A study of the correlation between seniority and the number of work accidents in mining enterprises between 2003-2017

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Abstract. A work accident comprises a number of interrelated adverse technical, organizational, environmental, and human events. However, it has been claimed that the main contributing factor responsible for work accidents is a human error (disruption). The causes of human errors may include: incapacity, nature of tasks being performed as well as physical and social environment. It is important to note that the first element is strongly related to both age and seniority. Based on available literature, the impact of seniority on work accidents is not clearly defined. Advanced age of employees favors the acquisition and consolidation of professional knowledge, but it can also be associated with greater automation of behaviours in work environment. This can lead to an error resulting in a dangerous situation or accident. Bearing in mind the above, this study examined the relationship between seniority and the number of work accidents among individuals employed in mining enterprises. The study was carried out using the Pearson's correlation coefficient. The source of analysis included statistical data on the size of employment in individual seniority groups and the number of work accidents in mining enterprises between 2003-2017. The research showed a correlation between age and the number of work accidents in hard coal mines.

1. Introduction

A work accident can be defined as a sudden work-related event caused by an external factor that leads to an injury or death of an employee. However, in the theory of causality of work accidents and related preventive occupational safety and health (OSH), this definition has changed - from accidents regarded as "accidental events or the effect of unpredictable force majeure" to "an accident model as a consequence of errors made due to the deficit of motivation, knowledge and experience of employees"[1]. This change prompts research on the prevention of accidents not only in the technical sphere, but also in areas like management and motivation, proper training, information flow, evaluation or analysis of the psychophysical features of employees and their adjustment to a workplace [2,3]. This is particularly necessary in a situation where, according to long-term statistical data provided by GUS, around 60% of work accidents in Poland are caused by the so-called human factor.

Progressive changes in the demographic structure of developed countries observed for many years have caused increasing disproportions in the workforce age distribution. Every year, the number of older employees is reported to be increasing as opposed to the number of younger employees, which is decreasing. This affects the sphere of OSH. A work accident comprises a number of interrelated adverse technical, organizational, environmental, and human events. However, it has been claimed that the main contributing factor responsible for work accidents is a human error (disruption). The causes of human

errors may include: incapacity, nature of tasks being performed as well as physical and social environment. It is important to note that the first element is strongly related to both age and seniority.

Extensive work experience is associated with higher effectiveness. Longer seniority favors the acquisition and consolidation of professional knowledge, but it can also be associated with greater automation of behaviors in work environment. This can lead to an error resulting in a dangerous situation or accident. Bearing in mind the above, this study examined the relationship between seniority and the number of work accidents. The source of analysis included statistical data on the size of employment and the number of work accidents in mining enterprises.

2. Seniority and accident rates

Based on available literature, the impact of seniority on work accidents has not been explicitly defined. On one hand, many studies show that greater work experience leads to a smaller number of work accidents due to better knowledge of procedures, regulations, occupational safety policy, and skills to cope with emergency situations [4,5,6,7,8]. On the other hand, other studies indicate that the longer seniority, the lower physical fitness, work efficiency, and, above all, the perception of threats. This may result in higher work accident rates at higher seniority levels and more serious consequences[9,10]. Also, employees with shorter seniority often lack life and professional experience, which makes them more exposed to work accidents and less aware of the consequences of dangerous behaviors[11]. It is important to note, however, that the same employees do not fall into a work routine, and can perceive risks more effectively.

With regard to the foregoing, the relationship between seniority and work accidents is a very complex issue, which prompted the author of this study to conduct research in this area based on mining enterprises.

3. The number of work accidents versus seniority among individuals employed in mining enterprises – presentation and research analysis.

The statistical data from 2003-2017 were used to analyze the relationship between changes in the number of employees in given seniority groups and the number of work accidents in mining enterprises [12,13].

The study was carried out using the Pearson's correlation coefficient. This coefficient is used to study the linear relations of studied variables, in which an increase in the value of one characteristic causes proportional changes in the mean values of the other characteristic (increase or decrease). Poor or lack of relationship occurs at values below 0.2.

