

## ANALYSIS OF WORK-RELATED INJURIES IN MINING INDUSTRY IN SERBIA

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**Abstract:** The mining industry in Serbia has an important place in the country's economic development. Bearing in mind that the number of injuries that occur in the mining industry is unacceptably high, occupational safety and health is a challenge that existing and future mines will have to deal with. Studying injuries in mining, it was noticed that injuries requiring an absence from work for more than three days (especially fatal ones) are diametrically different in relation to the cause and manner of events related to injuries for which an absence from work is not necessary. In this research, authors focused on injuries that were characterized as ones requiring an absence from work. The statistical analysis of work-related injuries in mining is presented, as well as analysis of the direct causes of injuries, which are described as unsafe conduct of employees, unsafe conduct of company's management and/or unsafe working environment. In relation to classification of causes of injuries, a recommendation on what needs to be changed in order to remedy this situation in Serbia is given.

**Keywords:** mining industry, safety, work-related injuries, absence from work due to injury

### 1. INTRODUCTION

The mining sector is industry with numerous occasions of the work-related (occupational) injuries. Many studies testify that this industry belongs into the group of the most dangerous ones with respect to the number of fatalities and grave injuries. CDC (1988) states that, related to the total number of workers, the largest number of fatalities occurs in mining.

Mining is distinguished from other branches of industry by the specifics of the working conditions. According to the operating conditions, two groups can be distinguished, the surface mines and mines with underground exploitation. The fact is that there is a number of injuries during underground exploitation, which is explained by the specif-

ics of the working conditions. On the other hand, large-scale mechanization is used in surface exploitation where a large number of injuries occurs, as well.

As main causes of injuries are listed the harsh working conditions, interaction with the present mechanization, but also the unsafe conduct of workers. What should be singled out is failure of the management to comply with the procedures.

Injuries that occur in both branches of mining were the subject of study of many researchers. For the data processing, the most frequently are used the statistical methods, which were analyzing the tendency and frequency of injuries for certain categories of workers. The frequency of injuries was analyzed for various categories of workers based on individual parameters. Leigh et al. (1990), Margolis (2010) and Liley et al. (2018) were analyzing influence of workers age, while Sanmiquet et al. (2010) and Margolis (2010) were considering the work experience. Kumar et al. (2010) and Stojadinovic et al. (2012) were studying the workers' qualifications, while Maiti and Bhattacharjee (2001) analyzed influence of the working place and Tong et al. (2018) were focused on the unsafe conduct. Combinations of the single parameters were also studied, as well as many other factors. Technology of the coal mining is also the influential parameter for causing injuries, Sari et al (2004). Financial investments into the occupational safety are also significant parameter in studying the causes and frequency of injuries. Asfaw et al. (2015) concluded that the less profitable mines have larger number of injuries. Researchers also noticed that the most significant cause for occurring of injuries is the unsafe conduct of workers. Awareness of workers about their own safe conduct, increased caution of workers, positive working atmosphere could all increase the quality and culture of safety, Suchman (1970). On the other hand, Zhao and Nie (2011), Zheng et al. (2016) and Yin et al. (2017) point out that the human factor and the unsafe conduct are the most frequent causes of the collective injuries and great accidents in Chinese mines.

Injuries that happened in mining industry in Serbia are analyzed in this paper, with the aim to define the most frequent direct cause for their occurrence. The statistical analysis was performed by application of the Statistical Package for the Social Sciences (SPSS) program package. The SPSS (now officially IBM SPSS Statistics®) is the statistical software package into which almost all the conventional statistical methods are implemented.

## **2. DATA ACQUISITION AND METHODS**

The law on safety and health at work (2017) in Serbia defines occupational injuries as Light, Medium and Fatal. If those definitions are compared to definitions by The MINER Act (2006), the Light injury would correspond to No Lost Days injury, the Medium injury to Non-Fatal with Lost Days injury and the Fatal injury is the same.

In this paper are analyzed only the medium and fatal injuries, which occurred in mining industry in Serbia. The data are obtained from Ministry of Energetics and Mining of Republic of Serbia, for the period from 01.01.2016. to 31.12.2016. During that period 108 injuries occurred, out of that 2 were fatalities.

Seven variables were used for analyzing and defining the most frequent causes of injuries: location of the injured person, type of mine, worker's age, qualification, working place, working experience and injured body part.

The statistical analysis and forensic experts' opinions were used for relating the cause of injury and mentioned variables.

