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ASSESSING RISKY BEHAVIORS BASED ON THE INDICATOR ANALYSIS OF STATISTICS ON ACCIDENTS AT WORK

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Abstract:
The aim of the paper was to analyze risky behaviors in the mining industry on the example of the indicator analysis of the statistics on accidents at work. Selected criteria of generic analysis (structure index – causes of accidents) and indicator analysis (intensity index – frequency indicator of accidents) were used in the research. The source of data for the analysis of accident rate were the publications of the Statistics Poland entitled "Accidents at work" in Poland for 2010-2021. The study aimed at human causes, which included the following five groups: lack or improper handling of a material factor by the employee, failure to use protective equipment by the employee, improper willful behavior of the employee, improper mental and physical state of the employee, improper behavior of the employee. For the analysis of risky behaviors, the proposition of the frequency indicator of accidents at work was used in the form of the probability indicator of accidents caused by risky behaviors per 1,000 working people. Based on the indicator analysis of risky behaviors, a comparative analysis of statistics on accidents at work in the period 2010-2021 according to the criterion of human causes was developed for Poland and mining. The research is based on the data of the Statistics Poland (GUS), but can be extended with other data, e.g. industry data according to the State Mining Authority (WUG). The results of the research can be used for a comparative analysis of the statistics on accidents at work in relation to other sectors and sections of economic activity of the NACE (PKD). The publication contains the original results of the indicator analysis of the statistics on accidents at work according to the criterion of human causes in the mining industry, and they can be addressed to persons managing of mining plants and managers of mining supervision authorities.

Key words: *risky behaviors, statistics on accident rate, causes of accidents, mining industry*

INTRODUCTION

According to the data of the Statistics Poland [1], in the years 2010-2021, 1,022,201 accidents at work and 2,015,510 causes of accidents were registered in Poland, where human causes accounted for 75.64% of the share, and the dominant cause was the incorrect behavior of the employee (58.42% share). In the mining industry, the following were recorded respectively: 28,851 total accidents, 66,045 total causes, 72.22% share of human causes, and 52.85% share of accident caused by improper behavior of the employee.

Human behaviors in the work environment in the aspect of occupational safety and health, and in particular risky behaviors, are the subject or element of many publications, and popular directions of research and analysis in this area are, among others, safety culture, analysis of accidents at work or occupational risk assessment. The publication contains the original results of the indicator analysis of risky behaviors in the form of comparative analysis of statistics on accidents at work for Poland and the mining industry for the period 2010-2021 according to the criterion of human causes (currently only preliminary data for 2022 are available without an analysis of the causes of accidents at work). Selected criteria of generic analysis (structure index – causes of accidents) and indicator analysis (intensity index – frequency indicator of accidents) were used in the research, and the addressees of the research results may be persons managing mining plants and managers of mining supervision authorities. The presented results are one of the elements of the author's research in the field of risky behavior in the mining industry, and the basic theoretical and methodological assumptions in this area are presented in the monograph [2].

LITERATURE REVIEW

Risky behaviors can be the subject of research and analysis in different areas of science, knowledge and practice. Human behaviors in the aspect of safety problems can be considered formally in the area of two scientific disciplines (according to the current classification of science according to the regulation [3]): safety sciences in the field of social sciences and safety engineering in the field of engineering and technical sciences. The research of risky behaviors is undertaken, among others, in one of three aspects: safety culture, analysis of accidents at work, occupational risk assessment.

The work organisation and safety culture are essential for ensuring occupational safety and health. Each accident at work is the result of one event, but most often the result of several causes, therefore the sum of causes of accidents is greater than the number of total accidents. In 2021, 68,777 injured people and 138,422 causes of accidents were registered, dominated by improper behavior of the employee (60.8% share), including insufficient concentration of attention (25.7%) and surprise at an unexpected event (23.6%) [1].

