



ANALYSIS OF THE STATISTICS, TYPOLOGY AND CAUSALITY OF OCCUPATIONAL ACCIDENTS OCCURRED AT LIVEZENI COLLIERY FROM 2020 TO 2024

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DOI: 10.2478/minrv-2026-0014

received – 13.04.2026 / revised – 27.04.2026

accepted – 03.06.2026 / published – 19.06.2026

Abstract: *Statistical analysis of work accidents is essential for identifying common causes, assessing risks and implementing preventive measures that contribute to improving safety and health in the professional environment. The information provided by the history of undesirable events produced in an industrial field marked over time by multiple events with catastrophic consequences, such as underground coal mining from gritty deposits with a pronounced tendency to self-ignition, will facilitate organizational learning in order to optimize prevention. This article provides a structured and coherent picture of the undesirable "landscape" of work accidents occurring at a mining unit in the Jiu Valley, based on the analysis of their typology and causality, formulating a series of relevant conclusions and realistic and pragmatic proposals intended to substantiate prevention-protection plans aimed at minimizing specific risks.*

Keywords: *colliery, occupational injury, analysis of accident statistics, cause and typology, prevention, risk mitigation*

1. Introduction

The well-being and safety of a company's employees is a major concern and priority in a responsible and successful organization [1, 2, 3]. Identifying patterns of work accidents is important to reduce and prevent new accidents and injuries [4]. To improve the safety of the work environment, accident data must be analysed to identify possible risk factors, the level of severity and their effects on the human factor [5].

Occupational accidents constitute an extremely serious problem in our society, given the psychological, health, social, economic and organizational consequences associated with them [6]. Occupational accidents have been shown to be caused by organizational factors in the workplace, including irregularities and/or errors in management [7, 8]. It was also found that 6.9% of serious and fatal accidents in the mining industry could have been avoided if measures had been taken in the design of equipment and its appropriate provision [9].

The level of accidents, apart from the situation on the labour market and the financial situation of companies, is significantly affected by the lack of a level of occupational safety culture of workers and the lack of technical culture in enterprise [10, 11].

Learning from accidents means extracting, putting together information, analysing, communicating and obtaining information about accidents and events, from their occurrence, throughout the investigation of the event until their conclusion [12]. The aim is to prevent similar events from occurring, limit damage and therefore improve work safety [13].

The scientific literature on feedback from experiences accumulated following accidents has grown significantly in recent decades [14, 15]. However, this literature is still quite fragmented and much remains to be done to develop a unified and integrated approach to learning from accidents, integrating knowledge and experience from different disciplines and application areas [16]. Furthermore, most of the literature focuses on specific parts of the experience feedback process, particularly accident investigation methodology [17, 18]. Much less has been written about the activities that take place before or after the accident investigation, such as initial reporting, selection of accidents for investigation, dissemination of information, and experience-based accident prevention [19, 20].

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The purpose of this paper is to present a perspective on the feedback of experience covering the entire process and to identify major research needs related to the different components of the work process. The article set as its primary objective the analysis of the statistics, typology and causality of work accidents occurring at Livezeni Mining Branch of Valea Jiului Energy Complex S.A. during the period 2020-2024. We mention that all primary data regarding work accident statistics were collected, and subsequently processed and interpreted, with the written consent of the management of the mining unit investigated within the case study undertaken.

Although for scientifically and rationally justified reasons, during the documentation process, the target interval was restricted to the last 5 years, it can be assessed that the study has fulfilled its purpose, considering the findings made, the correlations established and – in particular – the conclusions and proposals formulated regarding the technical and organizational possibilities identified regarding the minimization of the risks of accidents and occupational diseases of workers exposed to risk factors specific to mining activity within the investigated unit.

2. Functional description of the relevant particularities of the investigated unit from an accident-related perspective

General description

Livezeni Mining Branch is part of Valea Jiului Energy Complex S.A. Company, which was established on October 6th, 2023, with a total of 2011 employees in the company and 558 employees in the branch. The *activity profile* is the extraction of high-grade coal, and the form of ownership: majority state capital.

Work schedule: daily activity in 4 shifts of 6 hours, during 5 working days in a week, with two non-working days, but also a schedule of 3 shifts of 8 hours each. From an *administrative point of view*, Livezeni mining perimeter belongs to Petroșani municipality. Access to the perimeter is ensured by the electrified railway Filiași – Tg.Jiu – Petroșani – Simeria and the national road Tg.Jiu – Petroșani – Simeria. The relief of the perimeter is hilly with heights reaching altitudes of 850 m, except for the terrace areas and the Jiu meadow, with altitudes below 600 m. The *hydrographic network* consists of the East Jiu River and its main tributaries that cross the perimeter. The lands related to the *Livezeni mining perimeter* are: mining enclosures, including tailings dumps, enclosures for various enterprises, sports arenas, arable lands, yards, gardens, orchards, forests, pastures, streets, roads and paths, cemeteries, waters and pebbles.

The activity within Livezeni Mining Exploitation is carried out at workplaces with normal and special conditions. The actual number of employees is 558, of which 471 are underground workers (special conditions), and 87 are surface workers. Occupational health and safety management at Livezeni Mining Exploitation has aimed and continues to aim at:

- prevention of work accidents and occupational diseases;
- ensuring health and safety conditions for all employees, both in underground and surface activities;
- checking compliance with labour legislation provisions in the field of occupational health and safety;
- checking the status of implementation of the measures established during inspections carried out by control bodies within CEVJ - SA and ITM Hunedoara.

Work technologies: at E.M. Livezeni, the following works are being carried out:

1. Preparation-Base Gallery Bl.VII, str.13, Pan.6;
2. Preparation –Attack plan Pan.6, bl.VII, str.13;
3. Preparation-Base Gallery Pan.6, str.13, bl.VII, horiz.100;
4. Preparation-Base Gallery-section assembly room, horiz.100;
5. Reopening-Transverse Gallery, horiz.100;
6. Reopening-Collector Gallery str.13, bl.IX, horiz.100.

The **mining methods** applied at E.M. Livezeni respect the framework method, the mining works being put into operation and received based on the minutes.

- a) The electricity supply is adequate, with a double supply for the fan installations, compressors and pump stations for the evacuation of water from the underground. E.M. Livezeni has three main pump stations, which ensure the evacuation of water from the horizon 475, 300 and horizon 100. These are equipped with pumps appropriately sized according to the flow rate and discharge height.
- b) The underground and surface water supply is made from the Maleia Sud filtration-chlorination station.
- c) The underground compressed air supply is made from the Main Precinct using ATLAS Copco compressors, and from Maleia Precinct using ATLAS Copco compressors (only in case of need).

Within Livezeni Mining Exploitation, there are 5 LDM 45 locomotives in the inventory, of which 3 locomotives are in operation (two on the 300 horizon, and one on the 100 horizon), and two locomotives are parked at the mechanical workshop, these being incomplete (without engine and without chassis). The belt conveyors function properly. Revision and repair schedules are drawn up in accordance with the provisions of the RSSM and the technical book. During January 2025, 40 upper rollers were changed on the 2A belt, 30 upper rollers on the 3A belt, 20 lower rollers on the 3A belt. On the 4A belt, 20 garlands of 3 rollers were changed on the upper part and 20 garlands of 6 rollers on the lower part. Lighting along the belt flow route is provided at the drive ends, the turning stations and at the silos. The equipment with PSI means is adequate, with sand boxes and powder extinguishers. The scraper conveyors are operating normally, the anchoring method and safety devices being restored and permanently maintained according to the provisions of the RSSM. The deposits of small spilled material are cleaned by the service personnel of the *Production sector*.

The scraper conveyors have drawn up inspection and repair schedules in accordance with the provisions of the RSSM and the technical book. Two monorail installations are in operation within the exploitation, namely: KSP 63 on the 100th horizontal and KSP 32 on the 300th horizontal (10 roller batteries were installed on these monorail lines). They function properly. The KSP 32 monorail parts (batteries and lines) are dismantled and the KSP 63 is installed at the 100th horizontal.

General and partial ventilation. Mine fires. Methane monitoring: methanometry and telegrisometry

At E.M. Livezeni, general ventilation is provided by two fan stations of the V.O.D.-2.1 and V.A.D.-2.1 type, the first being located in Maleia area, and the second at P.A. - Est in Dîlja Mică area [21]. Each station is equipped with two fans that operate alternatively, according to the operating schedules displayed at the stations and ensures ventilation of the workplaces as follows:

V.O.D. Fan Station – 2.1 - serves the mining works related to street 3, block VI and the mining works in bl. VI -VI A located below the main fan depression.

V.A.D. Fan Station – 2.1 – serves the mining works in street 13, bl. IX-VII, located below the main fan depression.

At E.M. Livezeni there are 3 mining works with downward ventilation over 100 for which there is a permit, namely: Crossing aeration layer 13, block IX, Crossing aeration layer 13, block VII and Plan aeration Pan 4N, layer 3, block VI. Mining works with downward ventilation are checked daily, on each shift, by specialized personnel from the ASM sector, the results of the checks being recorded in the report registers of CAMS specialists and/or CFL foremen and engineers.

Within EM.Livezeni the following workplaces are ventilated by means of partial ventilation installations in a forced-air system:

1. Dosing chamber – Main shaft - activation;
2. Transport plan to silo no. 2, or.300 - activation;
3. Attack plan pan. 6, str.13, bl. VII oriz 100 – partial exhaust ventilation;
4. Base gallery pan.6 str. 13 bl VII oriz 100 – partial exhaust ventilation.

The installation of partial ventilation installations is based on projects drawn up by the sectors and approved by the management of the unit. The commissioning of partial ventilation installations is carried out, according to the RSSM, based on a reception report. For the proper functioning of partial ventilation installations, good tightness of the related ventilation columns is taken into account. The verification of the operating parameters of partial ventilation installations is done through measurements, the results of which are highlighted in the documentation related to partial ventilation projects. In the event of deficiencies in partial ventilation installations, operative measures are taken to eliminate them, establishing deadlines and responsibilities.

There are *no endogenous fires* at E.M. Livezeni [22]. In order to prevent and avoid self-heating phenomena, the following measures have been taken: Excavation of mining works, regardless of their destination, will be carried out under strict supervision. In mining works that have been excavated in friable coal or in portions where collapses have occurred, the gaps will be filled with non-combustible materials and will be additionally insulated with boxes and clay beaten with salt or with mesh and/or resins. Also, when carrying out excavation or re-profiling works near exploited areas and/or in friable coal, prone to cracks, measures will be taken in advance and permanently to reduce the tendency for self-ignition of coal, simultaneously with the application of measures to eliminate the possibility of uncontrolled air circulation through the massif or through the exploited areas. The direction of air currents along the mining works route located below the general depression of the mine will be done in strict accordance with the provisions of the RSSM 2024 of CEVJ-SA, Part V, Chapter IV, Point 2. Specific requirements for general ventilation. In the

case of isolation constructions located near the paths and/or main ventilation circuits, measures will be taken to reduce the influence of the ventilation circuit on closed and isolated areas. These constructions are checked in accordance with the provisions of the RSSM 2024 of CEVJ SA, Part V, Chapter VI, Point 7. The results of the checks will be brought to the attention of the technical management of the branch in due time.

The methane meters of the following types: AUER 402, AUER 502, VM-1p, SIGNAL, AUER 510 and MX21+, OLDHAM 2000 (100%), etc. are all irreparable defects, some of which are very degraded and have been scrapped, and the rest are to be scrapped. Currently, only the DRAGER and ALTAIR 4x methane meters are used. There are 16 portable methane measuring devices in operation.

The telegrisometric stations have the role of controlling and recording CH₄ concentrations for automatic signaling to the dispatcher, as well as automatic disconnection of electricity in case the maximum permitted values of methane concentrations are exceeded. E.M. Livezeni has two telegrisometric stations in operation [23]. The supervision and maintenance of the two stations is carried out by: 4 authorized operators, 11 authorized underground electricians and an engineer responsible for the telegrisometric station. For the proper functioning of the telegrisometric station, checks are carried out as follows:

- daily at stations;
- weekly by CH₄ standard samples and decoupling verification;
- monthly;
- annually by S.C. SIP Petrita.

Underground stations and equipment have metrological verification bulletins issued by the manufacturing company for the KSP-2C type and SC SIP Petrita for CTT.63/40U. The recording graphs of the detection points on the station are filed and kept for at least 12 months. Electrical equipment from an AGR point of view is checked by a team of electricians from the electrical workshop, authorized from an AGR point of view. The deficiencies found are remedied on the spot, and those with a high severity are remedied based on a work program drawn up by the sector.

The telegrisometric stations, CTT-63/40 U – French and the KSP-2C station – Polish, operate at normal technical parameters. Currently, the central degassing station performs degassing behind the following dams: dam no. 98, located in the connecting gallery with Petrita Sud, horizon 575 and dam no. 69, from Poroşniuc ventilation gallery, block VI A, horizon 475.