### 3. RESULTS AND DISCUSSION

Analysis of medium injuries and fatalities in the mining industry in Serbia, which occurred in 2016, shows that the highest number of injuries occurred in underground mines (59.30 %), in the coal mines (76.90 %), for workers aged 35 to 40 (21.30 %), with qualification of high school or qualified worker, directly engaged in production (60.20 %) and with working experience of 1 to 5 years (36.10 %). The majority of injuries were injuries of the upper extremities (37.00 %).

In this research, location of injuries was defined in the following way: the underground space, surface part of the mine, offices and geological surveys. The largest number of injuries occurred in the underground space 59.30 %, while at the surface occurred 38.00 % of injuries, in offices 0.90 % and during the geological surveys 1.90 %. These results are presented in Figure 1.

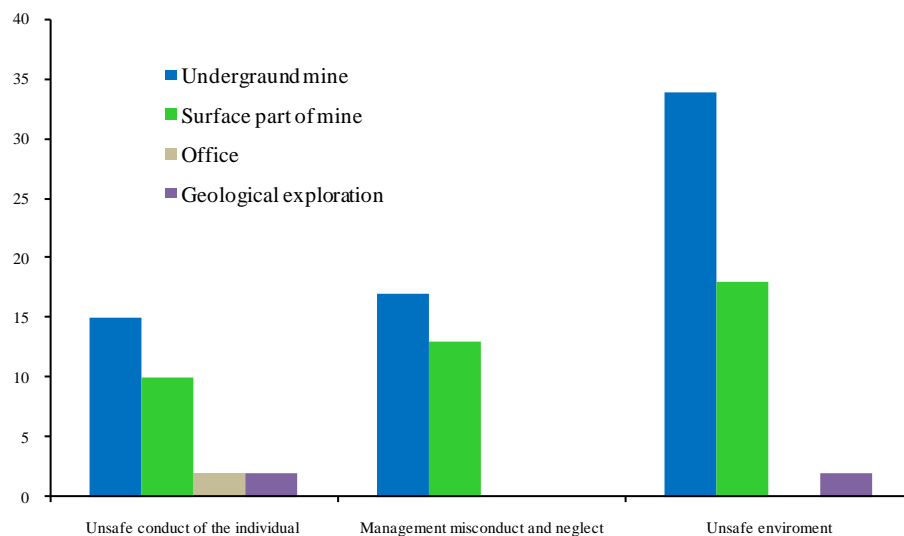


Fig. 1. Location of injuries occurrence in the mining industry in Serbia in 2016

From Figure 1 can be seen that the Unsafe Environment (UE) is the leading factor in injuries occurrence in the underground mines (50 %), Unsafe Conduct of Individual (UIC) has share of 23.4 % and Management Misconduct and Neglect (MMN) participates with 26.6 %.

At the surface of the mine the number of injuries due to the unsafe environment is smaller – 43.9 %, due to MMN is 31.7 % and due to UCI is 24.4 %.

There are three types of mines in Serbia: coal mines, metal ore mines and quarries. In Figure 2 are presented causes of injuries related to the type of mines.

From Figure 2 can be observed that the largest number of injuries happened in the coal mines. The leading cause of injuries was the unsafe environment 50.60 %. In the metal ore mines this share is lower, 40.90 %. In the quarries the UE is not the major cause of injuries (0.0 %). There the main cause is the human factor, i.e. the UIC with 66.7 %, followed by MMN with 33.3 %.

Worker's age is the category that has been studied the most by numerous researchers. In Figure 3 is presented the cause of injuries in relation to the workers' age.

It is a common opinion that the young workers are more prone to injuries than the older ones. However, from Figure 3 can be seen that the highest number of injuries is