Correlation (interdependence of features) defines interrelations between selected variables. Here, values are accepted when in the range between -1 and 1. Positive correlation (correlation coefficient from 0 to 1) informs that an increase in the value of one characteristic is accompanied by an increase in the mean values of the other characteristic. Negative correlation (correlation coefficient from -1 to 0) informs that an increase in the value of one characteristic is accompanied by a decrease in the mean values of the other characteristic. If a given correlation coefficient is negative, it may be claimed that when the values of one variable increase, the values of the other variable decrease, and the other way round.
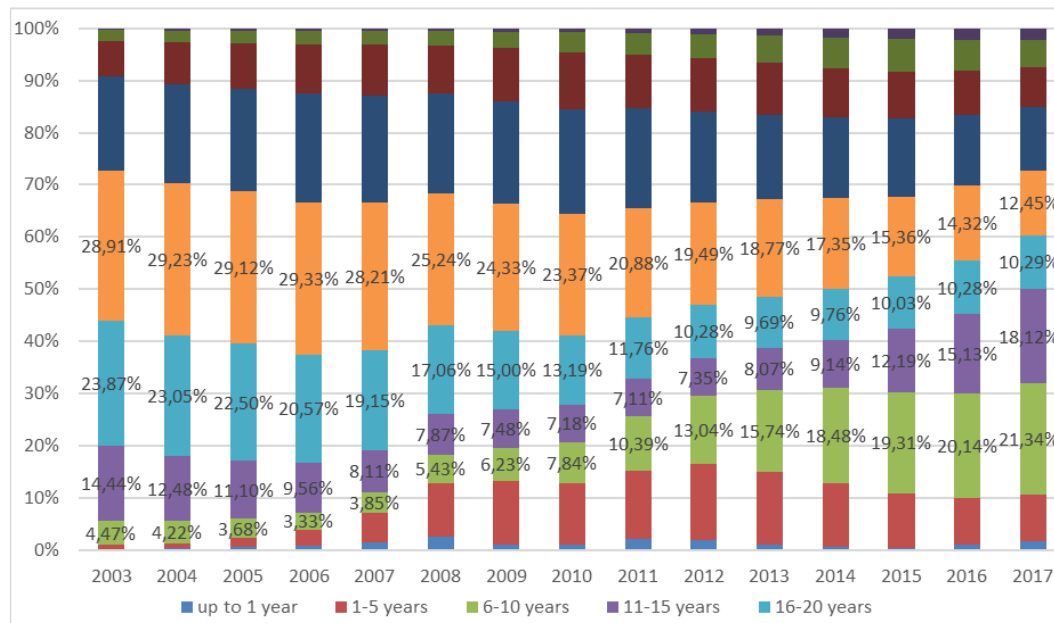
Figure 1. Shares of individual seniority groups in mining enterprises reported between 2003-2017.

Based on the analysis of the seniority structure in mining enterprises between 2003-2017 (figure 1), the seniority group dominating for many years was the one between 16-25 years of service. When considering the time at which workers employed underground currently reach the retirement age (after 25 years of work), it can be concluded that the dominant seniority group includes employees approaching their retirement age. As the research shows, employees in the lowest seniority groups constitute a very small group that failed to satisfy the competency needs of their companies when the natural wastage, such as retirement, occurred. However, in recent years, positive changes in the seniority structure can be noticed, including an equal share of groups of employees with different seniority in the total structure. This is a very positive trend that should be constantly studied and supported by a balanced employment policy in mining enterprises.
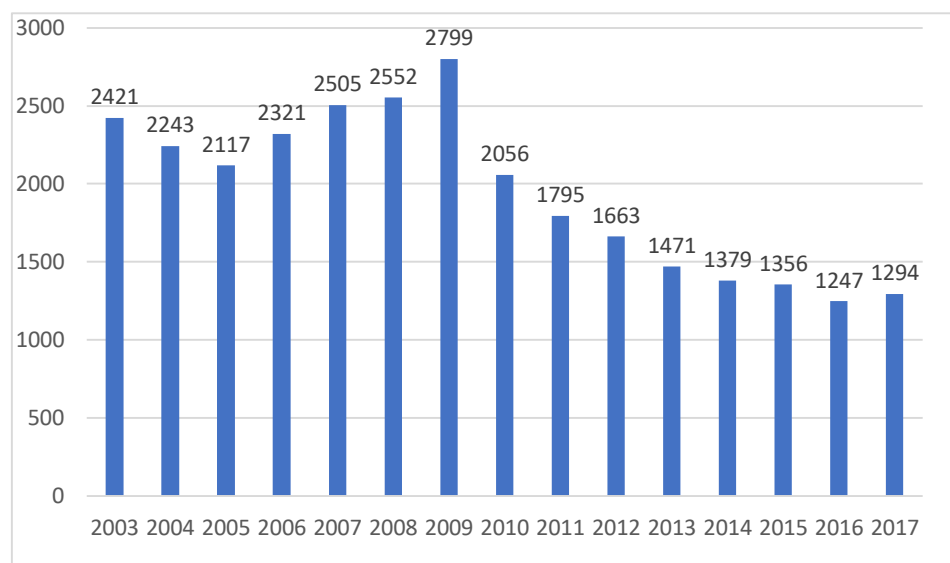

Figure 2. Total number of work accidents in hard coal mines between 2003-2017 [12].