The parameters recorded at the Central Degassing Station are the following:

▪ depression on the station:	min / max	=	50 mm. col. Hg
▪ pressure on the station:	min / max	=	15 mm. col. Hg
▪ gas flow:		=	1,3 mc / min
▪ cooling flow		=	200 l / min.
▪ concentration of CH ₄ :	min	=	38 %
	max	=	85 %

Service orders were issued at sector level to train personnel responsible for measuring, recording and registering underground methane concentration values, so as to comply with the legal provisions in force regarding the procedures applied in case of exceeding the maximum permitted methane concentrations, namely: the obligation to maintain contact with the dispatcher and the staff of the telegrisometric station, reporting underground methane concentrations, the causes, the measures taken and the time at which the methane accumulation was eliminated, as well as recording the results of the manual methane control in the individual methane book, on the methane record board at the workplaces and in the *Methane Record Register* at the sectors..

Explosive materials

Starting with 29. 11. 2012, the explosive materials necessary for the underground activity were stored at the Consumer Warehouse of E.M. Vulcan, based on the documents concluded between the parties. The transport of explosive materials from the consumer warehouse of E. M. Vulcan to the main premises of E.M. Livezeni is carried out by a special, licensed and authorized vehicle, accompanied by security personnel from the County Inspectorate of Gendarmerie, based on the contract for the provision of security services. The explosives that accompany the transport of explosive materials are workers designated by Decision, are trained and authorized for this activity. Daily, on each shift, the traceability of explosive materials is carried out.

Underground shooting operations are performed based on the approved shooting provisions. After each shooting operation, the bombardiers who carried out the shooting operations draw up reports in specially designated registers, which are signed according to the provisions of the RSSM 2024 of C.E.V.J. S.A.

Petroșani. The shooting provisions are drawn up by the APM engineer from the SSM service, are signed by the sector heads, the SSM inspector, the chief production engineer and approved by the branch manager.

During October 2024, the annual permit was obtained, valid until 19.10.2025, both for the possession and transport of explosives and for the underground room with a capacity of up to 200 kg of TNT equivalent. The monthly accounting check at the underground room was carried out on the 3rd of each month, no differences were found between the actual and written stock. Since July 2021, the type of explosive used has changed, the shooting works are carried out with EMULINIT PM explosive. Explosive materials are stored in accordance with Law 126/2013. E.M. Livezeni branch has a number of 14 explosives, being authorized for the right to shoot by I.T.M. Hunedoara.

Other occupational safety issues

Currently, there are *1269 self-rescue masks in inventory* (of which 659 POG-8M type masks and 610 MSI 94 type masks), 379 self-rescue masks are in use, 1 pc. at the training office, 41 in reserve. Since 134 MSI 94 type masks expired in December 2020, 277 MSI 94 type masks expired in April 2021 and 199 MSI 94 type masks are scrapped, 239 POG-8M type expired in May 2024, it is necessary to purchase 88 pcs. Self-rescue masks, because E.M. Livezeni branch has a number of 467 wearers. On 18.10.2021, 100 pcs. POG-8M self-rescue masks were purchased, with a manufacturing date of 08.2021, and were put into service on 20.10.2021, as a result, the validity period is until 20.10.2026 (5 years). In May 2024, **250 pcs. POG-8M self-rescue masks** were purchased, with a validity period until November 2029. In November 2024, 69 pcs. POG 8M self-rescue masks were purchased, with a validity period until November 2029. POG-8M masks are checked monthly by immersion. The masks in use are adequate.

The technical and organizational measures established in the updated prevention and protection plan to reduce the level of noxious substances and improve working conditions were not implemented due to lack of financial resources. The Occupational Health and Safety Committee meets quarterly or whenever necessary. Within E.M. Livezeni branch, the following training stages were carried out:

- *General introductory training:*

- *Additional periodic training:* 12 of which job / position training, - 8, after an absence of more than 30 days – 1, upon resuming activity after a work accident – 3.

- *Periodic training:* planned – 94, completed – 87, absent – 7, of which: sick leave – 5, vacation leave – 1, unpaid leave – 0, retirement – 0, suspended – 0, liquidated – 0, death – 0, delegation – 0, rest – 1.

Checks carried out on occupational health and safety

a. Checks carried out by workers from the branch's SSM-SU-PM Department

During underground inspections, it is taken into account whether: each workplace has an SSM document, workers carry out their activity according to their duties, methane detection heads are properly placed, etc. CAMS specialists within the ASM sector carry out gas control at all dams, their values being recorded in the records located at the ASM sector. Compliance with the program of measures to ensure occupational health and safety in the unit is monitored daily, through operational reports kept with the CAMS specialists, who report to the ASM sector head the deficiencies found at all active and inactive workplaces, both in terms of gas concentrations and the state of support for mining works, ventilation installations and deficiencies found at the controlled workplaces, taking immediate measures - if necessary, to establish a state of normality. The concentrations of mine gases measured with the multigas device at **DIZ 40 B** and **DIZ 39 H** showed the following values:

1. **DIZ 40 B**, Head panel gallery. 4N, str. 3, bl. VI, fel. 2nd, horizon 300.

- CH₄= 0,0 %, O₂=20,9 %, CO₂ = 0,00 %, CO= 0,00 % - in profile in front of the dam;

- CH₄= 0,03 %, O₂=20,37 %, CO₂ = 0,20 %, CO= 0,00 % vol - measured with the probe in the control tube.

2. **DIZ 39 H**, Collector plan panel 4N, layer 3, block VI, 2nd floor, horizon 300;

- CH₄= 0,0 %, O₂=20,9 %, CO₂ = 0,00 %, CO= 0,00 % - in profile in front of the dam;

- CH₄= 0,05 %, O₂=20,45 %, CO₂ = 0,20%, CO= 0,00 % vol - measured with the probe in the control tube.

Regarding deficiencies found in terms of the state of the mining works, mining works requiring replacement and restoration work were reported.

- Stanca ventilation plan - the work shows broken bandages and slight swelling of the hearth;
- transverse ventilation gallery bl. VII- IX, the wooden yokes in the work are broken, require replacement and restoration of the support and optimal section of the mining work;
- water accumulated on the horizontal 100 transverse gallery.

- on the main transport gallery, or.300 (Iscroni main road) there are water accumulations on the hearth which are drained through channels, periodically cleaned by the ASM maintenance brigade and detachments of bolts and rock from the ceiling of the work the area is secured with wooden yokes.
- areas with reduced section ventilation plan str.13, block IX or.100.

Periodically, brigades are placed in the affected areas to remedy the deficiencies found (restoration of sections, replacement of damaged support elements, provision of additional support, etc.)

b. Checks carried out by technical staff from the Health and Safety Department of Valea Jiului Energy Complex SA.

Verifications were carried out by the engineers responsible for SSM within the SSM Service of SCEVJ SA, who prepared notes of findings in which the deficiencies found were mentioned. For these deficiencies, programs of measures with deadlines and responsibilities were drawn up, programs that were submitted to the SSM Service of SCEVJ SA [24].

3. Collection of primary data on work accidents that occurred

Legislative and methodological premises regarding the statistical analysis of work accidents

Currently, the European statistics EUROSTAT define an accident at work as "*an isolated event occurring in the course of a professional activity, which leads to physical or mental harm*". In this context, several significant differences should be noted between the EUROSTAT definition of an accident at work and that in the Romanian legislation, which transposes Directive 89/391/EEC" [25].

Accident reports are often collected in databases. Accident databases have been used less than expected. It seems that those responsible for accident prevention do not use accident databases as a general learning tool, but refer to them only when they are already aware of a hazard. Since considerable resources are spent on creating, updating and maintaining accident databases, this is not satisfactory. It is possible that the databases should be rebuilt to be equally useful to the intended users. The selection of accidents for investigation can be carried out in different ways, for example with a preference for representative accidents, unusual accidents, accidents with unknown causes or accidents with particularly serious outcomes. An increasing number of accident reports requires an increasing number of follow-up investigations, and this can lead to delays in the investigation. If investigations take place too long after the event, witnesses may forget significant details about the incident. This makes the selection process particularly important in a reporting system that receives a large number of incident reports. Of course, it is essential that the selection process does not exclude certain types of accidents, or accidents with certain types of causes, from which important lessons can be learned. If this happens, then the effectiveness of the learning process can be seriously affected. In analysing the circumstances of an accident (fig. 1), the accident team should consider:

- activities carried out by the injured person;
- what machines (devices) he operated, what substances or agents he worked with,
- whether he used the personal protective equipment and other necessary protections,
- whether the protections were functional and properly selected for the tasks performed,
- whether the injured persons complied with the health and safety regulations and rules and whether they had adequate qualifications to perform the work,
- whether the injured person had up-to-date training, medical check-up and whether he knew the occupational risk at the workplace, as well as the occupational health and safety instructions, the operation of the machine.

The following variables are considered in the EASW methodology [25]:

- ***information about the accident and the injured worker*** (economic activity of the employer; occupation of the victim, professional status of the victim; age, gender and nationality of the victim; geographical location of the accident, date and time of the accident, size of the enterprise; working environment, workplace and work process);
- ***information about how the accident occurred***, under what circumstances and how the injuries occurred (specific physical activity at the time of the accident, deviation from normal practice, how the injury occurred, details about the associated material agents – there are three variables regarding material agents: material agent associated with the specific physical activity, material agent associated with the deviation, material agent associated with the contact – how the injury occurred),
- ***information about the nature and severity of the injuries***, the consequences of the accident (injured body part, type of injury, number of days lost).

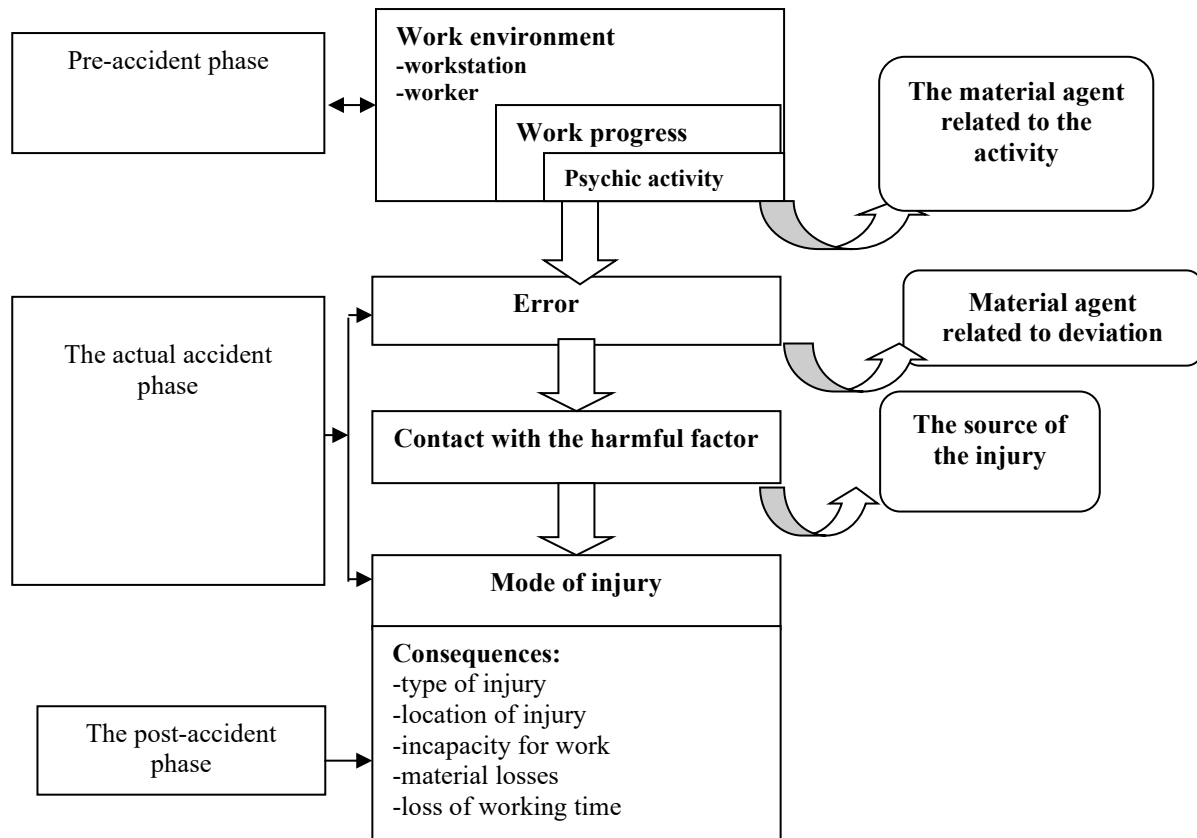


Fig. 1. Diagram of the statistical accident model

The use of statistics on work accidents allows the assessment of the safety status in an enterprise [26]. Statistics also allow the formulation of various factors that can be used to assess the accident rate, the workplaces with a particular risk of accident, the realization of various comparative analyses in the field of accident investigation and corrective actions in order to reduce hazards. Statistical studies, imposed by the need to analyse the causes of work accidents, however, use several ways of classifying them based on various criteria. Except for those already present in the legislation, the following classifications can also be listed:

- by the nature of the direct causes: mechanical, electrical, chemical, thermal, radiation or combined;
- by the nature of the injuries: contusions, wounds, punctures, cuts, crushes, burns, sprains, fractures, amputations, poisonings, electrocutions, sunstrokes, multiple injuries;
- by the location of the injury: to the head, trunk, upper or lower limbs, with multiple locations;
- by the moment when the effects are felt: with immediate effect or with subsequent effect;
- by the nature of the causes of work accidents: of a technical or organizational nature;
- by the origin of the causes of accidents: dependent on the work environment, work equipment, work load or performer.