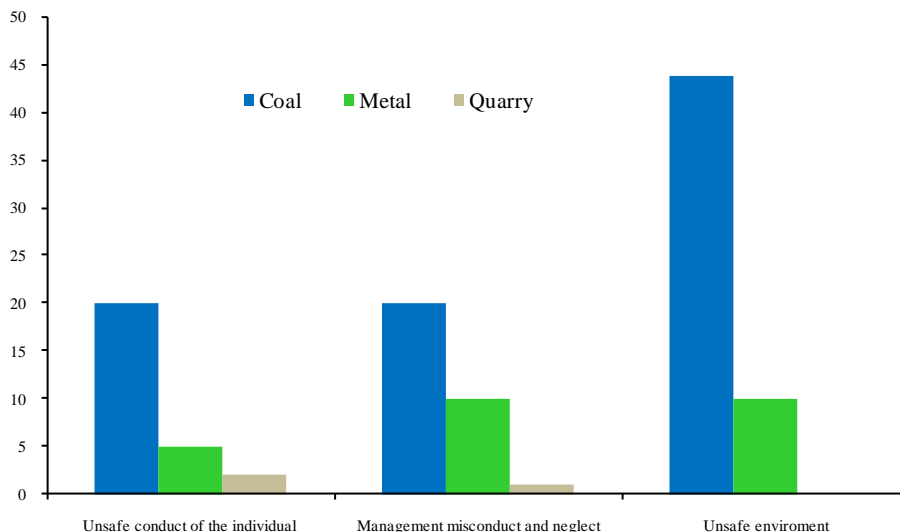


Fig. 2. Causes of injuries in mining industry in Serbia related to the type of mines

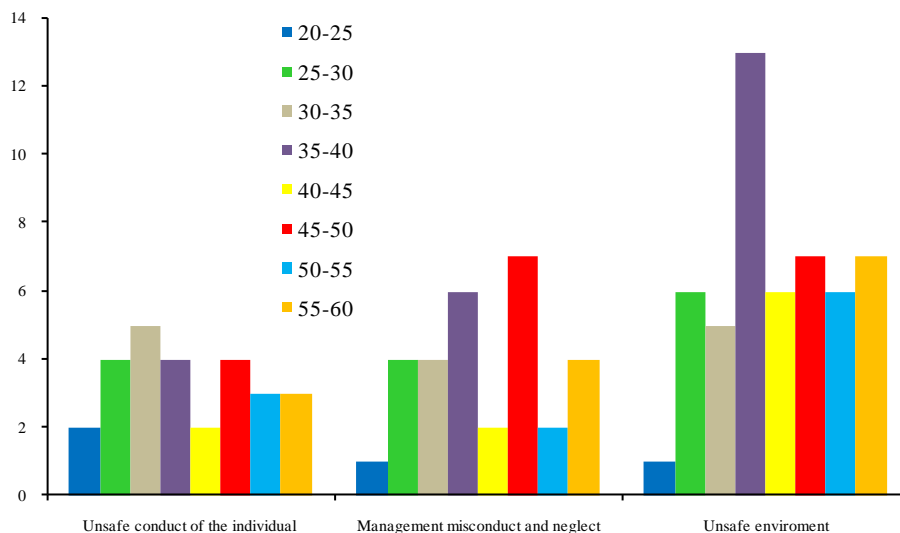


Fig. 3. Causes of injuries in mining industry in Serbia related to the workers' age

for the middle-age workers, age group 35 to 40 years. In the mining industry, workers of this age group are the most productive and practically the carriers of production. The required speed of work implies that they are often exposed to risk but also to stress, so it often happens that they are not able to react in a timely manner and assess the danger. The older workers, as well as the younger ones, are assigned to the less risky working places. The most frequent cause of injuries of workers in the age group 35 to 40 years was the unsafe environment, UE, with 56.5 %. In category of the younger workers, age group 20 to 25 years, the main cause of injuries was UCI 50.0 %. For the oldest workers, age group 50+ years, the main cause was also UE with 50.0%.

In Serbia the level of qualifications is defined in the following way: VSS (Faculty diploma) corresponds to college degree (total of 16 years of education – elementary school of 8 years, high school of 4 and college of 4); SSS (High School) corresponds to high school education (total of 12 years of education), while VKV (Highly qualified

worker), KV (Qualified worker) and PKV (Semi-qualified worker) are the companies' internal qualifications awarded after the training programs within the company and NK (Non-qualified worker) means a worker without education, or with education of less than 8 years (no elementary school finished). In Figure 4 is shown the cause of injuries related to workers qualifications.

