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CHARACTERISTICS OF HAZARDOUS EVENTS IN A POLISH CONSTRUCTION COMPANY USING TIME SERIES

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Abstract
The construction industry is highly dangerous worldwide. Despite preventive measures, accidents and hazardous events leading to injuries or fatalities still occur. Researchers emphasize the significance of studying occupational accidents and near misses, considering the latter as accident precursors. There are numerous studies supporting the thesis that a significant proportion of accidents in the construction industry could be prevented with improved safety management based on information derived from near-misses recorded in company archives.
The article includes the results of a study of occupational accidents and near misses recorded at a construction company implementing construction projects in Poland, from 2015 to 2022. Based on the data downloaded from the hazardous event registration system, the values of indicators illustrating the ratio of the number of near misses to the number of accidents at work were calculated. Considering the nature of construction work and circumstances of incidents, eight categories have been specified: Being hit by objects (k_1), Being run over by a vehicle/hit by a vehicle (k_2), Working environment (k_3), Fall of a person (k_4), Electricity (k_5), Fire/Explosion/Finding unexploded munition (k_6), Collapse/Being covered/Being trapped (k_7), Contact with moving machine parts (k_8). From the analyzed data, time series for hazardous events were established.

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Keywords: Near miss, Accident at work, Construction, Time series, Safety management

1. Introduction

The construction industry is characterized by high susceptibility to various forms of hazardous events. [1], [2]. Despite the increasing application of better collective and personal protective measures on construction sites, accidents at work remain an unresolved issue. Many researchers emphasize the significance of near misses as precursors to accidents at work. [3], [4], [5], [6]. Analysis and concluding near misses are necessary to reduce the number of accidents at work and improve safety in construction [6],[7]. Near misses are dangerous conditions, actions, or procedures, as well as adverse events or their sequences, that may precede and lead to accidents at work [3].

This article aims to analyze hazardous events in the Polish construction industry based on data collected from one of the Polish construction companies. The analysis aims to understand the qualitative and quantitative structure of these events and identify the direct causes of their occurrence. Additionally, the article aims to determine the characteristic features of individual groups of events. As part of the data analysis, the ratio of near misses to accidents was calculated, allowing for the assessment of the relative risk of hazardous events occurrence.

2. Materials and Methods

Empirical historical data concerning hazardous events recorded by one of the Polish construction companies between 2015 and 2022 were analyzed. The methodology of the conducted research was as follows:

- A database of hazardous events was created. These data were extracted from the hazardous event registration system implemented in the aforementioned company. The system recorded events that occurred at construction sites located in various parts of Poland. According to the definition, these events included adverse occurrences or sequences of events preceding an accident and those leading to accidents at work. The system registered 1680 near misses (*NW*) and 716 accidents at work (*AW*).

- The structure of hazardous events registered in the database was examined. The set of events was divided into a set of near misses (*SNM*) and a set of accidents (*SA*). In each of the above sets, events were categorized according to the direct cause of the event. Eight event categories were identified. The structure and designations of the sets of hazardous events are presented in Fig. 1.

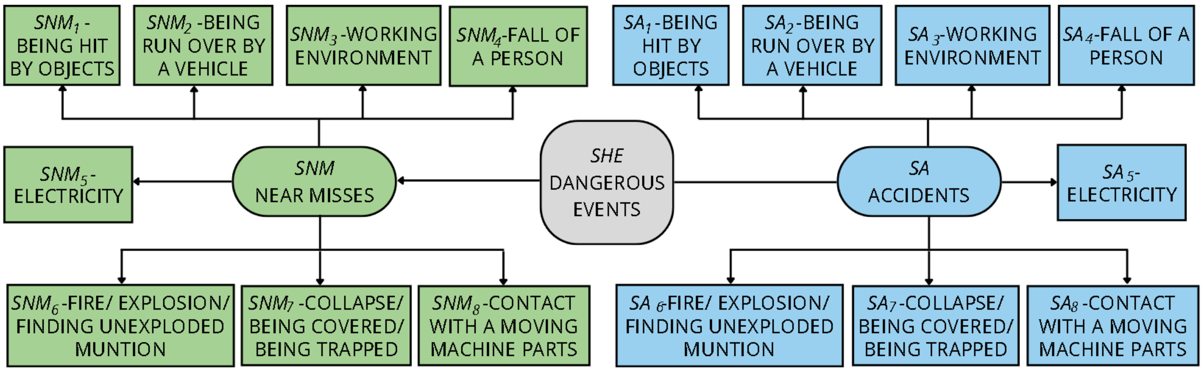

Fig. 1. Structure of categorization of near misses (*NM*) and accidents at work (*AW*).