Statistical indicators of work accidents

There are several possibilities to highlight, from a statistical point of view, the situation of work accidents or occupational morbidity. In the specialized literature, primary indicators or expressed in absolute values and derived indicators or expressed in relative values are used.

Primary indicators of work accidents

Primary indicators are obtained during the primary processing of statistical data following a process of centralizing the data of a statistical observation. For this reason, primary indicators are also called **absolute indicators** or indicators expressed in absolute quantities and constitute the informational basis of statistical knowledge. In the case of statistical analysis of work accidents, the following primary indicators are used:

- *Total number of injured persons* – represents the number of injured persons for whom the consequences of accidents are considered to have ended in the reference period, regardless of whether the event occurred in the same period or in previous periods.;

- *Total number of victims* – represents the number of injured persons (deceased or temporarily incapacitated for work), recorded in the reference period;
- *Number of days of temporary incapacity for work* – results as a result of the work accident, corresponding to the total number of injured persons. Depending on what is being pursued through statistical research, days of temporary incapacity for work lost take into account calendar days or working days.

Often in statistical studies of this kind reference is made to the average number of employees. In establishing this indicator, all the activities of an enterprise as well as the flow of personnel during the reference period must be taken into account. Primary indicators provide a suggestive picture of the extent of the situation, without however allowing a correct curve of the evolution over time of the phenomenon of work-related accidents to be drawn.

Derived indicators of work accidents

Derived indicators are calculated as a ratio between two absolute values, so they are also known as indicators expressed in **relative values**. In the case of statistical analysis of work accidents, the following derived indicators are used:

- *The average duration index (IDM)* expresses the average duration of work incapacity (ITM) of an injured person, expressed in calendar days.
- *The severity index (GI)* expresses the extent of accidents that occurred within the statistically analyzed entity. It is determined by the total number of man-days of work incapacity, reported to 1000 workers.
- *The frequency index (FI)* expresses the frequency of accidents within the analysed entity, respectively, how many accidents occur per 1000 workers

The frequency, severity, average duration indices allow for factorial analyses, value distribution analyses, etc., thus making it possible to study common factors and deviations that may be of practical interest. It should also be emphasized in this context the difference between the indicators used in Romania and those used in the EUROSTAT system, in which the number of injured persons is related to the average number of hours worked. Table 1 presents the synthesis of a quasi-exhaustive analysis carried out on work accidents occurring during the period 2020-2025 at E.M. Livezeni.

Table 1. Centralizer of work accidents occurred at E.M. Livezeni during 2020 -2024

No.	Age	Job	Seniority in occupation	Seniority at work	Brief event description	Month	Day	Hour	Year	Place of occurrence	Diagnostic	Severity of consequences
1.	47	Miner	4 years	3 mnth	While he was cleaning the place in the pit, a piece of coal broke off the side wall and hit him, injuring him.	01	27	21	2020	Base gallery, panel 4, seam 13	Chest contusions	Between 3-45 days (small)
2.	54	Machinist	4 years	1 week	As he lowered a 108 mm compressed air pipe from his shoulder, he caught the middle finger of his right hand between the pipe and the railroad track.	02	11	20	2020	Gal. main tailings tank, horizon 300	Traumatism of the phalanx of the third finger of the right hand.	Between 45-180 days (average)
3.	40	Machinist	7 years	2 yrs.	While traveling on lane no. 3 A, he tripped off the lane and fell, hitting his head on a pier post..	02	14	4	2020	Route of lane no. 3A	Cervical spine contusion	Between 45-180 days (average)
4.	39	Miner	3 months	1 month	While clearing the area for the conveyor extension, coal came loose from the front, hitting him in the back.	02	28	5	2020	Head gal., pan 3 South, undermining	Lumbosacral contusion	Between 45-180 days (average)
5.	44	Miner	16 years	1 year	While he was cleaning the coal within section 126, a large piece of coal broke off, landed on TR 7, and broke into pieces. One of these pieces hit his left foot.	03	15	4	2020	Ab. Frontal, pan. 3N, second slice.	Left leg injury	19 days Between 3-45 days (small)
6.	37	Miner	2 years	1 week	While he was handling a crowbar during the coal evacuation operation, a piece of coal hit the crowbar, which was torn from his hand and hit him under the chin on the left side.	03	25	22	2020	Frontal face, panel 3 South, undermining	Left submandibular contusion wound.	14 days Between 3-45 days (small)
7.	28	Mech. Eng.	2 years	2 yrs	While he was carefully watching the operation of the lower rollers, being very close to the running belt no. 3A, a piece of rock rolled off the belt and hit him in the face.	05	22	11	2020	Collector plan band 3A	Nasal contusion wound	40 days Between 3-45 days (small)

8.	40	Miner	7 years	2 yrs	While he was sewing the metal mesh at section no. 78, several pieces of coal came off the front and hit him in the left leg.	05	23	20	2020	Frontal face pan. 3N, slice II	Left ankle injury	39 days Between 3-45 days (small)
9.	38	Miner	6 years	2 yrs	While he was tensioning an SVJ pole with the help of a staple gun, it jumped out of the valve and hit him in the left eye.	06	18	23	2020	Frontal face pan. 3N, slice II	Eye contusion	Between 45-180 days (average)
10.	42	Surveyor	3 years	9 mnth	While he was checking the direction of the mining work with his back to the working face, a piece of rock broke off from the top of the face and hit him in the back.	06	19	24	2020	Ventilation plan pan. 4, str. 13, bl. IX	Contusion of the lumbosacral spine.	78 days Between 45-180 days (average)
11.	41	Miner	10 years	4 mnth	While handling an SVJ pole, together with Janos, he caught his ring and little fingers on his left hand between the pole handle and the edge of the TR5 conveyor chute.	06	21	11	2020	Frontal face, panel 3 South, undermining	Crushing trauma to finger IV of left hand	70 days Between 45-180 days (average)
12.	49	Electrician	20 years	8 yrs	While moving towards the blind shaft ramp, walking on the CFI line, he lost his balance and in the fall hit his right shoulder on the CFI rail.	07	5	11	2020	Blind shaft ramp	Right femur dislocation	149 days Between 45-180 days (average)
13.	37	Miner	11 years	4 mnth	While moving near column number 20, he stepped on a dismantled gutter from TR 5, slipped, and in the fall he leaned on his left hand, dislocating his little finger.	07	16	19	2020	Frontal face, panel 3 South, undermining	Sprained finger phalanx	44 days Between 3-45 days (small)
14.	40	Miner's help	4 years	10 mnth	While moving in the area of the TR3 drive station no. 4, rushing to catch up with his colleague, he stepped crookedly, injuring his left knee.	07	28	9	2020	Plan aeraj, pan. 4, str. 13, oriz. 100	Left knee contusion	4 days Between 3 and 45 days
15.	33	Miner	2 years	6 mnth	While shovelling coal onto the TR7, a piece of coal broke off the top of the front and ricocheted off the side of the TR.7 and hit him in the right shoulder.	08	30	21	2020	Ab.fr.Pan.3N, 2nd slice	Right scapula fracture	62 days Between 45-18 days (average)
16.	37	Miner	7 years	1 mnth	While crossing TR.7, he stepped on its chute, lost his balance, and hit his right ankle on the edge of the conveyor.	09	11	17	2020	Attack plan, panel 4	Right ankle contusion	19 days Between 3 and 45 days (small)
17.	44	Miner	7 years	11 mnth	While moving on the transverse gallery, oriz.100 pushing a platform wagon, he stepped on the CFI rail, slipped and hit his left knee on the wagon.	09	15	5	2020	Transverse gallery, horizon 100	Left knee contusion	74 days Between 45-180 days (average)
18.	37	Machinist	7 years	7 yrs	While descending the stairs from level 6 to level 0, he slipped and fell several steps.	10	9	22	2020	Separation plant	Left femur fracture	162 days Between 45-180 days (average)
19.	22	Unskilled worker	3 weeks	3 weeks	While manipulating a sliding cylinder, he slipped on the fine material deposited on the work bed, lost his balance and caught his right index finger between the cylinder cover and the work bed.	11	13	23	2020	Equipment corridor, panel 2, seam 13, block 9	Crush wound on right index finger	15 days Between 3 and 45 days (small)
20.	44	Miner	8 years	1 mnth	While manoeuvring the monorail at the intersection of the base gallery, pan.4, with the connecting gallery to the equipment corridor pan.2, a chain with which the monorail was connected to the right branch, of TR 3 no.2, caught the drive station of TR.3 no.1, moving it to the left in the direction of flow, injuring the miners: Sebeşi Erno and Mătiţă Liviu	11	27	20	2020	Intersection of the base gallery, panel 4, with the connecting gallery to the equipment corridor, panel 2.	Right leg fracture	207 days Between 45-180 days (average)
21.	43	Miner	14 years	2 mnth	While manoeuvring the monorail at the intersection of the base gallery, pan.4, with the connecting gallery to the equipment corridor pan.2, a chain with which the monorail was connected to the right branch, of TR 3 no.2, caught the drive station of TR.3 no.1, moving it to the left in the direction of flow, injuring the miners: Sebeşi Erno and Mătiţă Liviu	11	27	20	2020	Intersection of the base gallery, panel 4, with the connecting gallery to the equipment corridor, panel 2.	Calf contusion	79 days Between 45-180 days (average)
22.	51	Machinist	15 years	1 mnth	While repairing a broken chain on the TR.7 conveyor, he caught his middle finger on his left hand between it and the conveyor chute.	12	1	21	2020	Equipment corridor, panel 2, seam 13, block 9	Left medius crush	61 days Between 45-180 days (average)

23.	28	Unskilled worker	1 month	1 mnth	While manipulating a GSA 1250 S beam, which he grabbed by one end to place it over another beam, he caught the middle finger of his left hand between the two beams.	12	30	14	2020	Frontal face pan.3 undermining	Crushing trauma of the right index phalanx	25 days Between 3 and 45 days (small)
24.	35	Electrician	13 years	3 days	While positioning an AG 125 A box, next to the gallery wall, together with two other electricians, he stuck his middle finger on his right hand between the edge of the box and the leg of the TH armature.	01	8	10	2021	Base gallery, panel 4, 13th seam, building IX	Right middle distal phalanx fracture	44 days Between 3 and 45 days (small)
25.	41	Miner	13 years	2 yrs	While he was re-banding the ceiling, a piece of rock came loose and caught his little finger on his left hand, between the wooden bandage and the TH reinforcement.	02	15	19	2021	Head panel gallery 3N	Crushing trauma to finger 5, left hand.	55 days Between 45-180 days (average)
26.	41	Miner	13 years	2 mnth	While he was clearing between sections with a hoe, a piece of coal broke off from the upper part of the front and fell onto the side of TR.7 and ricocheted, hitting him in the left hand.	02	21	2	2021	Frontal face, panel 2	Left index phalanx fracture.	34 days Between 3 and 45 days (small)
27.	36	Miner	6 years	2 trs	While he was placing a wooden bandage on the ceiling, his index finger on his right hand was caught between it and a piece of rock detached from the ceiling.	02	25	8	2021	Base gallery, panel 3 N	Left index phalanx fracture.	35 days Between 3 and 45 days (small)
28.	44	Miner	19 years	1 year	When the miner reached the wagon from which he was going to take a roll of metal mesh, he stepped on the CFI rail, slipped and, falling, hit the edge of the wagon with the lower part of his face.	03	5	2	2021	Transverse gallery, horizon 100	Facial trauma	14 days Between 3 and 45 days (small)
29.	43	Miner	7 years	5 mnth	While handling a TH beam, together with another worker, wanting to place it in the stack, he got his left hand caught between the beam and other TH elements in the stack.	03	11	13	2021	Head gallery, panel 2, 13th seam, block IX	Right annular fossa fracture	51 days Between 45-180 (average)
30.	39	Miner	13 years	1 mnth	While he was hammering the ceiling of the gallery with a miner's hammer, a piece of tailings came loose and hit him, injuring him.	05	15	13	2021	Collectors' gallery, panel 4, 13th seam, block IX, 100 level	Left shoulder contusion	12 days Between 3 and 45 days (small)
31.	39	Electrician	18 years	2 yrs	While handling an AG 63 A box, together with two other colleagues, he caught his little finger on his left hand, between the edge of the box and the TH armature.	06	16	9	2021	Base gallery, panel 4, 13th seam, block IX, level 100	Fracture of the phalanx of the 5th finger of the left hand	46 days Between 45-180 days (average)
32.	43	Machinist	14 years	2 yrs	While Babiuc and another worker were moving a TR.3 chute, the locksmith stepped crookedly, lost his balance, and hit his right foot.	06	23	17	2021	Base' gallery, panel 4, 13th seam, block IX, 100 level	Right leg contusion	18 days Between 3 and 45 days (small)
33.	41	Miner	9 years	3 mnth	While miner Barta, together with the shift leader miner, lifted a TR.7 connecting frame, miner Barta did not grab it well with his hands, it slipped and hit his left leg on the inside of his calf and ankle.	07	6	11	2021	Attack plan, pan. 4, str. 13, bl. IX, level 100	Left calf strain	87 days Between 45-180 days (average)
34.	22	Unskilled worker	1 year	2 weeks	While moving past the stack of materials, he slipped, fell over it and in the fall, caught his right hand fingers between the edge of the TR.7 side beam and the TH leg of the reinforcement.	07	13	2	2021	Base gallery pan. 4, str. 13, bl. IX, level 100	Crushing trauma to phalanx 2, 3, 4, 5 right	64 days Between 45-180 days (average)
35.	47	Min. Eng.	16 years	2 yrs	While the CFL engineer was moving on the base gal. pan .4, he stepped on a side of the TR.5 conveyor no.9, slipped and caught his foot between it and the next side.	07	16	11	2021	Base gallery pan. 4, str. 13, bl. IX, level 100	Right ankle contusion	108 days Between 45-180 days (average)
36.	30	Miner's help	2 years	2 yrs	While the miner's assistant was stopped from the cutting operation, with the felling hammer, a piece of coal came off the upper part of the front and hit him on the right forearm.	08	4	10	2021	Collector gal., pan.5, horizon 100	Right forearm wound	48 days Between 45-180 days (average)
37.	37	Miner's help	1 year	1 mnth	While carrying a TH element with a colleague, the miner's assistant stepped on the wrong foot and fell, crushing the TH element on his right little finger.	08	20	16	2021	Longwall face, panel 4, seam 13, horiz. 100	Right articular fracture	156 days Between 45 and 180 days (average)
38.	45	Miner	8 years	3 weeks	While the miner was pulling an SVJ pole, together with another colleague, pulling the pole towards him to remove it from the pit, the pole tilted and caught his right foot between it and the pit.	09	22	10	2021	Base gallery intersection, panel 4 with mechanized face	Right leg contusion	70 days Between 45-180 days (average)