The mining industry is a traditional field that has continued to develop for hundreds of years, but still belongs to the high-risk section, where many tragic accidents and disasters occur. Research in the field of hazards and related risk are an important part of any safety analysis, especially in industrial system. Hazard identification, risk assessment and management are of great paramount significance for the safe and efficient production of industrial system in the mining industry [4]. Accidents in mines are the subject of many scientific studies, and the systematic literature review (SLR) identifying 57 studies related to mining accidents in the years 2015-2019 from the ScienceDirect and Scopus databases. The following human and organizational factors were distinguished among the trends in the theme of research in the terms of accident causes: leadership behaviors of superiors (18), unsafe behaviors of employees (16), organizational deficiencies (16), human errors (15) [5].

Accidents at work have specific economic consequences, which is why they can be an indicator supporting decision-making in the field of improving occupational safety and health, examples of research in this field are, among others: research of the costs of benefits for accidents at work in the aspect of the number of people injured (total, fatal and serious accidents) and the number of days of incapacity to work, based on data from the Statistics Poland for the years 2010-2017 [6], research of the length of post-accident absence using decision trees and their ensembles, based on modeling the prediction of the duration of incapacity to work due to accident at work, on the basis of company documentation from the construction industry [7], research of the early warning model on accidents at work in coal mines in China based on the analysis of the number of total accidents, the number of accident death toll and the severity level of accidents using the neural network model [8], research of the relationships between workers demographic characteristics of underground hard coal mines in Turkey and an accident causing loss of a working day on the basis of the analysis of accidents at work in 2014-2019 using logistic regression analysis [9].

Risk assessment includes various classifications of research methods, including the use of qualitative, quantitative or mixed methods. Research of risk in the aspect of human behavior and risky behavior include, among others: human reliability analysis (HRA) and logic tree analysis (e.g.: ETA, FTA, FMEA) [2, 10, 11, 12]. Examples of research in this field are, among others: analysis of the impact of erroneous behaviors on human reliability based on the classification scheme and estimation of the Human Error Probability (HEP) in the Human Reliability Analysis (HRA) on the basis of data from the simulator [13], identification of gas hazard in industrial enterprise, based on the FTA method (industrial catastrophe) and the ETA method (gas explosion), in the aspect of the analysis of technical causes (safety systems) and human causes (human errors) [14], analysis of risk factors in HDD technology, based on the FMEA method and Pareto-Lorenz analysis, in the aspect of the proposed model for assessing risk factors for human and equipment (including: failure, occurrence, severity, detection, risk, priority) [15], analysis of the impact of human errors on human reliability in nuclear power plants based on the framework of Bayesian Belief Networks (BBN) in the aspect of research of the relationship between performance shaping factors (PSF) [16].

The concept of safety culture can be interpreted in various ways, but more important than the definition may be the interpretation of the perception of safety and hazards, which translates into risk and accidents. The study of safety culture is based mainly on the survey method, most often including techniques of questionnaire and interview [2, 11, 12, 17]. Examples of research are, among others:

- use of behavioral approach (BBS, behavioural-based safety), e.g.: analysis of behavioral safety on the example of advantages and criticism of implementing the BBS, on the basis of interview among 11 experts and 60 working students (main method) and observation (complementary method) [18], analysis of the impact of behavioral approach on the modification of behaviors, based on the implementation of the BBS in small enterprise, on the basis of survey before and after implementation (leading method) and document analysis (auxiliary method) [19];
- research dedicated to the SME (small and medium enterprises) sector, e.g.: identification of occupational hazards in micro and small enterprises, on the basis of survey among 1006 entrepreneurs (leading method) and analysis of document (EU-OSHA reports), direct interview and observation (auxiliary methods); analysis of the impact of technical, organizational and human factors on the accident rate in small enterprises, on the basis of questionnaire (main method) and direct interview and observation (complementary methods) among 1600 entrepreneurs [20];

- research dedicated to the mining industry, e.g.: analysis of the impact of occupational safety and health management system on the safety and health of employees, on the basis of the analysis of accidents at work in 1997-2011 and questionnaire research among 120 people in selected hard coal mine; research of occupational safety and health culture in the mining industry, based on the analysis of the level of organizational culture in the field of occupational safety and health, on the basis of questionnaire research among 100 postgraduate students [21].