As shown in figure 2, when analyzing the number of work accidents in mining enterprises reported between 2003-2017, it is difficult to clearly determine a dominant trend. Only in 2009 could a downward trend be observed, which turned into an upward trend again in 2017. It is worth noting that in 2009, an increase in the total number of work accidents in mining enterprises was found, which coincides with a very large staff turnover in the previous year. According to the statistical data on mining industry, in 2008, almost 14,000 employees were dismissed, and more than 17,200 people were employed [13].

Table 1. The number of employees of mining enterprises in different age groups and the calculated correlation coefficient for given seniority groups.

YEAR	Total number of accidents (end of december)	up to 1 year	1-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years	31-35 years	36-40 years	over 40 years
2003	2421	202	1267	6106	19699	32575	39450	24469	9449	2845	386
2004	2243	526	1125	5365	15856	29296	37151	24237	10061	2961	508
2005	2117	688	2130	4536	13704	27771	35935	24438	10611	3080	518
2006	2321	992	3647	3979	11409	24548	34997	24928	11205	3009	598
2007	2505	1623	6741	4486	9443	22292	32843	23858	11449	3029	642
2008	2552	3149	12187	6502	9420	20421	30215	22786	11133	3260	640
2009	2799	1330	14504	7405	8889	17837	28921	23456	11964	3818	751
2010	2056	1125	13583	8948	8194	15052	26660	22814	12468	4324	921
2011	1795	2357	15088	11870	8127	13438	23855	21934	11838	4696	1032
2012	1663	2248	16356	14773	8323	11639	22079	19810	11452	5271	1305
2013	1471	977	15024	16794	8614	10338	20030	17249	10578	5524	1565
2014	1379	685	12107	18605	9205	9829	17469	15554	9498	5857	1866
2015	1356	290	9528	17361	10960	9015	13808	13458	8097	5509	1898
2016	1247	860	7359	16624	12491	8485	11824	11250	6918	4847	1890
2017	1294	1417	7135	17209	14608	8293	10034	9714	6117	4361	1737
correlation coefficient		0,21	-0,23	-0,91	0,09	0,78	0,86	0,88	0,65	-0,81	-0,91

The analysis of the relationship between data presented in figures 1, 2 and in table 1 on the seniority of individuals employed in mining enterprises and the work accident rates indicates a strong negative and positive correlation for 7 groups. The calculated Pearson's correlation coefficient is between -0.91 and 0.88.

When studying the results presented in table 1 for the years 2003-2017, a strong negative correlation can be noted between the characteristics in the seniority groups with 6-10 and over 36 years of service. This means that an increase in one parameter (the number of employees in mining companies) is accompanied by a decrease in the value of the other parameter (the number of work accidents). By contrast, a strong positive correlation can be observed between changes in the number of employees in the seniority group with 16-35 years of service and the number of work accidents. This means that an increase in the number of employees in this group of seniority is accompanied by an increase in the number of work accidents in subsequent years.

For a more in-depth analysis, below are presented 3 figures that show the following seniority groups compared with the number of work accidents:
- 0-10 years of service,
- 16-35 years of service,
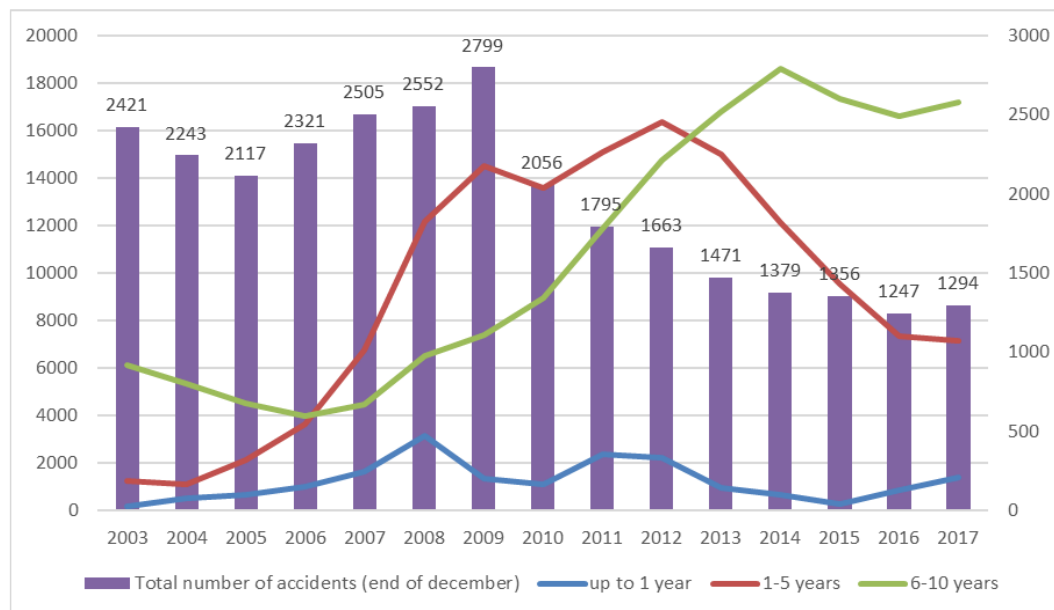- 36 and more years of service.