39.	42	Miner	9 years	2 mnth	While the miner was standing in front of section No. 6 and guiding the water hose of the combine, a piece of coal hit him in the left hand.	10	6	16	2021	Complex mechanized frontal face, panel 4	Left hand contusion	53 days Between 45-189 days (average)
40.	44	Miner	8 years	1 week	While the replacement miner, the shift leader, was digging the upper area of the front, on the right side of the gallery using a miner's hammer, a piece of rock broke off from the ceiling and hit him in the face, nose and right arch.	10	13	21	2021	Collector plan seam.13, horiz.100	Nasal pyramid fracture	48 days Between 45-189 days (average)
41.	43	Miner	12 years	3 mnth	While manually cleaning near section no. 55, a piece of coal came off the front, fell on TR.7 and ricocheted off its side and hit the miner on the right side of his body and his right knee.	11	3	4	2021	Ab.fr. mechanized, panel 4, seam 13	Right knee sprain	33 days Between 3-45 days (small)
42.	42	Miner	8 years	3 week	While he was loosening a clamp from the old reinforcement with a wrench, the clamp broke and a piece of it hit him in the left arch.	11	5	21	2021	Collector gallery panel 4	Left eye trauma	36 days Between 3-45 days (small)
43.	41	Miner	16 years	3 mnth	While the miner on the working bridge was digging the front using a crowbar, a piece of tailings came loose from the front, and the miner jumped off the bridge and fell to the left side, but the piece of tailings tipped over the bridge and slid over his feet.	12	9	8	2021	Ventilation plan, pan. 4N, seam 3, block VI,	Left leg contusion	59 days Between 45-189 days (average)
44.	38	Miner	13 years	13 ani	While he was performing the cutting operation with the felling hammer, in order to create the ripping location, the TR.7 drive station, coal particles were projected into his left eye.	12	19	9	2021	Frontal mechanized complex, panel 4, 13th seam, building IX, horizon 100	Left eye trauma	22 days Between 3-45 days (small)
45.	44	Miner	4 years	4 mnth	While the miner and the shift leader were lifting the TH beam from the ceiling of the work, a piece of rock broke off and hit him on the right hand.	01	14	16	2022	Ventilation plan, panel 4N	Severe contusion of the right hand	125 days Between 45-180 (average)
46.	47	Miner	22 years	6 mnth	While the miner was cutting with a jackhammer, at some point, a piece of rock broke off from the ceiling of the mine and fell onto his left hand, injuring his ring finger.	01	16	5	2022	Intersection of base gallery with wall panel 4, seam 13	Crush wound, finger 4, left hand	44 days Between 3-45 days (small)
47.	40	Driller	8 years	8 yrs	While the driller was placing the WD-02EA drill motor on the mining hearth, it slipped from his hands, trapping the two little fingers on both hands between the hearth and the drill motor.	01	18	8	2022	Ventilation plan, pan. 4N, seam 3, block VI,	Crushing trauma to finger 5, left and right hand	43 days Between 3-45 days (small)
48.	44	Miner	13 years	1 mnth	While the miner was performing the cutting operation with a jackhammer on the right side of the gallery, in order to install the TH leg, a piece of rock broke off from the upper area of the wall and fell on his right foot.	01	29	20	2022	Base gal. pan.4, seam13	Sprained finger 3, 4, right hand	19 days Between 3-45 days (small)
49.	42	Miner	13 years	5 mnth	While performing the baking operation, on the work bridge, a slab of waste rock came loose from the upper part of the front. At that moment, trying to escape, he fell from the work bridge onto the hearth of the work.	03	7	15	2022	Ventilation plan, pan. 4N, seam 3, block VI,	Severe contusion of the left leg	55 days Between 45-180 days (average)
50.	43	Machinist	23 years	1 week	While he was taking a wrench out of the toolbox, the lid of the box accidentally closed and trapped his right index finger between the edge of the box and the lid.	04	6	19	2022	Transverse ventilation gallery, 13th seam, block IX	Open fracture of the right index phalanx.	38 days Between 3-45 days (small)
51.	41	Miner's help	2 years	4 days	While cutting the working face with the felling hammer, he lost control of it and fell on his right foot.	04	14	14	2022	Base gallery, panel 4, 13th str, 9th block, 100th floor	Wound contusion of right forefoot	17 days Between 3-45 (small)
52.	43	Machinist	8 years	2 mnth	While he was maneuvering a crowbar with a colleague, a Tr.5 type drafter, to position it closer to the gallery wall, the crowbar slipped, and the reducer crushed his left foot against the TH leg, the gallery rigger's leg.	04	21	11	2022	Base gallery, panel 4, seam13, bl.IX, horiz.100	Bruised wound on right forefoot	58 days Between 45-180 days (average)
53.	42	Miner	14 years	6 days	While he was on a ladder and trying to stretch the metal mesh, he wanted to turn around, at which point he lost his balance and fell on his left foot.	05	11	15	2022	Heading gallery ap, pan.5, seam 13, bl.7	Left ankle sprain	5 days Between 3-45 days (small)

54.	40	Miner	7 years	1 mnth	While carrying a piece of wood with a colleague, he slipped on the small material spilled on the work site, lost his balance and dropped the wood from his hand onto the calf of his right leg.	06	1	11	2022	Collectors' gallery, panel 5, 13th seam, VII block, horizon 100	Right calf wound	30 days Between 3-45 days (small)
55.	33	Unskilled worker	2 years	1 mnth	While carrying a TH element, together with the shift chief miner, he lost his balance by stepping on the small material on the hearth and fell, hitting his head on the TR 5 no.6 drive station, and the TH element fell on him, hitting him on the right side of the chest.	06	9	7	2022	Collectors' gallery, panel 5, 13th seam, VII block, horizon 100	Thoracic trauma	5 days Between 3-45 days (small)
56.	44	Miner	9 years	10 mnth	While he was pushing with a crowbar, pushing a TR.5 editor, the crowbar slipped, and he fell over the crowbar, hitting his left chest on it.	06	10	14	2022	Base gallery, panel 4, 13th seam, VII block, horizon 100	Thoracic trauma	36 days Within 3-45 days
57.	53	Machinist	7 years	2 week	While carrying a TH element, he tripped over a rock on the hearth and fell.	06	30	18	2022	Master gallery horiz. 300,	Left ankle sprain	49 days Between 45-180 days
58.	23	Unskilled worker	1 month	1 mnth	While placing a TR.5 trough, together with a colleague, he did not synchronize his teamwork and got his right thumb caught between the manipulated trough and the one in the stack.	07	28	10	2022	Collector plan, pan. 4N, seam 3 bl. VI horiz. 300	Right thumb phalanx fracture	72 days Between 45-180 days (average)
59.	39	Miner	14 years	1 year	While standing between the shaft and transporter TR. 7, monitoring the cleaning operation of the shaft bed, a piece of rock broke and hit him.	08	4	5	2022	Intersection of mechanized frontal face, panel 4, with the base gallery, panel 4, horizon 100	Contuzie coloană cervicală	43 zile Între 3-45 zile (mici)
60.	36	Miner	2 years	1 mnth	While he was cutting forward in the ceiling area, on the working bridge, making room for reinforcement, a piece of rock broke off and hit him in the left leg, after he had jumped off the working bridge.	09	06	11	2022	Intersection of the head gallery, panel 5, seam 13, with the transverse ventilation gallery, horizon 100	Left calf fracture	117 days Between 45-180 days (average)
61.	39	Miner	5 years	1 year	After opening the pressure valve on the pressure distributor, and returning to tension the hydraulic column, the hose clamp on the inlet pipe snapped, the hose came out of the caulking gun, and made an uncontrolled movement towards the miner, hitting him in the left cheek.	09	15	23	2022	Intersection between the head gallery and the mechanized face pan. 4, seam 13	Left zygomatic hematoma	8 days Between 3-45 days (small)
62.	38	Miner's help	10 years	1 year	While he was making the location for mounting a TH leg, a piece of tailings came loose from the side wall and hit him in the back.	09	21	22	2022	Gal. head pan.5, seam.13, block VII, horizon 100	Chest contusion	38 days Between 3-45 days (small)
63.	43	Miner	5 years	6 mnth	While he was cutting the face with the rock hammer, a piece of rock broke off and injured his middle finger on his right hand.	09	22	02	2022	Collector plan block VI, horizon 100	Right medius crush syndrome	58 days Between 45-180 days (average)
64.	45	Miner	26 years	1 year	When the miner stopped cutting with the jackhammer and placed it on the hearth on the upper part of the wall, from a height of approximately 3m, a piece of rock broke off and hit him on the head.	10	17	14	2022	Mechanized face, 4th panel, 13th seam, horizon 100	Head injury	157 days Between 45-180 days (average)
65.	42	Machinist	8 years	3 yrs	While inserting the coupling onto the engine, he caught the second finger of his right hand between the coupling and the engine.	10	25	11	2022	Collector gallery, panel 4, 13th seam, IX block, horizon 100	Traumatism finger 2 right hand	25 days Between 3-45 days (small)
66.	39	Machinist	17 years	2 mnth	While the locksmith was carrying a piece of wood to his workplace at a level crossing, he slipped and fell onto TR.3, which was stationary.	12	13	01	2022	Horizontal cross gallery 100	Left femur fracture	269 days Between 45-180 days (average)
67.	42	Miner	10 years	3 yrs	While the foreman miner was lowering a 108-gauge pipe from his shoulder, its board caught on the power cable of the miner's lamp, he lost balance, leaned on the stack of pipes with his left hand, and the pipe slipped from his right hand and fell onto the fingers of his left hand.	01	25	09	2023	Collector gallery, panel 5, seam 13, horizon 100	Fracture of finger 4, left hand	52 days Between 45-180 days (average)