Investigations of accidents at work are based mainly on the analysis of statistics on accident rate, which includes the criteria of absolute, generic, indicator and correlation analysis, as well as methods of accident investigation, among which the TOL systematics and the HFACS system are most often used [11, 12, 22, 23]. Examples of research are, among others:

- use of the TOL systematics (classification of technical, organizational and human causes) and the HFACS system (human factors analysis and classification system), e.g.: research of the causes of accidents at work in industrial company based on the TOL systematics (93% are human causes, including 59% improper behavior of the employee), on the basis of company documentation in 2010-2012 [24], analysis of the impact of human and organizational factors on mining accidents in Iran based on the human factors analysis and classification system (HFACS) in combination with Bayesian network (BN) on the basis of the analysis of 295 accidents in mines [25], research of causal relationships between the causes of accidents at work in China based on the development and validation of the human factors analysis and classification system for the construction industry (HFACS-CI) using the χ^2 test and Apriori algorithm [26];
- research dedicated to the construction industry, e.g.: analysis of the state of accident rate in the construction industry in the European Union countries, based on the number of people injured in accidents at work and the frequency indicator of accidents per 100,000 employees (total and fatal accidents), on the basis of EUROSTAT data for 27 European Union countries in 2008-2012 [27], research of the development of accident event in the construction, based on the model of accident situation (circumstances, causes and effects of the accident), on the basis of data (350 accidents at work) from the National Labour Inspectorate in 2008-2014 [28], research of the correlations between parameters of accident at work in the construction sector, based on the method of cluster analysis in the study of statistics on accident rate, on the basis of data from the District Labor Inspectorate in Krakow in 2014-2016 [29], research of the change in the number of fatal accidents at work in Turkey based on the EU guidelines (ESAW) and the specifics of the construction sector (NACE), on the basis of the analysis of 3,517 fatal accidents in the construction industry in 2012-2019 [30], system of construction accident prevention comprising detection system based on Radio-Frequency Identification (RFID) and communication system based on the use of Internet of Things (IoT) and wireless technology of LoRa [31];
- research dedicated to the mining industry, e.g.: research of the relationships between human factors and accident proneness of coal mine workers in China in the aspect of the depth perception, dark adaptation and vigilance abilities on the basis of survey among 239 coal mine workers [32], research on the impact of unsafe behaviors on gas explosions in coal mines in China based on the identification and classification of human factors on a population of 201 significant gas explosions and 5,410 fatal accidents in the years 2000-2014 [33], research of the causes of extraordinarily severe coal mine accidents (ESCMA) in underground hard coal mines in China based on the statistical analysis of 188 disasters (at least 30 fatalities in one accident) in the years 1950-2018 [34], research of the impact of human error on accidents at work in underground hard coal mines in India based on the retrospective analysis of mining accident reports using error reduction strategies and fuzzy mathematical concepts [35], research of trends in the value of accident rates and the share of causes of accidents in Japan based on total accidents, serious accidents and fatal accidents on the basis of the analysis of statistics on accidents in the years 1924-2014 in the mining industry [36].

Based on the literature review, it can be concluded that research of risky behavior is undertaken, among others, by in the aspect of safety culture, occupational risk or accidents at work. Depending on the research concept adopted, various research methods can be used, e.g.: survey, observation, document analysis, methods of accident investigation, analysis of statistics of accidents. Therefore, to research of risky behavior in the aspect of the analysis of accident causes, it is possible to propose the use of indicator analysis of statistics on accidents at work, including structure and intensity indicators, in addition to recognized research strategies, such as, for example, survey research, methods of HRA, TOL or HFACS.

The author's monograph [2] proposes the basic theoretical and methodological assumptions for the research of risky behaviors of mine rescuers, including presents a proposal for a synthetic assessment of risky behaviors of mine rescuers for six problem areas (assessment parameters) and a proposal for indicators characterizing risky behaviors, including, for example, a proposal for indicators of frequency and severity of accidents at work, such as probability indicator of accidents caused by risky behaviors per 1,000 working people.

METHODOLOGY OF RESEARCH

Accidents at work are the subject or element of many publications, and the basic theoretical and methodological assumptions for the analysis and investigation of accidents at work are discussed, among others, in the following compact publications (chronologically): general requirements – [22, chapter 5.2], [10, chapter 8], [23], [11, chapter 5.1]; industry requirements – [37, chapter 5], [38], [2, chapter 8], [12, chapter 6.2].