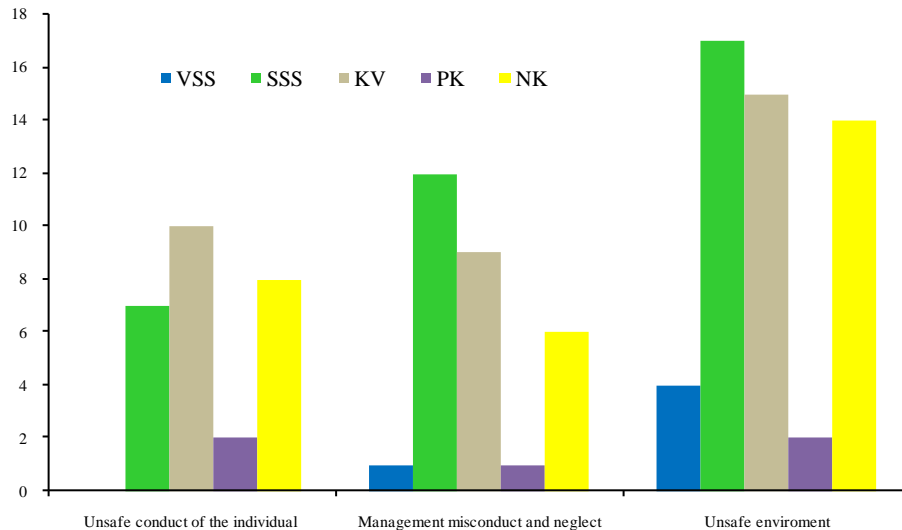


Fig. 4. Causes of injuries in mining industry in Serbia related to the workers' qualifications

As can be seen from Figure 4, the highest number of injuries occurred in qualification groups SSS (High School) and KV (qualified) workers, though one would expect that the numbers would be higher for the non-qualified workers (NK). In all the categories, the major cause of injuries was the unsafe environment (UE).

The nature of the work the worker deals with also affects the frequency of injuries, so it is assumed that the greatest number of injuries occur in production, because those workers are the most exposed to dangers, which is confirmed by Figure 5 that shows the causes of injuries in the Serbian mining industry in relation to the workplace type.

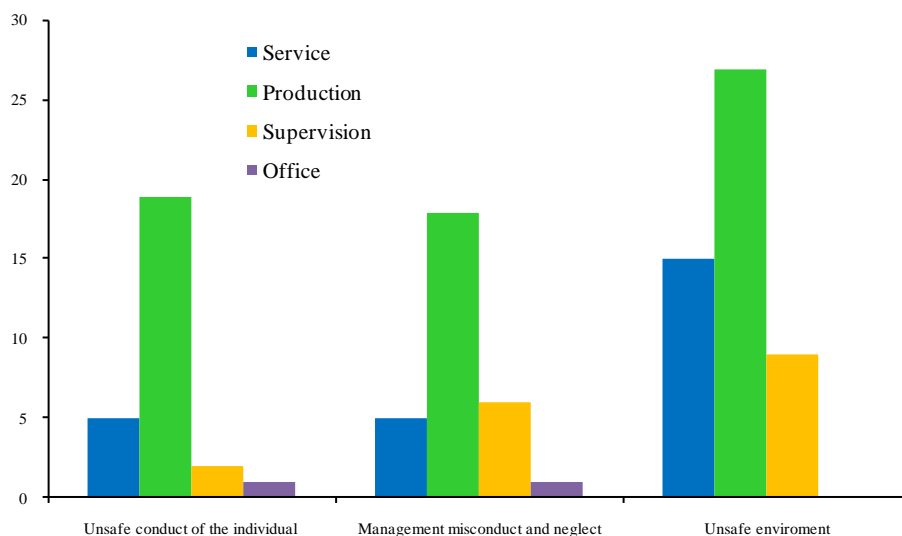


Fig. 5. Causes of injuries in mining industry in Serbia related to the workplace type

Results shown in Figure 5 are quite the expected ones. The highest percent of injuries occurs in production and in machine maintenance.

The work experience is a significant indicator related to occupational injuries. The less experienced workers are more frequently prone to injuries. In Figure 6 is presented the cause of injuries related to the workers' experience.