68.	39	Unskilled worker	6 months	2 yrs	While the wagon driver was manoeuvring a beam to position it next to the other previously stacked TH elements, he released and caught his left ring finger on a TH element that was on the hearth of the mining work.	02	13	14	2023	Head Gallery, panel 4, seam 13, block 9, horizon 100	Left ring phalanx wound	26 days Between 3-45 days (small)
70.	44	Shotfirer	11 years	11 yrs	While the bomb disposal expert was moving along the transverse gallery from horizon 100 towards the abattoir, to make the turn, like SP.CAMS, when he arrived near the dump, he stepped on a wet piece of wood and fell, injuring his right leg.	04	05	16	2023	Horizontal cross gallery 100	Right leg fracture	57 days Between 45-180 days (average)
71.	38	Miner	12 years	6 mnth	While the miner bent down to pick up a bandage that had fallen from the formed slope following the blasting operation from the ceiling of the mining work, a piece of coal measuring 20/20 cm broke off, hitting him on the left side of his shoulder in the lumbar area.	05	05	16	2023	Basic gallery horizon 100, panel 5, seam 13, block VII	Left lumbar trauma	22 days Between 3-45 days (small)
72.	40	Miner	15 years	2 yrs	While the miner was placing a wooden beam on the stack, the wood dropped from his hand and the fingers of his left hand were caught between two pieces of wood.	05	17	03	2023	Basic gallery, panel 4, 13th seam, horizon 100	Bruised wound on left index finger	44 days Between 3-45 days (small)
73.	39	Min. Eng.	20 years	8 yrs	While he was leaning on the side of TR.7, a piece of rock fell on the 5th finger of his left hand.	06	28	16	2023	Frontal face pan. 4, seam 13, horiz. 100	Crushing trauma to finger 5, left hand	65 zile Între 45-180 zile (medii)
74.	40	Miner	4 years	3 mnth	While he was shovelling away the rubble from the work front, a piece of rock broke off and hit him on the thumb of his right hand.	07	03	14	2023	Basic directional gallery, panel 2, short front, seam 13, horizon 100	Traumatism prin strivire police mana dr.	19 days Between 3-45 days (small)
75.	41	Miner	2 years	2yrs	While the shift foreman was manoeuvring a hydraulic pole with the miner's assistant, he lost his balance and fell, catching his 4th finger on his left hand between the pole and the side of the TR.7 conveyor.	07	10	21	2023	Mechanized Frontal face, pan.4, seam13, bl. IX, horizon 100	Finger 4 left hand crush	49 days Between 45-180 days (average)
76.	49	Elmec. Eng.	17 years	10 mnth	While manoeuvring to check the operation of the glider at elevation 6, he accidentally pressed the glider's translation button, at which point his left foot was caught between the belt buffer and the mechanical stop at the end of the stroke.	07	13	12	2023	Separation level 6	Left calf fracture	111 days Between 45-180 days (average)
77.	42	Miner	10 years	1 mnth	While the miner, the brigade leader, was performing the operation of cutting the front in order to remove a reinforcement from the ceiling of the mining work, a piece of tailings came loose, which, sliding down the inclined plane, hit him in the back.	07	20	04	2023	EM LUPENI Aeration plan seam 3, bl.2	Sacral vertebral trauma	104 days Between 45-180 days (average)
78.	45	Machinist	16 years	16 yrs	While traveling with a colleague on the pedestrian crossing in the Dacia Square area, Petroșani gate 1 EM.LIVEZENI, she was fatally injured by a car.	07	27	22	2023	DN 66, B-dul 1 Decembrie –trcere pietoni poarta 2 EM LIVEZENI	DEATH	Maximum 7 DEATH
79.	49	Machinist	23 years	23 yrs	While she was walking with a colleague on the pedestrian crossing in the Dacia Square area, Petroșani gate 1 EM.LIVEZENI, she was hit by a car.	07	27	22	2023	DN 66, 1 Decembrie Blvd. – pedestrian crossing gate 2	Bruised wound on right forefoot	90 days Between 45-180 days (average)
80.	31	Machinist	20 days	20 days	While transporting the tape stapling machine on the 300-100 horizon collector plane, together with a colleague, the locksmith slipped on the right side of the TMB lane, no. 2 A, and fell, spraining his left ankle.	08	21	09	2023	Collector plan. Horizon 300 lane 2A	Left leg dislocation	68 days Between 45-180 days (average)
81.	42	Miner	8 years	1 mnth	While he was performing the yoke operation, the mounting of his foot under the beam, the neighbouring stud, weakened and hit him from the front in the neck area.	09	20	17	2023	Base gallery horizon 100, panel 2 short front	Thyroid cartilage fracture	10 days Between 3-45 days (small)

82.	37	Miner	17 years	6 mnth	While he was unloading a 45 KW engine using a Pneumoplan, which he transported onto the monorail line, the crane hook slipped and hit him in the face.	09	28	21	2023	Collectors Gallery, Horizon 100, Pan.4, Seam 13, Block 9	Right mandible contusion	86 days Between 45-180 days (average)
83.	40	Miner	5 years	2 yrs	While the miner's brigade leader was removing a clamp from a piece of reinforcement that he was removing for rebar, it gave way and a piece of it broke off. The piece hit him in the forehead, breaking his protective helmet.	10	2	12	2023	Gallery base panel 4, str.13, bl.9 oriz.100	Craniofacial trauma	32 days Between 3-45 days (small)
84.	39	Unskilled worker	2 months	2 mnth	While carrying clamps on the transverse gallery next to TR.5, no.7, he stepped on the wrong foot and injured his left ankle.	10	20	05	2023	Transverse gallery seam 5, TR.5 no. 7 collector	Left spinal sprain	19 days Between 3-45 days (small)
85.	24	Miner's help	9 months	9 mnth	While he was manoeuvring a 145 KW engine with a crowbar to position it closer to the gallery wall, he lost his balance and fell, hitting his head on a reinforcement.	10	27	17	2023	Basic gallery pan.4, str.13, bl.9, TR.5 no.32, horiz.100	Left temporal wound	22 days Between 3-45 days (small)
86.	42	Miner	5 years	2 days	While the miner was lifting the 3rd beam from the front of the ceiling in the quarry, a piece of rock broke off and hit him in the back and pelvis.	11	07	09	2023	Frontal face pan.2 short front, str.13, horiz.100	Thoracolumbar polycontusion	17 days Between 3-45 days (small)
87.	37	Machinist	17 years	12 yrs	While the locksmith was searching the toolbox for some keys, the lid of the box fell off and hit him over the front of his helmet. He fell backwards, his right hand came out of the box, at which point it was caught between the lid and the edge of the box.	11	14	02	2023	Horizon100 gal. cross-section pump station	Right hand contusion	21 days Between 3-45 days (small)
88.	39	Miner	16 years	8 mnth	While he was moving towards the exit, at the end of the second shift, next to TR.5 no.4, on the collector gallery, he was injured.	11	24	18	2023	Collector gallery pan. 5, seam 13, horizon 100 TR.5 no.4	Facial trauma.	15 days Between 3-45 days (small)
89.	42	Driller	2 years	2 yrs	When the driller was moving towards pier 101, together with his colleagues, where he was going to carry out the planning operation, he arrived at the pump for draining water from the sump at the TM 4A conveyor belt. He probably slipped and his overalls were pulled by the pump shaft. He was pulled towards the elastic coupling that had no guard, being injured in the left shoulder and face.	12	04	14	2023	Collector gallery panel 2, seam 13, horiz.100, pier 101. Veneer band 4A	DEATH	DEATH
90.	41	Unskilled worker	5 months	5 mnth	While the unskilled worker was giving materials to the shift leader miner who was installing a TH reinforcement leg, a piece of rock broke off from the side wall and injured his right calf.	12	08	17	2023	Base gallery, panel 5, 13th seam, section 2, block VII, horizontal 100	Right calf injury	55 days Between 45-180 days (average)
91.	44	Miner	27 years	1 year	While the shift leader miner was placing a new TH element on the stack, together with a colleague, one of the TH elements in the stack moved, at which point the shift leader miner dropped the TH element he was carrying and his fingertip was cut between two TH elements.	01	19	21	2024	Basic gallery pan.,2, seam13, horiz. 100	Amputation of finger 5, right hand	89 days Between 45-180 days (average)
92.	39	Machinist	21 years	2 mnth	While he was lifting the TR 7 turning head using a pneumatic crane, the chain link gave way (a bolt) and the turning head fell, injuring his left foot.	03	02	14	2024	Head gallery intersection, with pre-collapse, panel 5, seam 13, horiz.100	Metatarsal fracture 1, 2 left foot	91 days Between 45-180 days (average)
93.	48	Machinist	30 years	18 ani	While trying to dismantle the AH 78P350 high-pressure pump regulator, a jet of hydraulic fluid (water + emulsion) hit him in the left eye.	03	20	12	2024	Metal fabrication workshop	Eye trauma	25 days Between 3-45 days (small)
94.	26	Miner's help	4 years	1 year	While the miner was waiting for the shift supervisor who was supposed to distribute the work tasks on the ceiling of the mining operation, a wooden bandage came off, injuring his fingers on his left hand.	03	22	00	2024	Basic gallery, panel 5, seam 13, horizon 100	Bruised wound of left index phalanx	56 days Between 45-180 days (average)

95.	44	Miner	23 years	10 yrs	While the miner was preparing the place for installing the TH reinforcement leg, with the downhole hammer, from the upper part of the front, a piece of rock broke off and after falling onto the working bridge, ricocheted onto the miner's left leg.	04	03	21	2024	Collector gallery, panel 5, seam 13, bl. IX, horiz. 100	Fracture of phalanx of finger 4, left foot.	39 days Between 3-45 days (small)
96.	29	Miner's help	10 years	1 year	While the miner's assistant was holding the TH armature leg in position, on the upper part of the front, a piece of rock broke off and fell onto the fingers of his right hand, injuring him.	04	18	18	2024	Transversal ventilation gallery, horiz. 100, bl. IX panel 5	Right hand trauma	37 days Between 3-45 days (small)
97.	41	Miner	18 years	6 yrs	While the miner was on the overhead gallery, a piece of rock fell on his head.	05	23	09	2024	Heading gallery pan. 5 seam 13, horiz. 100 bl. VII	DEATH-Cardio-respiratory arrest	DEATH
98.	33	Unskilled worker	9 months	7 mnth	While the electrician was lifting a 45 KW motor, the hook slipped from the chain it was attached to and hit him on the right cheek.	06	06	10	2024	Intersection of the transverse gallery with the collector gallery, pan. 5, seam 13 and the connecting gallery, lane 4A, horizon 100	Epiritexis anterior	3 days Between 3-45 days (small)
99.	43	Miner's help	10 years	22 days	While the miner's assistant was working on the TR.7 conveyor's rip-off site, at the cutting edge, a hydraulic pole operated by two colleagues nearby was dropped by them and as it fell, the pole touched the miner's assistant on the back, on the left side.	06	27	13	2024	Mechanized face pan. 5, seam 13, horiz. 100, bl. VII	Cervico-thoracic spinal trauma	4 days Between 3-45 days (small)
100.	47	Machinist	10 years	9 yrs	At the end of the work schedule, the locksmith went to the miners' bathroom and after taking a shower, while walking towards the exit of the room, he slipped on a piece of soap, fell backwards, and injured his head.	07	07	07	2024	Miners' bathroom	Vertex contusion wound	9 days Between 3-45 days (small)
101.	43	Miner	25 years	16 yrs	While performing the cutting operation with the KS 3M front-end felling combine, a piece of coal broke loose and fell onto the combine, broke and ricocheted between the sections where the miner was, hitting him on the calf of his right leg.	07	20	23	2024	Mechanized frontal face, pan. 5, seam 13, bl. VII, horiz. 300	Right calf contusion	21 days Between 3-45 days (small)
102.	38	Miner	5 years	2 mnth	While he was pulling a TH element that was stacked against the gallery wall to load it onto the attached trolley, to the monorail line and transport it to the work front, another element in the stack moved and crushed his right index finger.	08	13	07	2024	Intersection of the 300 horizon transport tunnel, with the 35 lane connecting tunnel	Right index finger injury	47 days Between 45-180 days (average)
103.	26	Miner's help	4 years	1 year	After the miner's assistant unloaded a TR.5 chute from the transport cart, together with two other workers, the moment he put his weight on the mining hearth, his right hand was caught between the chute and the mining hearth.	09	24	03	2024	Main transport gallery, horiz. 300	Left middle index finger contusion wound	37 days Between 3-45 days (small)
104.	39	Machinist	16 years	3 yrs	While working on dismantling the drive star of TR.3, no. 2 from the base gallery pan. 4N, he hit the chisel with the hammer and a piece of veneer was projected into his left thigh.	09	28	11	2024	Base gallery, panel 4N, horiz. 300	Foreign body left thigh	13 days Between 3-45 days (small)
105.	39	Miner	4 years	2 mnth	While the miner was moving from the veneer towards the station, he slipped near section 40, fell and injured his right foot, hitting his left arch against the side of TR.7 at the same time.	10	26	22	2024	Mechanized frontal face, pa. 5, seam 13, bl. VII, horiz. 100	Right tibia fracture	91 days Between 45-180 days (average)

4. Data processing and interpretation of results

Evolution of statistical indicators of work accidents at E.M. Livezeni during 2020 - 2024

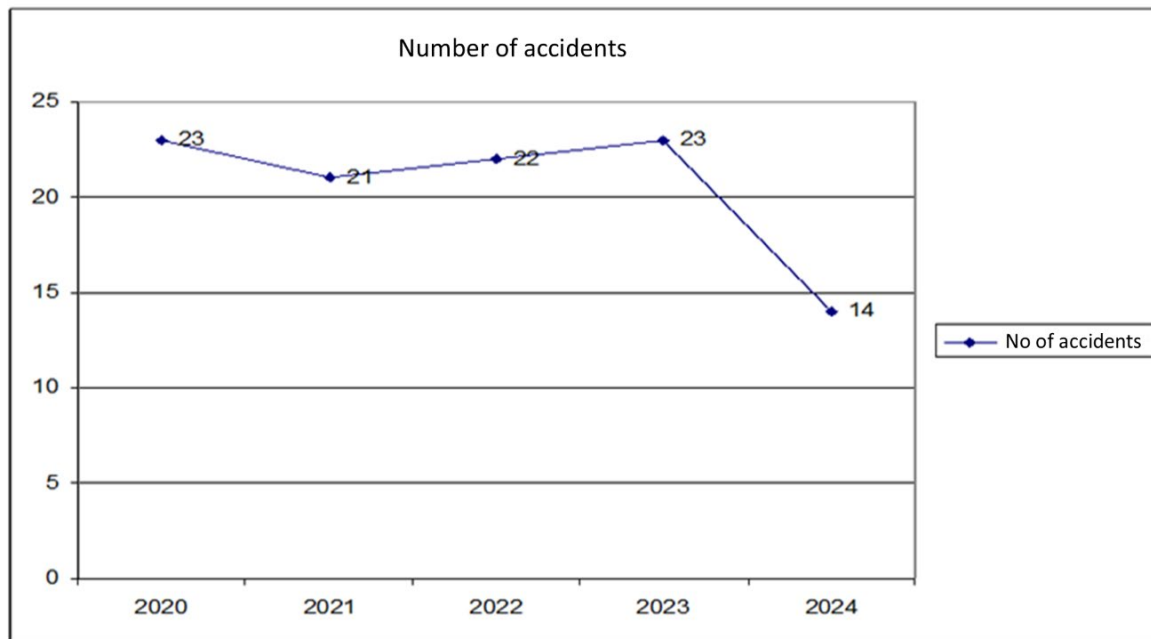


Fig. 2. Evolution of statistical indicators of total work accidents during 2020-2024 at E.M. Livezeni

The maximum number of work accidents is 23, recorded in 2020 and 2023. Since 2020, the trend is downward in 2021 with a number of 21 accidents, and then in 2022 a slight increase is recorded (22 accidents), after which the maximum number of 23 accidents is reached again in 2023 and then a sudden and significant decrease occurs in 2024 with a number of 14 accidents. (fig. 2).