Several basic criteria for the classification of indicators can be distinguished, such as: construction of indicators (simple and complex), frequency and severity of events (frequency, severity and risk), analysis of phenomena over time (retrospective and prospective), division of statistical indicators (structure, intensity and dynamics) [2, pp. 99-100].

The following two groups of statistical indicators were selected for the analysis of risky behaviors (abbreviations correspond to the Polish names) [2, p. 100]:

- structure indicators (WS), which use a relative number to determine the ratio of a part of the collective to the entire population, are often expressed as a percentage (equation 1):

$$WS = \frac{N_i}{N} \tag{1}$$

- intensity indicators (WN), which describe the severity of the phenomenon under study by creating a ratio of two logically related measures (equations 2-3):

$$WS = \frac{N_i}{N_n} \cdot 10^a, \tag{2}$$

$$WS = \frac{N_i}{N_t} \cdot 10^b, \tag{3}$$

where:
a – adjustment coefficient for population size,
b – adjustment coefficient for population exposure time,
N – number of all incidents,
N_i – number of incidents of a certain type,
N_n – the size of the population at risk,
N_t – exposure time of the population at risk.

The following two groups of intensity indicators were proposed for the analysis of risky behavior in mining industry [2, p. 101]:

- Frequency indicator of accidents caused by risky behaviors, which determine the probability of accidents due to human causes, as a ratio of the number of injured people to the population size or exposure time.
- Severity indicator of accidents caused by risky behaviors, which characterize the effects of accidents due to human causes, as a ratio of the number of days of incapacity caused by accidents to the number of injured people or exposure time.

For the study of risky behaviors, the probability indicator of accidents caused by risky behaviors per 1,000 working people (WPW_Z) was used (equation 4) [2, p. 101]:

$$WPW_Z = \frac{W_{PL}}{Z} \cdot 10^3, \tag{4}$$

where:
W_{PL} – number of people injured in accidents due to human causes,
Z – number of working people.

For the comparative analysis at the level of national average or industry (sections and subsections of economic activity), the relative number of people injured in accidents due to human causes can be estimated by determining the ratio of the number of causes of accidents due to employee behavior to the number of all causes of accidents, based on the analysis of accident statistics from, for example, the Statistics Poland (equation 5) [2, p. 103]:

$$W'_{PL} = W \cdot \frac{N_L}{N}, \tag{5}$$

where:
W'_{PL}– normalized number of people injured in accidents due to human causes,
W – number of people injured in accidents,
N_L – number of human causes,
N – number of all causes.

Source data on the statistics on accidents at work in Poland are made available in periodic publications of the Statistics Poland entitled "Accidents at work in … (year)" [1]. Data on accidents at work come from the form "Statistical accident card" [39] and concern those working in the national economy. Information on accidents at work provides detailed data on accidents and victims, circumstances, causes and consequences of accidents. The subject scope of the card of accident at work is aligned with the European Statistics on Accidents at Work (ESAW).

The analysis of the structure and intensity of accidents was used to study risky behaviors, which was based on the statistics on accidents at work in Poland and mining with the use of data from the Statistics Poland for 2010-2021 (due to the state of the pandemic, the number of people injured in accidents at work decreased, while the structure of the causes of accidents showed low variability). The following human causes were the object of the study (code according to statistics [1]): lack or improper handling of a material factor by the employee (141-159), failure to use protective equipment by the employee (161-179), improper willful behavior of the employee (181-199), improper mental and physical state of the employee (201-219), and improper behavior of the employee (221-239).

The value of the structure indicators were calculated based on equation 1. The values of the probability indicators of accidents caused by risky behaviors were calculated based on equation 4 per 1,000 working people, and the normalized number of people injured in accidents due to human causes was estimated according to equation 5. Measures characterizing human causes for the analysis of structure and intensity indicators included the following variables: range, arithmetic mean, standard deviation, coefficient of variation.

RESULTS OF RESEARCH

Selected research results for accidents at work in Poland and mining industry for 2010-2021 are presented in Tables 1-4. Tables 1-2 show the results of the analysis of the structure of the share [%] of human causes, and Tables 3-4 the results of the analysis of the frequency of accidents caused by risky behaviors.