Figure 3. Total number of work accidents in hard coal mines versus changes in the number of employees in given seniority groups between 2003-2017.

As can be seen from the statistical data presented in figure 3, there is a clear discrepancy in the trends of both studied values. Nevertheless, it is worth emphasizing that the total number of work accidents between 2003-2017 in mining enterprises is observed to decline. Also, the calculated correlation coefficient in the 1-5-year seniority group shows a weak negative correlation. On the other hand, for the seniority group with 6-10 years of service, a strong negative correlation was reported, i.e. an increase in the number of employees with this work experience is accompanied by a decrease in the number of registered work accidents. This is not the case, for example, when it comes to the seniority group with up to 1 year of service. Here, the correlation is very weak.
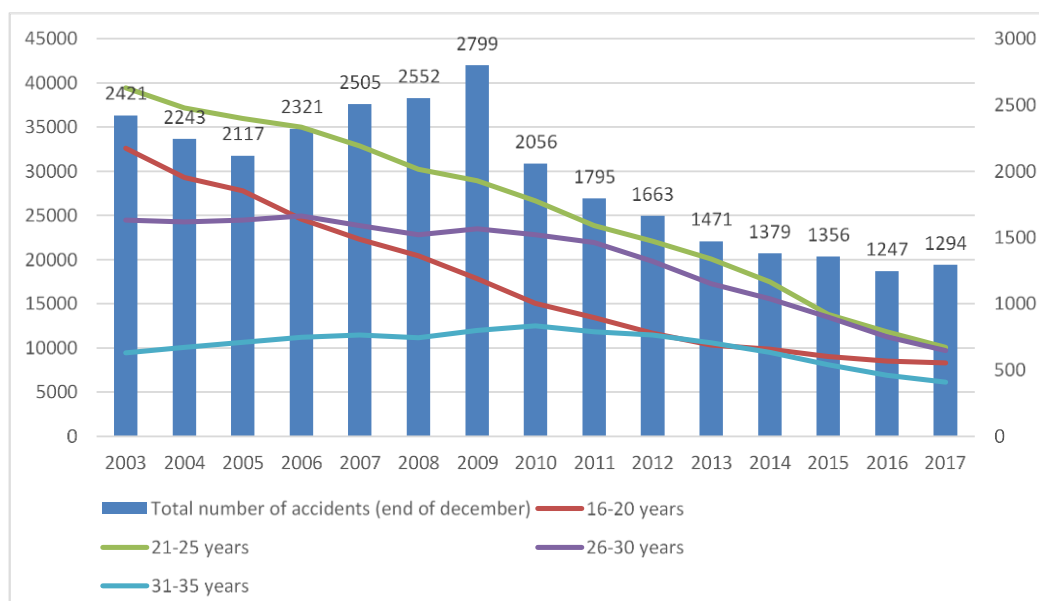

Figure 4. Total number of work accidents in hard coal mines versus changes in the number of employees in given seniority groups between 2003-2017.