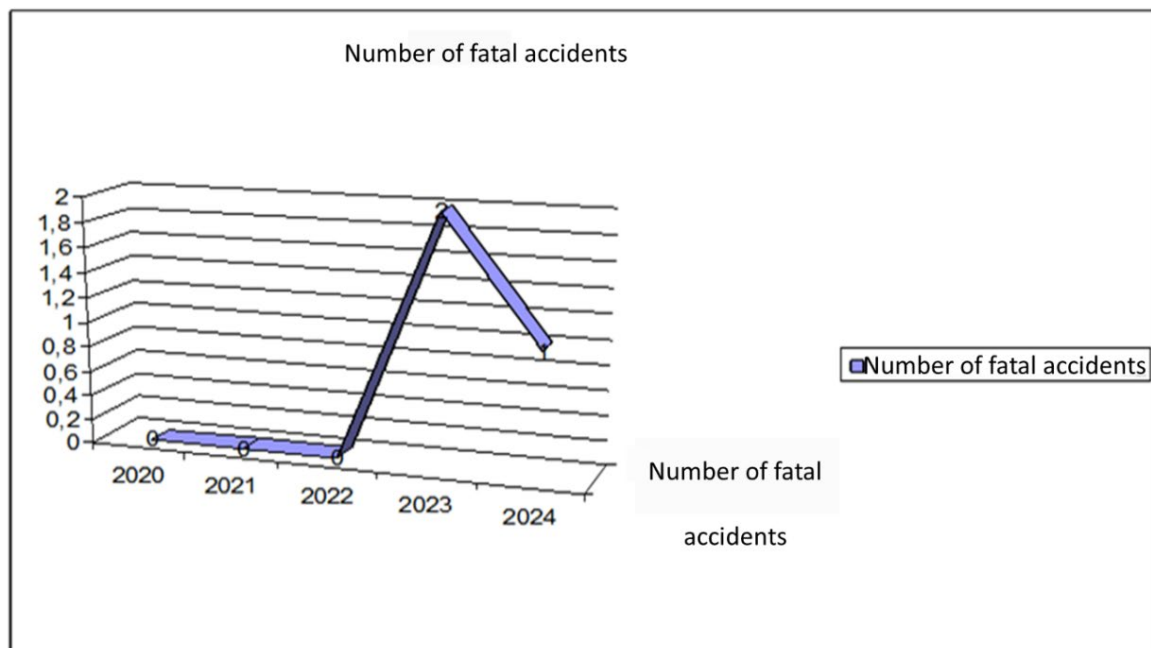


Fig. 3. Evolution of statistical indicators of total fatal accidents during 2020-2024 at E.M. Livezeni

In addition to the accidents shown in Fig. 2, **fatal accidents** were also recorded during the period 2020-2024. As can be seen in Fig. 3, the maximum number of fatal accidents is in 2023 (a number of 2 accidents), followed by a slight decrease in 2024, with a total of one fatal accident. These are added to the total number of accidents with temporary incapacity for work (fig. 3).

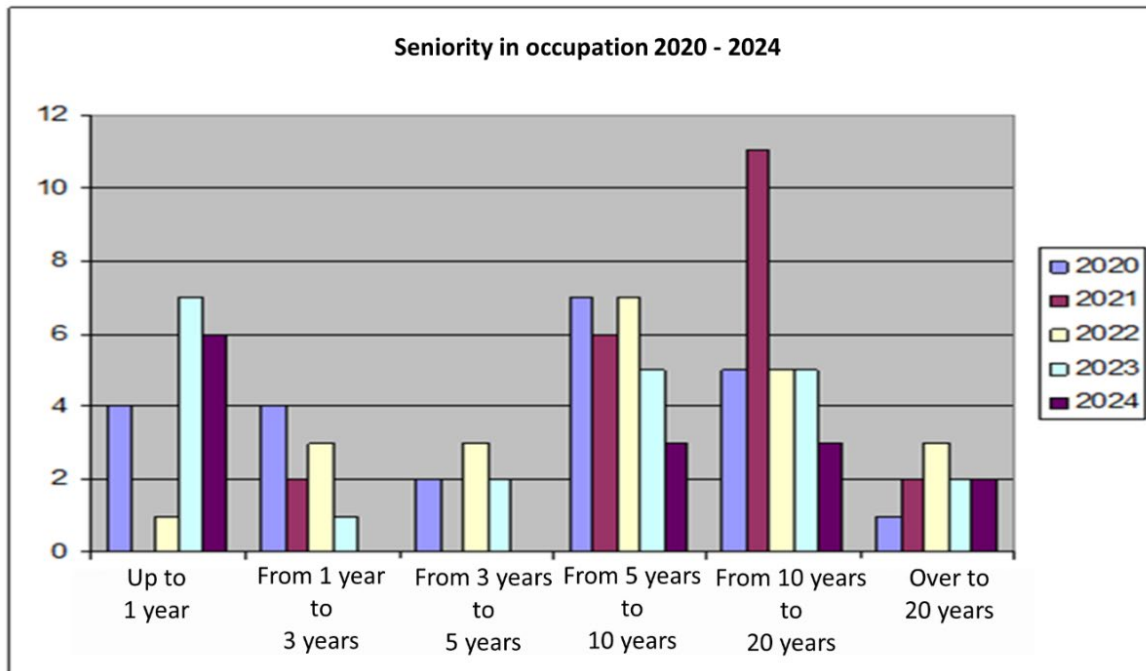


Fig. 4. Length of employment of victims of work accidents occurring at E.M. Livezeni 2020-2024

When analysing Fig. 4, we observe that the people who have been injured the least are the workers who have been in the occupation for over 20 years, and the workers who have had the most accidents are those with up to one year of experience in the occupation, due to the fact that being new to the occupation they exercise, they are more vulnerable and depend on workers with experience in the work they do. We observe that increased values also appear in workers with 10 to 20 years of experience in the occupation, probably due to the fatigue accumulated after years of work.

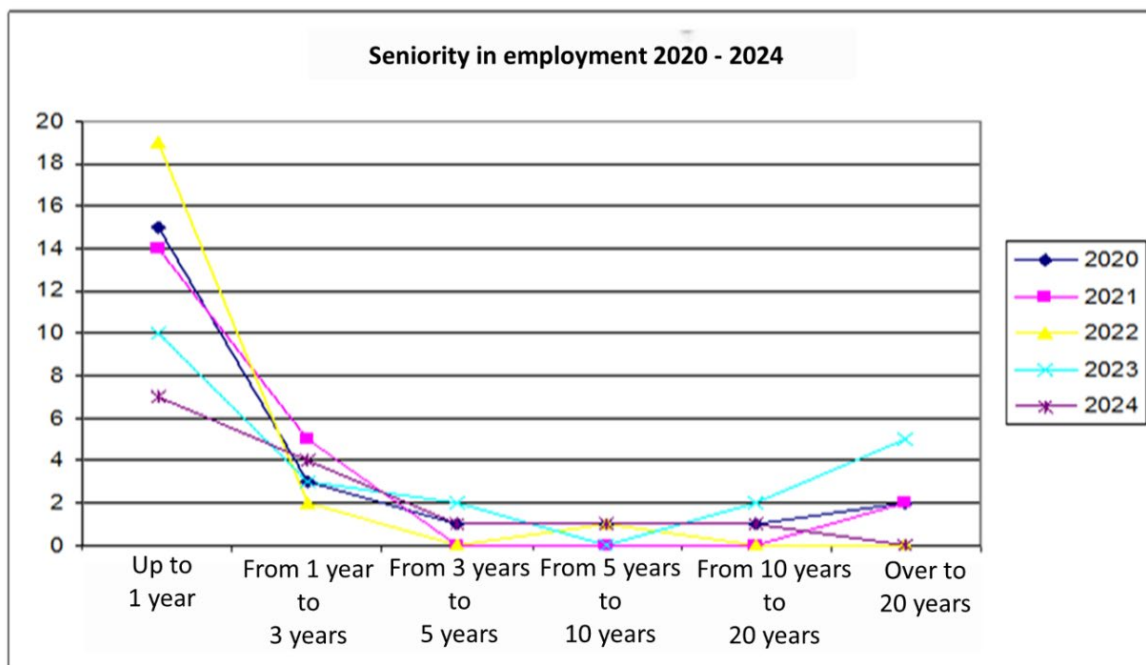


Fig. 5. Length of service at work of victims of work accidents at E.M. Livezeni 2020-2024

Regarding the **length of service** in workplace, the increased values are evident for workers with up to one year of experience, which indicates that workers employed in this mining sector find it quite difficult to adapt to the hard work underground in the first year of work, when everything is new and when the work environment favours accidents. (fig. 5).

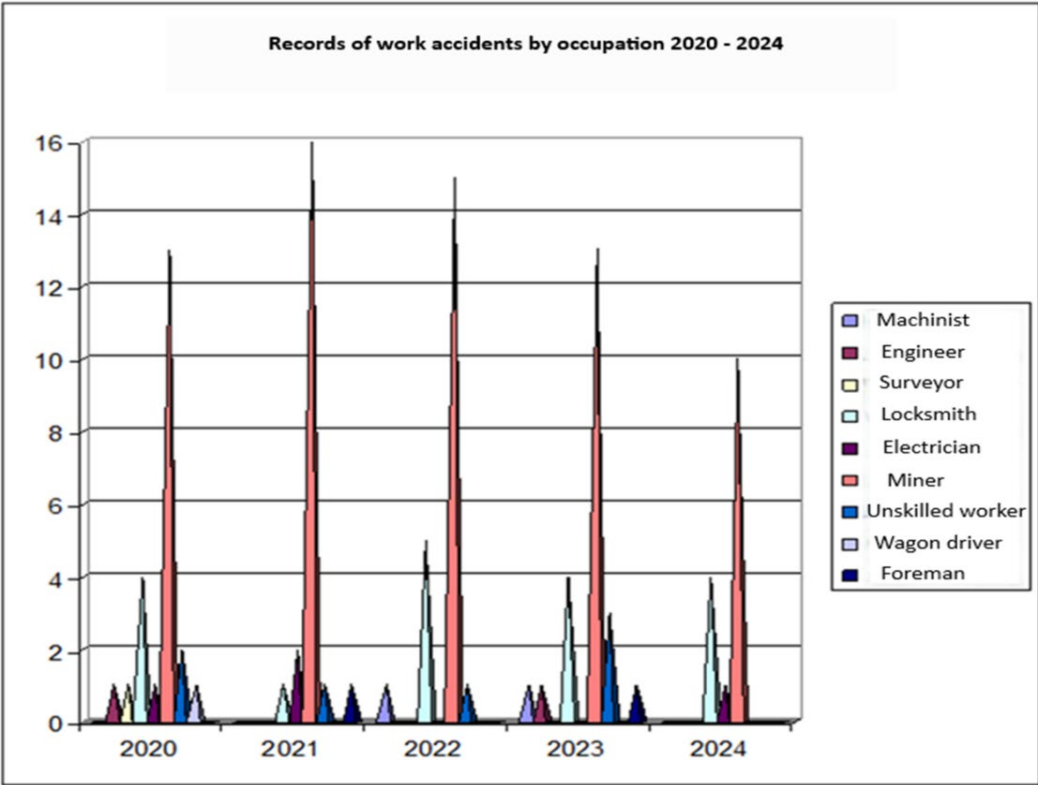


Fig. 5. Accident records at E.M. Livezeni by occupation during 2020-2024

When analysing the injured workers over the five years, we observe the categories of *occupations most exposed* to work accidents (fig. 5). In first place are miners, because they are the most exposed to risks, having direct contact with everything that the coal extraction operation and its auxiliary operations entail.