Table 1

Structure indicators – shares [%] of human causes for accidents at work in Poland for 2010-2021

Parameter	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
141-159	7.28	7.38	7,39	6.86	7.44	7.49	7.33	7.26	7.20	7.23	7.15	6.92
161-179	1.49	1.57	1.54	1.47	1.47	1.53	1.51	1.50	1.59	1.59	1.68	1.60
181-199	6.82	6.87	6.79	6.62	6.70	6.86	6.82	6.62	6.69	6.66	6.84	6.69
201-219	2.04	1.88	1.77	1.64	1.59	1.65	1.54	1.39	1.42	1.84	1.69	1.74
221-239	55.20	54.24	54.04	55.53	59.00	59.17	60.12	60.54	60.77	60.83	60.80	60.78

Source: own work based on [1].

Table 2

Structure indicators – shares [%] of human causes for accidents at work in mining industry for 2010-2021

Parameter	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
141-159	6.84	7.63	7.28	7.31	8.22	8.34	6.32	7.62	7.39	8.07	7.77	7.72
161-179	1.13	1.11	1.29	1.41	1.40	1.27	1.06	1.13	1.47	1.24	1.42	1.34
181-199	9.13	9.29	10.5	10.9	11.4	10.7	10.3	9.27	9.68	9.79	7.89	8.97
201-219	0.94	0.86	0.77	0.72	0.66	0.62	0.54	0.68	0.55	0.67	0.66	0.84
221-239	55.5	53.1	51.3	49.5	52.4	51.4	52.5	55.7	52.8	51.7	53.9	54.0

Source: own work based on [1].

Table 3

Intensity indicators – frequency indicator of accidents caused by risky behaviors for accidents at work in Poland for 2010-2021

Parameter	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
141-159	0.57	0.62	0.58	0.52	0.55	0.54	0.51	0.49	0.45	0.44	0.32	0.33
161-179	0.12	0.13	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.08	0.08
181-199	0.53	0.57	0.53	0.50	0.50	0.49	0.48	0.45	0.42	0.40	0.31	0.32
201-219	0.16	0.16	0.14	0.12	0.12	0.12	0.11	0.09	0.09	0.11	0,08	0.08
221-239	4.29	0.52	4.20	4.19	4.40	4.25	4.21	4.12	3.83	3.69	2.76	2.89

Source: own work based on [1].

Table 4

Intensity indicators – frequency indicator of accidents caused by risky behaviors for accidents at work in mining industry for 2010-2021

Parameter	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
141-159	1.22	1.27	1.12	1.02	1.15	1.22	0.97	1.21	1.20	1.40	1.13	1.21
161-179	0.20	0.18	0.20	0.20	0.20	0.19	0.16	0.18	0.24	0.21	0.21	0.21
181-199	1.63	1.55	1.62	1.53	1.60	1.58	1.59	1.47	1.57	1.70	1.14	1.40
201-219	0.17	0.14	0.12	0.10	0.09	0.09	0.08	0.11	0.09	0.12	0.10	0.13
221-239	9.90	8.87	7.88	6.92	7.33	7.54	8.05	8.82	8.58	8.96	7.83	8.44

Source: own work based on [1].

Summary of the results of the analysis of statistics on accidents at work in terms of indicator analysis of risky behaviors:

- The number of people injured in total accidents in Poland ranged from 62,740 to 97,222 (85183±9920); a small variation was observed (11.6%), an increase in 2011 (+3.2%), a decrease between 2011-2013 (-9.2%), stabilization between 2013-2017 (88149±399), a decrease between 2017-2020 (-29.0%) and an increase in 2021 (+9,6%); a decreasing trend (-27.0%) was observed, with a maximum in 2011 and a minimum in 2020.