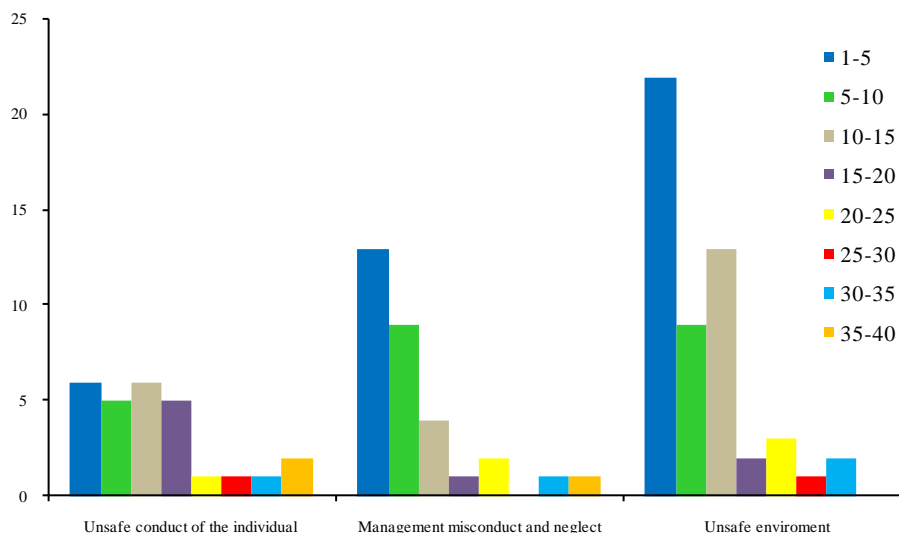


Fig. 6. Causes of injuries in mining industry in Serbia related to the working experience

From Figure 6 can be seen that for the considered period the highest number of injured workers had the working experience of 1 to 5 years – 36.10 %, share of the group with 5 to 10 years was 21.30 %, share of the group with 10 to 15 years was 21.30 %. Thus, it can be concluded that more than 70 % of injuries occurred to workers with experience of up to 15 years.

Injuries of extremities are present in all the types of industries. In Figure 7 are presented occupational injuries related to injured body parts.

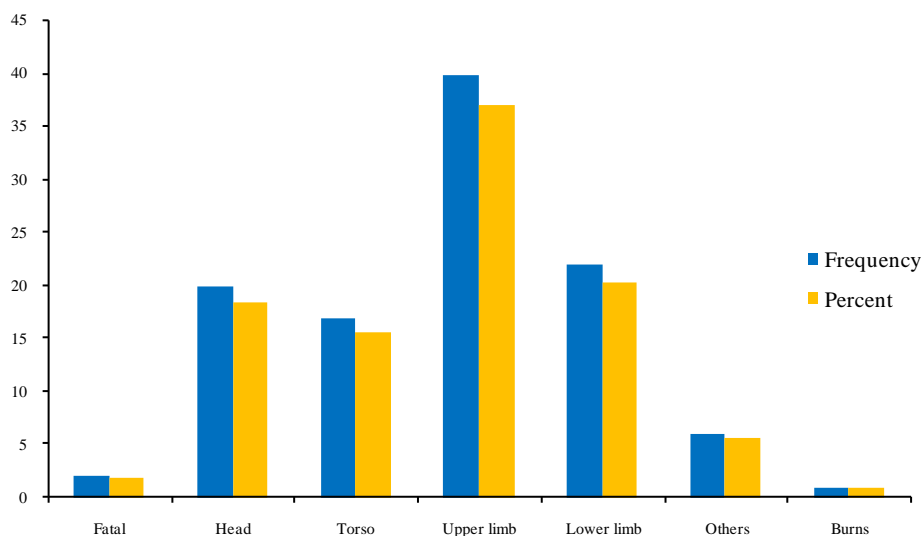


Fig. 7. Causes of injuries in mining industry in Serbia related to the injured body parts

From Figure 7 can be concluded that the most frequent are injuries of the upper extremities, while the burns are pretty rare.

#### 4. CONCLUSIONS

Injuries in the mining industry in Serbia that occurred in 2016 were analyzed in this paper in order to define their most frequent cause. Analysis has shown that more than a half of grave injuries and fatalities occur in the underground exploitation (59.8 %). It is also shown that variables, like worker's age, qualification, working experience, type and location of the working place, are related to direct causes of accidents (unsafe conduct of workers, unsafe conduct of management and the unsafe working environment). The statistical analysis was conducted with application of the SPSS programming package.

The performed analysis also points to conclusion that workers in Serbia have problems in obeying the safety and health measures at the working place, what is especially prominent in controlling the working environment conditions. The unsafe environment has being pinpointed as the leading cause of injuries. This can also be explained, to a certain extent, by the outdated equipment and exploitation technology, which is present especially in the underground mining of coal and mineral raw materials. Improving the working conditions requires investments in the new equipment and modernizing the technology of the coal exploitation. This kind of investments would definitely contribute to decreasing the number of injuries.

Analysis of the worker's age shows that injuries the most frequently occur within the middle-aged workers, age group of 35 to 40 years. This is the point that should be further investigated, since these workers have sufficient working experience.

The relationships between the considered variables and causes of injuries are complex and they require deeper analysis both of these variables and of their mutual relations.

#### ACKNOWLEDGEMENTS

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