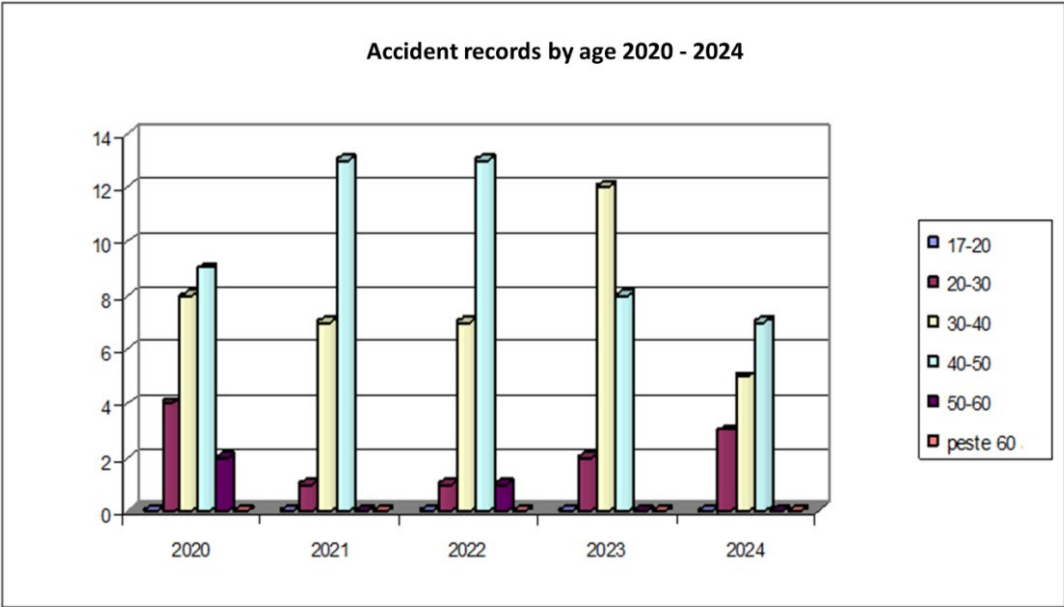


Fig. 6. Accident records at E.M. Livezeni by age during 2020-2024

Regarding the *record of accidents by age*, we note that the workers most exposed to work accidents are people aged 40-50, with the maximum number being 13 workers in 2021-2022 (a similar number), followed by the category of people aged 30-40, with a maximum number of 12 workers in 2023. (fig. 6).

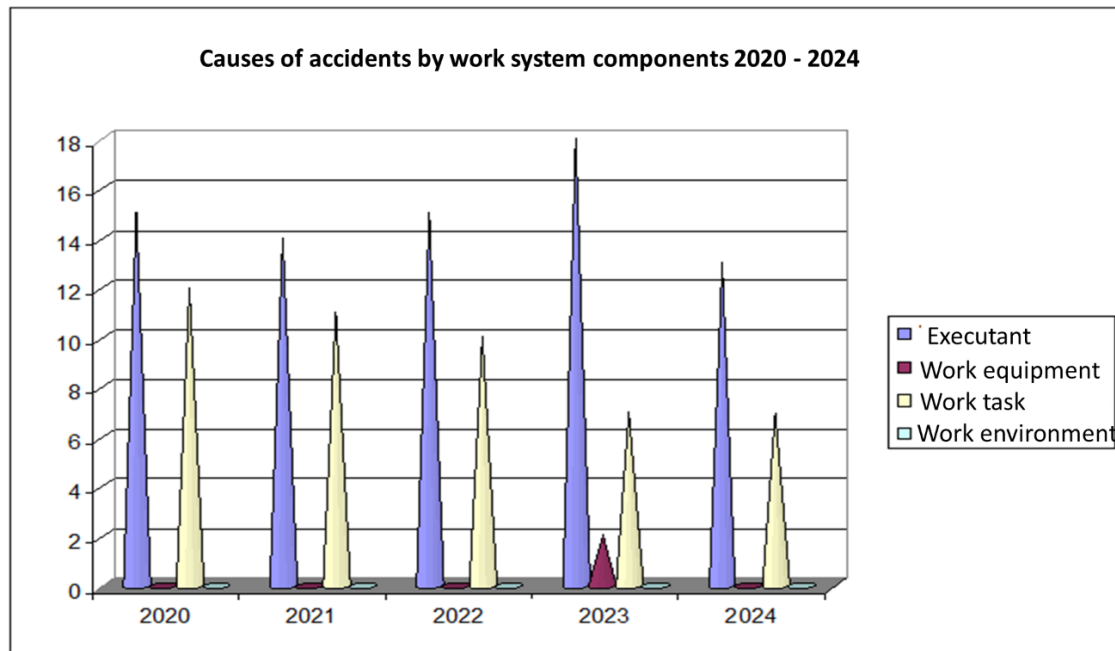


Fig. 7. Causes of accidents according to the components of the work system at E.M. Livezeni

Most of the accidents (fig. 7) are caused by the "human factor" with a maximum number of 18 accidents occurring in 2023 (75%), followed by 15 accidents in 2020 and 2022 (65.22%), preceded by the "workload" component of the work system, with a maximum number of 12 accidents (6.22%) in 2020, recording a decrease of up to 7 accidents in 2024 (46.67% -fig. 8).

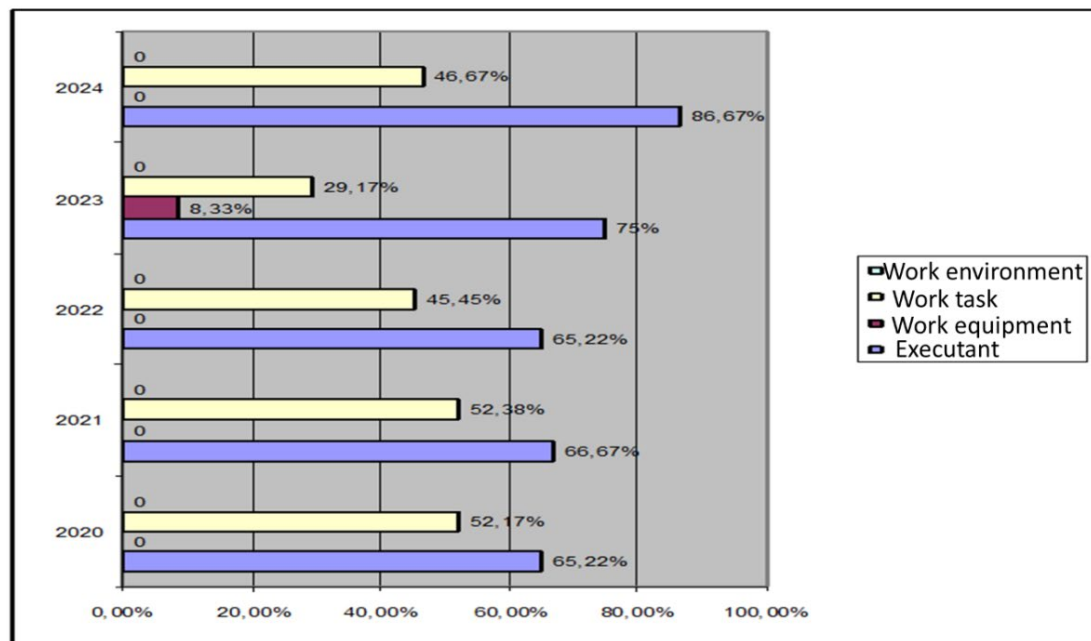


Fig. 8. Causes of accidents by work system components (in percentages) at E.M. Livezeni

When analysing the **effect on the body** that work accidents have in the period 2020-2024, we note that in the first position is "Other types of contusions" with a number of 10 accidents in 2020, decreasing in 2022 (a number of 7), then in 2023 (a number of 6), finally reaching a number of 0 accidents in 2024. The next category is "Bone fractures", being in second place which produced a fairly high number of accidents, namely in 2020, 2021, 2022, a number of 4 accidents remaining constant, then an increase of 2 accidents was recorded in 2023 (6 accidents in total), then a decrease by half of the number in 2023 (3 accidents), in 2024.

The **"injury location" indicator** shows that workers are most frequently injured in the fingers, with the maximum number of accidents being in 2021 with a number of 8, and the other years also having quite high

values (a number of 7 accidents in 2022 and 2024 and a number of 6 accidents in 2020-2023). Depending on the number of accidents, we note that we have a high number of injuries to the foot (a number of 3) in 2020 and 2022, followed by the head with a number of 4 accidents in 2023, respectively 3 accidents in 2024 and the "face area" also with a number of 3 accidents in 2024.

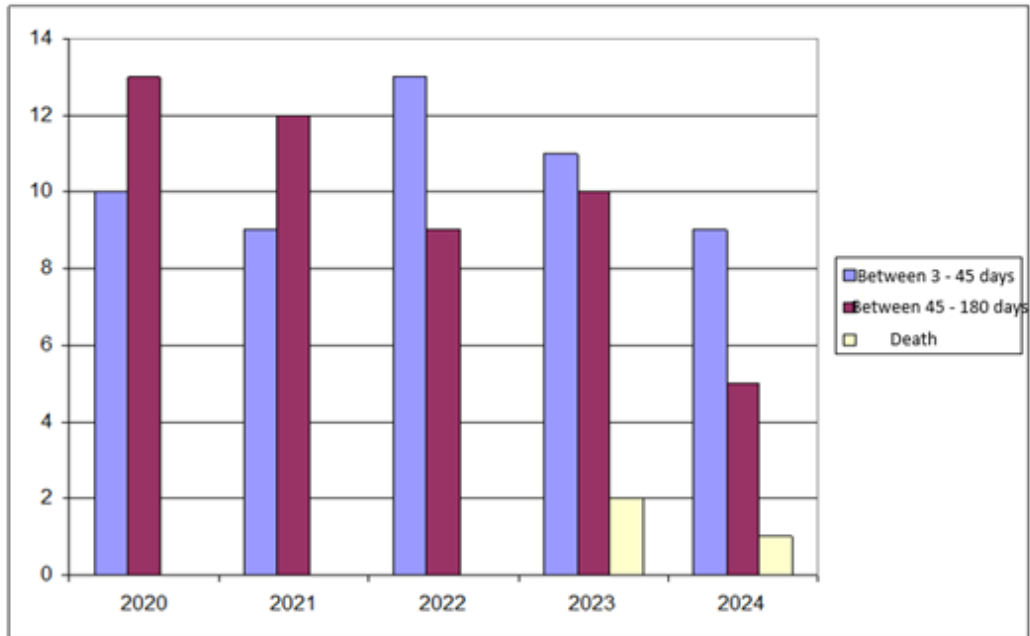


Fig. 9. Severity of consequences in the period 2020-2024 at E.M. Livezeni

Regarding the "**severity of consequences**", most accidents fall into accidents with "small" consequences between 3-45 ITM days, the highest value being in 2022 with a number of 13 accidents, followed by "medium" consequences between 45-180 ITM days, with a maximum value of 13 accidents in 2020, with an increasing-decreasing evolution until 2024 when 5 accidents in this category are recorded. (fig. 9).

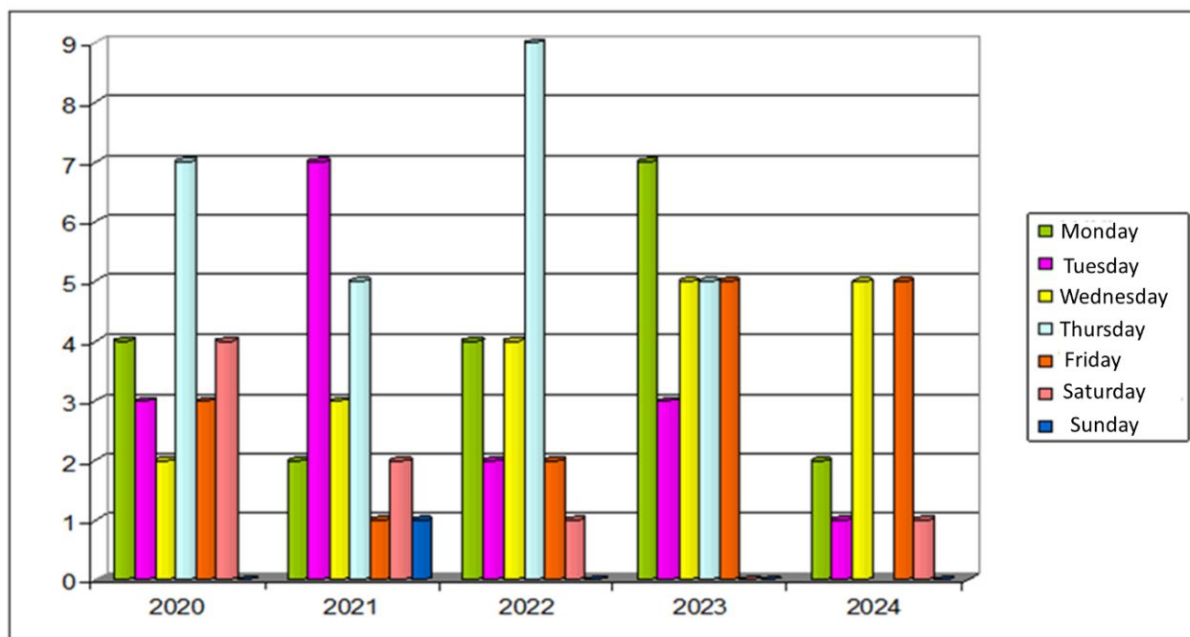


Fig. 10. Accident records by the day of the week during the analysed period

After analysing this indicator (fig. 10), we observe that the **day** on which most accidents occur is Thursday, with a maximum number of 9 accidents in 2022, followed in 2021 by Tuesday with 7 accidents and Monday also with 7 accidents in 2023.