- A time series of hazardous events was determined. To observe changes in accident rates in construction over the analyzed time period, time series were established illustrating the evolution of the number of near misses and accidents at work in successive periods covering individual months and subsequent analyzed years.

- The research results were summarized, and conclusions were formulated.

3. Results and Discussion

In Fig. 2, charts illustrating the percentage share of accidents at work and near misses in the analyzed database are presented. Table 1 shows the ratios of near misses to accidents at work.

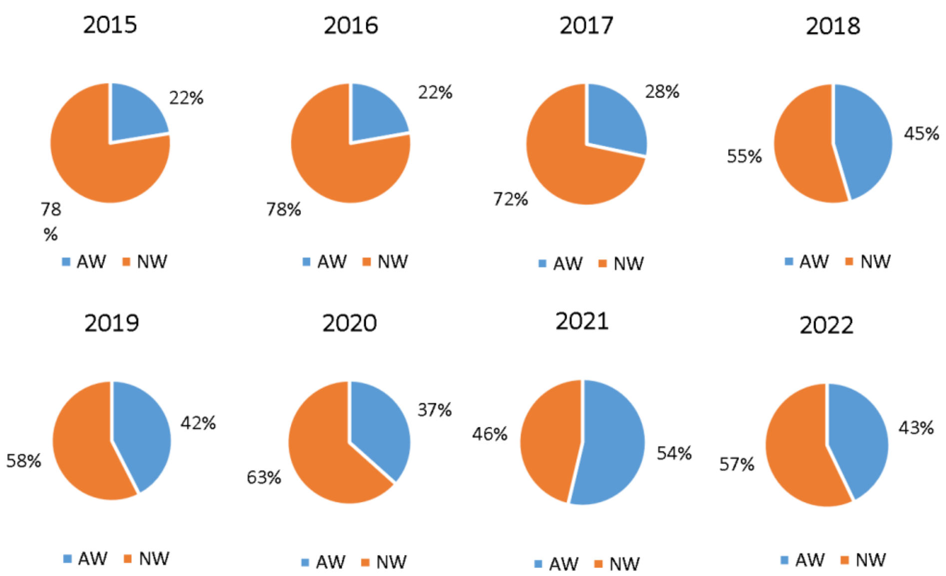

Fig. 2. The percentage distribution of near misses (*NM*) and accidents at work (*AW*)

Table 1. The ratio indicator of near misses to accidents at work

	2015	2016	2017	2018	2019	2020	2021	2022
Number of near misses (*NM*)	584	454	215	119	126	78	44	60
Number of accidents at work (*AW*)	169	130	85	99	93	45	51	44
Ration of the number of near misses (*NM*) to the number of accidents at work (*AW*)	3,46	3,49	2,53	1,20	1,35	1,73	0,86	1,36

In the first three years analyzed, the number of near misses is several times higher than the number of accidents at work. In the following years, a decrease in the number of reported near misses is observed. The smallest ratio of accidents to near misses was recorded in 2021.
Time series showing the evolution of the number of near misses and accidents at work in successive periods covering individual months and years are presented in Fig. 3.

