы, Қазақстан.

Раффаэлло Марчеллони - статистика, демографиялық және актуарлық ғылымдар магистрі, Статистика және актуарлық есептеулер департаментінің білікті актуарийі, Өндірістегі жазатайым оқиғалардан сақтандырудың ұлттық институты (INAIL), le Pastore ave., 6, Рим, Италия.

Әйтімова Шынар Тұрсынханқызы - экономика ғылымдарының магистрі, Еуразия ұлттық университетінің докторанты, Еңбек және халықты әлеуметтік қорғау министрлігінің Республикалық еңбекті қорғау ғылыми-зерттеу институты экономикалық өлшемдер және статистика бөлімінің статистика секторының меңгерушісі. Қазақстан Республикасы, Кравцова, 18, Астана, Қазақстан.

Sholpan Abikenova - corresponding author, cand. of phys.-math. sci., Associate Professor, Deputy General Director, ALE "National Confederation of Employers "PARYZ", al-Farabi ave., 77/8, Almaty, Kazakhstan.

Raffaello Marcelloni - Master's Degree in Statistical, Demographic and Actuarial Sciences, qualified actuary in General Statistical and Actuarial department, National Institute for Insurance against Accidents at Work (INAIL), le Pastore, 6, Roma, Italy.

Shynar Aitimova - Master's Degree of Economics, doctoral student of the Eurasian National University, head of the statistics sector of the department of economic measurements and statistics, Republican Research Institute of Labor Protection of the Ministry of Labor and Social Protection of the Population of the Republic of Kazakhstan, Kravtsova, 18, Astana, Kazakhstan.