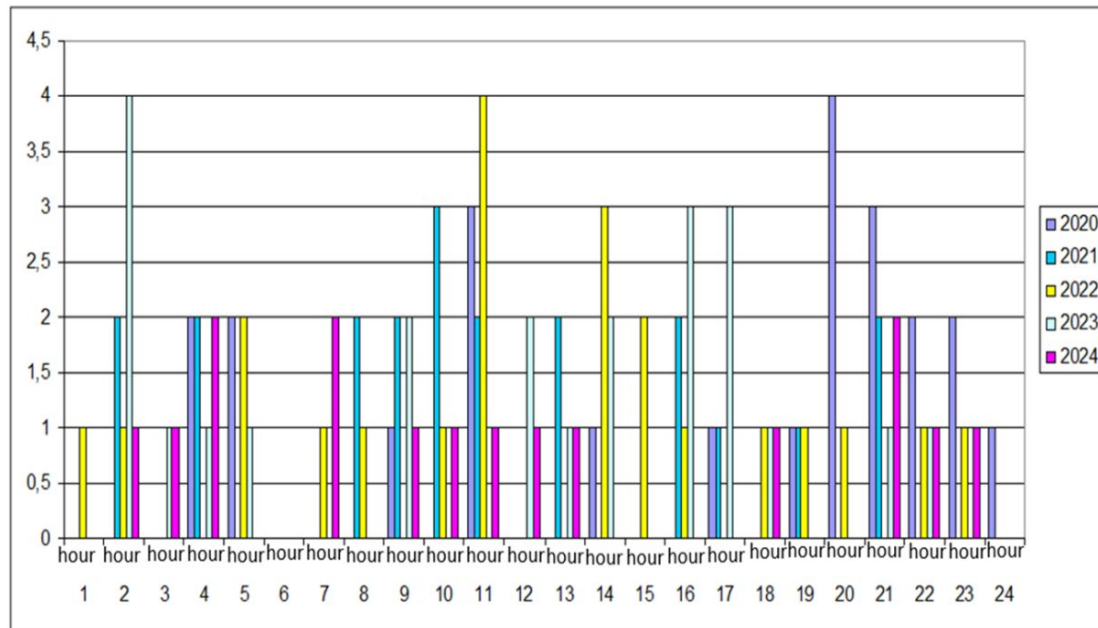


Fig. 11. Hourly accident records during the analysed period

The **time at which most accidents occurred** is 8 p.m. in 2022 (4 accidents), followed by 11 a.m. in 2022 (4 accidents) and then 2 a.m. in 2023. (fig. 11).

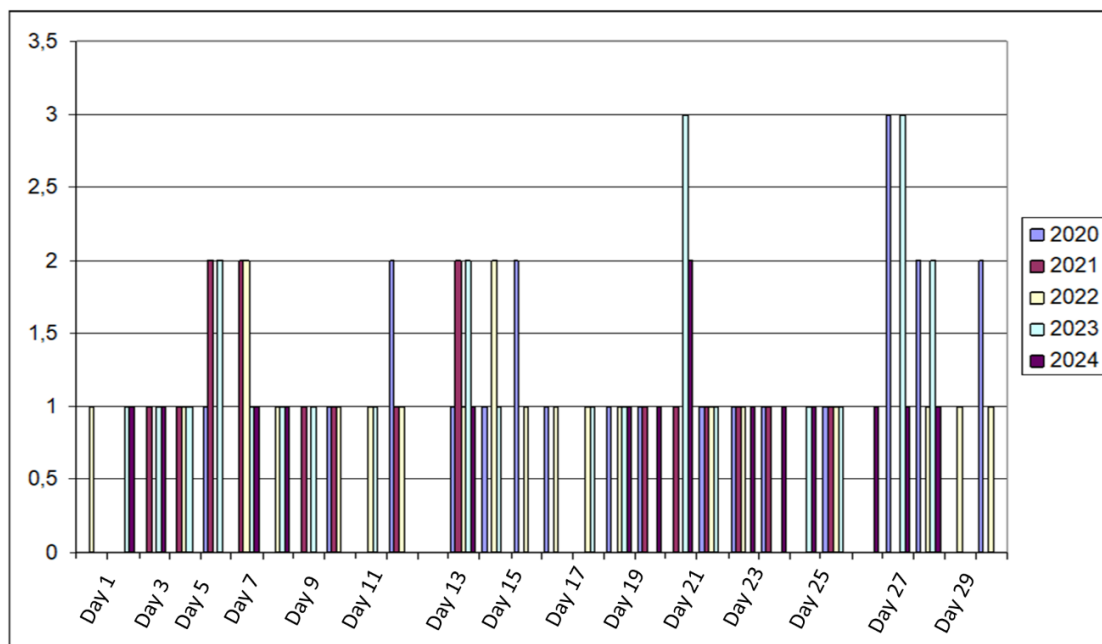


Fig. 12. Accident records by day of the month during 2020-2024 at E.M. Livezeni

When analysing the **day of the month** when most accidents occurred, we can see that the last part of the month is more prone to accidents than the first part of the month. Therefore, we have the maximum of 3 accidents on the 27th of the month in 2020 and 2023, followed by the 20th of the month when a maximum number of 3 accidents is recorded (fig. 12). In the first part of the month, days 1-4, we have a low accident rate, then an increase in the period 5-7, then we have a constant until the 12th, where they decrease to 0, then from day 13 we have a constant increase until day 20.

Analysis of frequency, severity and average duration coefficients

When analysing the coefficients of frequency, severity and average duration (according to table 2) for the period 2020-2024, we observe that the highest value of these coefficients is in 2023. The frequency index has a value of 30.69, because the number of accidents in the reporting period has a maximum value of 25 accidents.

Table 2. Summary of the 3 relevant indices for the period 2020-2024

Year	Frequency index	Severity index	Average duration index
2020	23.34	1094.13	53.90
2021	21.46	1400.22	59.56
2022	24.54	1251.76	48.78
2023	30.69	1729.71	64.04
2024	20.02	775.61	36.31

After analysing the severity index, we note that the maximum value is 1729.71, this fact being due to the large number of accidents. This number of 25 accidents also entails a large number of LTI (Lost Time Injury) calendar days. The average duration index shows us the highest value also in 2023 when we talk about the 25 accidents following which the number of LTI calendar days is the highest (in relation to other years), but this index has such a high value also due to the fact that out of 25 accidents, only 22 ended LTI during the reporting period, which shows us that the remaining 3 had more dangerous causes on the body (fig. 13).

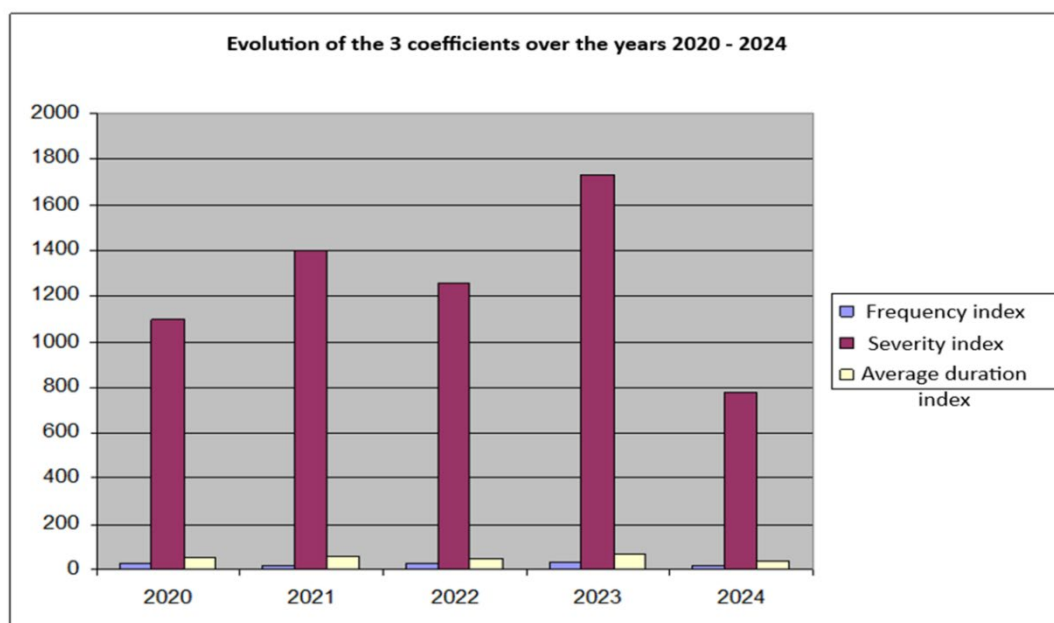


Fig. 13. Graph with the evolution of the 3 indices of work accidents at EM. Livezeni in the reference period

5. Conclusions and suggestions

Conclusions

To prevent accidents, it is essential to learn from accidents and previous events. Most accidents happen spontaneously, such as when a child changes his behaviour after falling off his bicycle. In other cases, learning from accidents needs to be institutionalized to cover various social barriers and disseminate information so that new perspectives in accident prevention are applied as widely as possible. Both governmental and private organizations have been created to ensure that appropriate conclusions are drawn from accidents. In-depth analysis of accident data is used to make strategic decisions in the field of occupational safety. In the event of an accident, the employer is obliged, among other things, to:

- implement measures to eliminate or reduce the hazard;
- provide first aid to the victim;
- determine the causes and circumstances of the accident (appointment of an accident commission);
- prevent similar work accidents in the future;
- prepare and archive accident documentation (accident process or accident card, statistical card);
- keep an accident register in which work accidents are recorded.

The use of statistics for work accidents allows the assessment of the safety status in the enterprise. Statistics allow us to formulate various factors that can be used in the assessment of the accident rate of workplaces with a special risk of accident, the performance of various comparative analyses in the area of accident investigation and corrective actions against hazard reduction.

From the analyses made above, we observed that the workers most exposed to accidents are those who have the function of "miner". This is understandable by the fact that they have the hardest working conditions, the working environment being a permanent danger. The main cause of these accidents suffered by miners is the fall of rocks from the front, thus justifying the fact that most of the effects are on the lower limbs with a diagnosis of bone fractures. The most frequently injured workers are miners with a seniority of one year and a seniority in the occupation between 10-20 years, with ages between 40 and 50 years. This is due to the fact that novice miners do not know exactly the dangers they face and perform inappropriate operations until they gain experience. On the other hand, we note that most injured miners have been in the occupation for 10-20 years, which shows us that physical and mental fatigue occurs in mining activity earlier than in other fields. Regarding age, between 40-50 years old the "midlife crisis" occurs in which actions in life usually have a dramatic impact not only on the person in question, but also on those close to them, often resulting in the breakup of the family, the destruction of the professional situation and the profound psychological impact of the person going through the crisis and those around them. Physical aging appears and then the mental one in which it is increasingly difficult to be active in a field like mining.

Therefore, it also emerges from this that most accidents are caused by the performer and that most have minor consequences between 3-45 days LTI, which means that there are many accidents but not with a maximum level of severity. The highest period of occurrence of work accidents is at the end of the week during night shifts. The fact that the level of work is high and the daytime rest is not sufficient, the latter produces the risk of greater errors than if the work were performed during the day.

Proposals

Based on the analyses made, proposals can be made to reduce the risk of accidents, such as:

- adapting work equipment to working conditions and purchasing quality equipment even if this requires changing suppliers;
- sending equipment that deteriorates before the deadline to the supplier;
- permanent coordination for a period of at least one year, by an experienced worker, of workers with less than one year of experience;
- taking more frequent breaks for workers with 10-20 years of experience in the occupation;
- focusing attention on psychosocial risks;
- theoretical and practical training carried out at shorter intervals or modifying the training technique;
- reducing the pressure on workers by hierarchical superiors;
- appropriate division into shifts and their rotation so that they have the necessary time for rest.
- prohibition of continuous shifts for more than 3-4 days;
- appropriate technology;
- acquisition of means of production that make the work of workers easier and safer.

"Aggressive" objectives can be set in terms of OSH training and the complexity of worker training can also be increased by introducing elements of risk assessment and Job Safety Analysis. Employees will be trained to identify and reduce occupational risks. Every six months, the indicators will be reviewed, their effectiveness will be evaluated and what needs to be done next will be determined, because this process must be one in constant motion, in continuous improvement.

The information presented in this work can be used not only to convince any executive manager of the importance of leading indicators and their predictive power, but also to demonstrate through examples how certain leading indicators can produce positive results. I emphasize once again that obtaining cooperation from top management to accept leading indicators is essential for their implementation, for minimizing risk and reducing incidents and accidents at work.

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