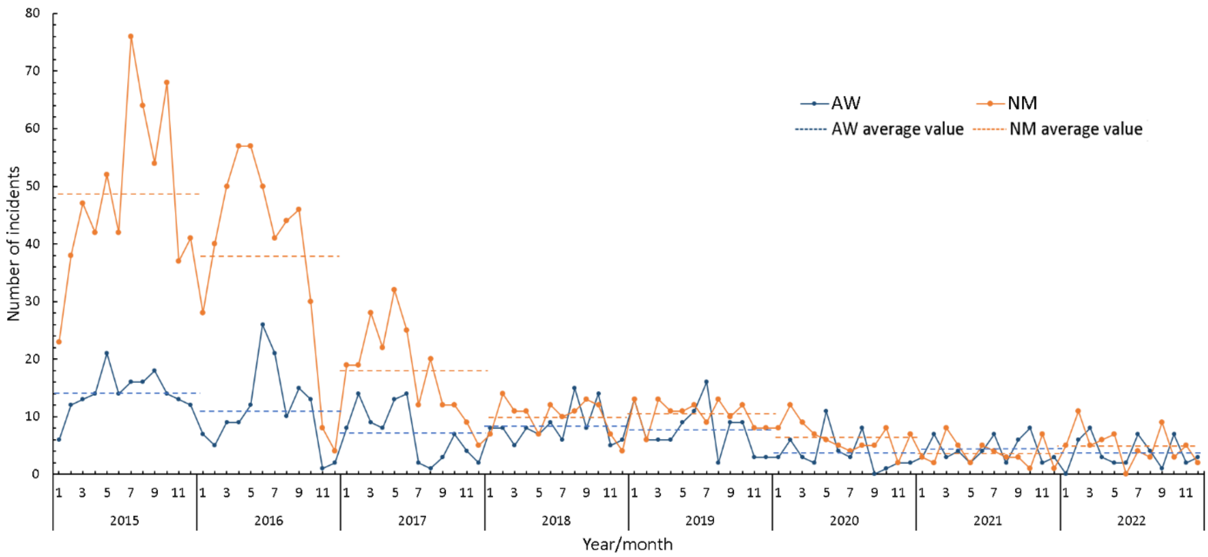

Fig. 3. Time series of near misses (*NM*) and accidents at work (*AW*).

The presented processes are non-stationary. In the initial years, the average values of event counts in individual years, marked on the graphs with dashed lines, are significantly varied in the case of the time series of near misses. Differences in average values also occur in the time series of accidents at work, but they are much smaller than in the case of near misses. In the last two years of the analyzed time period, similar average values for near misses and accidents at work can be observed. A decreasing trend is noticeable in both phenomena.

The time series of hazardous events serves as a measurable representation of safety system variability over time [4]. Their analysis enables the detection of various dynamic patterns occurring in complex systems. This allows for better preparation to respond efficiently in the event of a sudden series of accidents following a prolonged period of absence.

Conclusion

The article presents the results of the analysis of near misses and accidents at work that occurred in a selected Polish construction company from 2015 to 2022. To achieve the project's objective, a database of hazardous events was created, the structure of events registered in the database was examined, and time series of events were determined. Based on the results obtained, the following conclusions were formulated:

- The number of near misses in each year of the studied time period significantly exceeds the number of accidents at work. An exception is the year 2021, where the number of accidents slightly exceeded the number of near misses. The ratio of the number of near misses to the number of accidents shows a clear decreasing trend over the analyzed time period. This may indicate that there are factors in the work environment that discourage employees from reporting such events.
- The constructed time series of near misses and accidents at work showed a significant decreasing trend. The number of registered near misses and accidents decreased from 2015 to 2019 and then stabilized from 2020 to 2022. Factors that may have influenced the course of these phenomena include a reduction in the number of employees due to the COVID-19 pandemic and the associated decrease in the number of hours worked, or the promotion of a safety culture and the improvement of safety levels in the company.

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References

[1] Z. Zhou, Y. M. Goh, Q. Li, „Overview and analysis of safety management studies in the construction industry", Safety Science, tom 72, ss. 337–350, 2015, doi: https://doi.org/10.1016/j.ssci.2014.10.006.

[2] B. Hoła, T. Nowobilski, Z. Woźniak, M. Białko, „Qualitative and Quantitative Analysis of the Causes of Occupational Accidents Related to the Use of Construction Scaffoldings", Applied Science , Vol. 12, Page 5514, tom 12, nr 11, s. 5514, 2022, doi: https://doi.org/10.3390/app12115514

[3] M. G. Gnoni i J. H. Saleh, „Near-miss management systems and observability-in-depth: Handling safety incidents and accident precursors in light of safety principles", Safety Science, tom 91, ss. 154–167, 2017, doi: https://doi.org/10.1016/j.ssci.2016.08.012

[4] C. Zhou, L. Ding, M. J. Skibniewski, H. Luo, S. Jiang, „Characterizing time series of near-miss accidents in metro construction via complex network theory", Safety Science, tom 98, ss. 145–158, 2017, doi: https://doi.org/10.1016/j.ssci.2017.06.012.

[5] F. Chen, C. Wang, J. Wang, Y. Zhi, Z. Wang, „Risk assessment of chemical process considering dynamic probability of near misses based on Bayesian theory and event tree analysis", Journal of Loss Prevention Process Industries, tom 68, s. 104280, 2020, doi: https://doi.org/10.1016/j.jlp.2020.104280

[6] Z. Woźniak i B. Hoła, „The structure of near misses and occupational accidents in the polish construction industry", Heliyon, tom 10, nr 4, 2024, doi: https://doi.org/10.1016/j.heliyon.2024.e26410

[7] W. Wu, A. G. F. Gibb, Q. Li, „Accident precursors and near misses on construction sites: An investigative tool to derive information from accident databases", Safety Science, tom 48, nr 7, ss. 845–858, 2010, doi: https://doi.org/10.1016/j.ssci.2010.04.009.