- The number of people injured in total accidents in mining ranged from 1994 to 3175 (2404±349); a small variation was reported (14.5%), a decrease between 2010-2017 (-30.7%), an increase between 2017-2019 (+9.4%), a decrease in 2020 (-17.2%) and an increase in 2021 (+4.3%); a decreasing trend was reported (-34.5%), with a maximum in 2010 and a minimum in 2020.
- The number of causes of total accidents in Poland ranged from 127,436 to 188,767 (167959±17716); a small variation was observed (10.5%), this also applies to all groups of causes, an increase in 2011 (+2.7%), a decrease between 2011-2013 (-9.4%), an increase in 2014 (+2.1%), a decrease between 2014-2016 (-0.8%), an increase in 2017 (+1.1%), a decrease between 2017-2020 (-27.2%) and an increase in 2021 (+8.6%); there was a decreasing trend (-24.7%), with a maximum in 2011 and a minimum in 2020.
- The number of causes of total accidents in mining ranged from 4373 to 7325 (5504±884); a small variation was reported (16.1%), also in terms of all groups of causes, a decrease between 2010-2014 (-30.0%), an increase in 2015 (+2.9%), a decrease between 2015-2017 (-7.6%), an increase between 2017-2019 (+12.7%), a decrease in 2020 (-20.6%) and an increase in 2021 (+5,7%); a decreasing trend was reported (-36,9%), with a maximum in 2010 and a minimum in 2020.
- The value of the frequency indicator of total accidents in Poland ranged from 4.54 to 8.34 (6.79±1.19); a small variation was reported (17.5%), an increase in 2011 (+7.2%), a decrease between 2011-2020 (-45.6%) and an increase in 2021 (+4.6%); a decreasing trend was observed (-38.9%), with a maximum in 2011 and a minimum in 2020.
- The value of the frequency indicator of total accidents in mining ranged from 13.97 to 17.82 (15.61±1.25); a small variation was observed (8.0%), a decrease between 2010-2013 (-21.6%), an increase between 2013-2019 (+21.1%), a decrease in 2020 (-16,3%) and an increase in 2021 (+7,5%); a decreasing trend was found between 2010-2013 (-21.6%) and an increasing trend between 2013-2019 (+21.1%), with trend disruption during the pandemic in 2020-2021, with a maximum in 2010 and a minimum in 2013.
- The value of the probability indicator of accidents caused by risky behaviors per 1,000 working people in Poland ranged from 3.55 to 6.00 (5.12±1.40); a medium variation was reported for total causes (27.3%) and the improper mental and physical state of the employee (25.2%), high variation for the improper behavior of the employee (46,8%) and small variation for other causes, an increase in 2011 (+5.8%), a decrease between 2011-2013 (-9.3%), an increase in 2014 (+4.4%), a decrease between 2014-2020 (-37.5%) and an increase in 2021 (+3.9%); it can be argued that there was stabilization between 2010-2014 (5.67±0.21) and a decreasing trend between 2014-2021 (-35.0%), with a maximum in 2011 and a minimum in 2020.
- The value of the probability indicator of accidents caused by risky behaviors per 1,000 working people in mining ranged from 9.77 to 13.12 (11.28±0.96); a small variation was observed (8.5%), with the exception of the improper mental and physical state of the employee – medium variation (22.7%), a decrease between 2010-2013 (-25.5%), an increase between 2013-2017 (+20.6%), a decrease in 2018 (-0.8%), an increase in 2019 (+6.1%), a decrease in 2020 (-16,1%) and an increase in 2021 (+9,4%); there was a decreasing trend between 2010-2013 (-25.5%) and an increasing trend between 2013-2019 (+26.8%), with trend disruption during the pandemic in 2020-2021, with a maximum in 2011 and a minimum in 2013.

DISCUSSION OF RESULTS

Examples of research in the field of the analysis of statistics on accidents at work in the mining industry in Poland are, among others:

- analysis of the causes of accidents at work in mining for the years 2005-2008, including two dominant groups of human causes (improper behavior of the employee, improper willful behavior of the employee) and organizational causes (improper organization of the workplace, improper overall organization of work) [40];
- analysis of the causes of fatal accidents in underground mining for the years 2000-2009, including the proposed division into accidents caused by four groups of hazards: natural, mining, technical and other [41];
- analysis of statistics on accidents at work in terms of selected criteria of absolute and indicator analysis for Poland and mining for the years 2009-2013 based on data from the Statistics Poland [42];
- analysis of statistics on accidents at work in terms of the accident causation criterion (TOL systematics) for Poland and mining for the years 2009-2013 based on data from the Statistics Poland [43];
- analysis of statistics on accidents at work in the aspect of selected criteria of absolute, indicator and generic analysis in the hard coal mining industry in the period of restructuring for the years 1993-2010 based on data from the State Mining Authority and company documentation from selected hard coal mines [38];
- generic analysis containing the results of the analysis of accidents according to the age criterion, which proved the existence of a correlation between the age of employees and the number of accidents at work in hard coal mines in 2003-2017 [44];
- analysis of statistics on accidents at work in the aspect of selected criteria of absolute, indicator and generic analysis for Poland and the mining industry for the years 2010-2019 based on data from the Statistics Poland and the State Mining Authority [12];
- indicator analysis including the results of the study of correlations between three indicators determining the

level of employment, efficiency and accident rate, on the basis of industry statistics in hard coal mines in 2003-2020 [45].

On the basis of the indicator analysis of statistics on accidents at work in terms of human causes, the following conclusions were made:

- Among the causes of accidents at work in the period under review 2010-2021, the dominant group involved human causes, which accounted for ¾ of the share of causes in Poland and mining – an average share of 75.64% and 72.22%, respectively (mining over 3% less).
- The dominant cause of accidents was employee misconduct, which accounted for more than one in two causes of accidents in Poland and mining – an average share of 58.42% and 52.85%, respectively (mining over than 5% less).
- The structure of the share of human causes for Poland and mining shows some differences – at the top there is improper behavior of the employee, but the next places swap (positions 2-3 and 4-5); the biggest differences were found for improper willful behavior of the employee (the average share for Poland and mining) – 6.75% and 9.84% respectively (mining over 3% more).
- The proposed frequency indicator of accidents caused by risky behaviors per 1,000 working people was found to have a value over 2 times higher for mining than for Poland – 11.28 and 5.12 (2.20), respectively; a convergent result was also observed for the predominant human cause, i.e., improper behavior of the employee – 8.26 and 3.95 (2.09), respectively.

FINAL CONCLUSIONS

- Based on literature review and own research, it can be concluded that research of risky behavior is undertaken, among others, by in the aspect of assessing the safety culture or analyzing the accidents at work, therefore various research methods (as a leading method and/or auxiliary methods) are used, e.g.: analysis of statistics on accidents at work (including absolute, indicator, generic and correlation analysis), methods of accident investigation (TOL systematics and HFACS dominate), survey method (questionnaire and interview techniques dominate), observation method (including direct participating).
- The analysis of risky behaviors, based on the data of the Statistics Poland [1], is in line with the theme of the study of differences in the risk of accidents at work for the mining industry. It presents the results of the analysis of human causes in the aspect of comparative analysis for Poland and mining in years 2010-2021. Based on the indicators of structure and intensity, the analysis showed the dominant causes of total accidents in mining, namely – improper behavior of the employee, improper willful behavior of the employee, and lack or improper handling of a material factor by the employee.
- The proposed method of indicator analysis of risky behaviors, i.e. indicator analysis of statistics on accidents at work terms of the study of risky behaviors, is an alternative to the traditional analysis of the causes of accidents, both in general application (division into technical, organizational and human causes) and in industry application, where the concept cause of accidents in mining is often understood as a hazardous event in mining (meaning an event that causes injury).
- Human causes should be subjected to detailed study, especially the dominant cause of accidents – improper behavior of the employee, distinguishing, according to the regulation on statistical card of accident at work [39]: ignorance of the danger, ignorance of regulations and rules of occupational safety and health, disregard for danger, disregard for instructions from superiors, insufficient concentration of attention, surprise at an unexpected event, improper pace of work, and inexperience.
- The causes of accidents at work in mining (total, fatal and serious accidents) should be analyzed in detail, as there are significant differences in both statistics and their interpretation, such as general data (Statistics Poland – GUS, National Labor Inspectorate – PIP) and industry data (State Mining Authority – WUG, Central Mining Information Center S.A. – COIG, Central Mining Institute – GIG) [12, 38].

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