Based on the results, the number of work accidents compared to the seniority group with 16-35 years of service (figure 4) shows the strongest positive correlation. A decline in the number of employees in the studied group is accompanied by a simultaneous decrease in the number of work accidents.
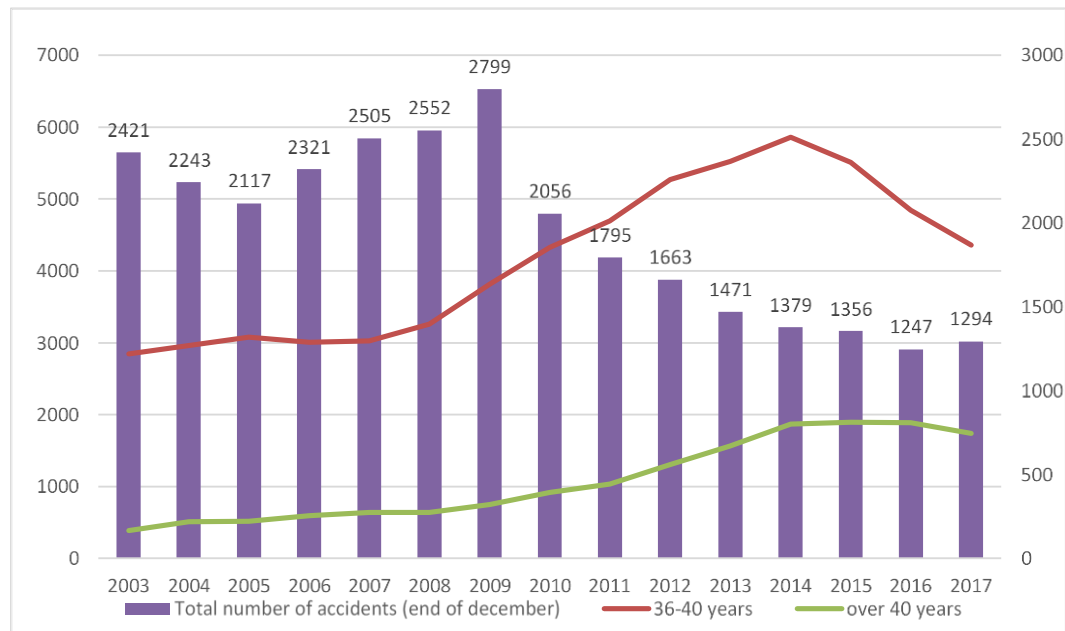

Figure 5. Total number of work accidents in hard coal mines versus changes in the number of employees in given seniority groups between 2003-2017.

Figure 5 that compares the number of work accidents to the seniority group with 36 and more years of service presents a strong negative correlation, which means that an increase in the number of employees with long work service in mining enterprises is accompanied by a decrease in the number of work accidents.

4. Conclusions

This study confirmed the existence of the relationship between seniority and work accidents, but at the same time indicated a large diversity of this relationship.

The results showed no correlations between the number of work accidents and the short (up to 5 years) seniority of employees in mining enterprises. Therefore, a theory that employees with short work service, and thus worse professional experience and knowledge of safe behaviors in work environment, are more likely to cause work accidents failed to be confirmed. Also, the research failed to find that the fluctuations in the number of employees in this seniority group could affect changes in the number of work accidents in mining enterprises. The situation is similar in the case of the seniority group with 11-15 years of service.

A strong negative correlation was observed in the group with 36 and more years of service. It comprised very experienced employees who oftentimes had already reached the retirement age but were still working to complement the shortages of staff and offer their employers high professional competences. With the increase in the number of employees in this seniority group, the number of work accidents was observed to decrease. Perhaps, employees with such long work service, complement their declining functional capacity with high professional experience and a cautious attitude to both risks and threats. Similarly, a strong negative correlation was observed between the number of employees with 6-10 years of employment in mining enterprises and the number of work accidents. The increase in employment in this group was accompanied by the decrease in the number of work accidents in the studied years (2003-2017). These were employees who were already well acquainted with the specificity

of work in hard coal mines, aware of threats, but still young and physically fit, which may have affected the lower accident rate in this group. What is more, the strongest positive correlation was demonstrated in the group with 16-30 years of service. The increase in the number of employees in this group of employees showed a strong correlation with the increase in the number of work accidents in mining enterprises. Therefore, professional experience that is said to grow with seniority, in the case of mine employees who have not yet reached the retirement age, failed to result in smaller accident rates in this group, but showed opposite effects. However, it does not seem to have been influenced by the lack of awareness of threats or the ability to cope with emergency situations. This result is probably due to the low culture of work safety in mining enterprises [14] and professional routine. It is worth noting that the number of work-related accidents reported in individual seniority groups could have also been impacted by the types of positions occupied by employees in various seniority groups. Employees with short seniority - inexperienced, were in positions often associated with a higher occupational risk compared to employees with longer work service. That is why, the results of this study should be taken into account when selecting employees for work positions, planning trainings and broadly understood accident prevention.

5. References

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