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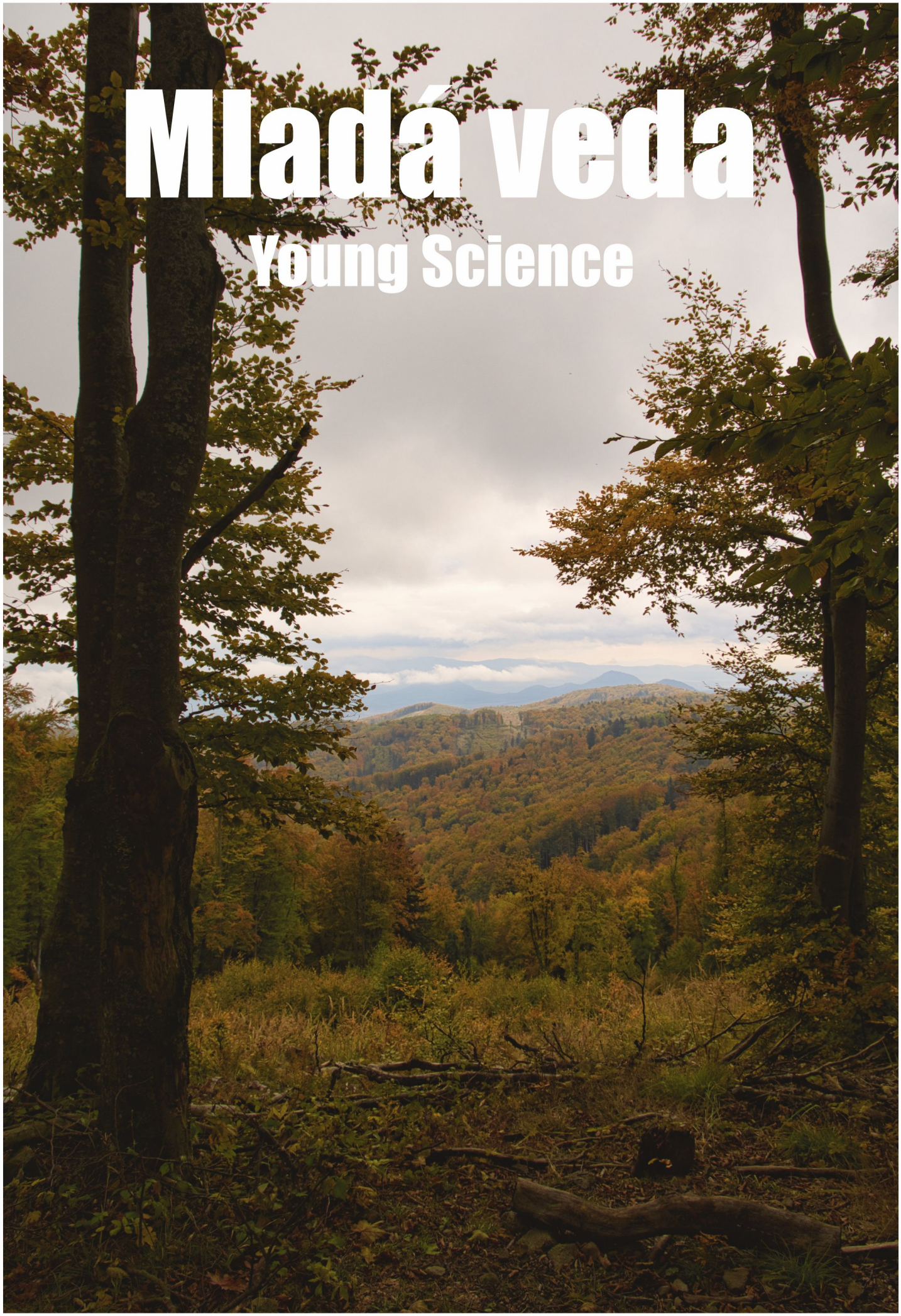

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THE HUMAN FACTOR AND OCCUPATIONAL ACCIDENTS AS DETERMINANTS OF BUSINESS SUSTAINABILITY

ĽUDSKÝ FAKTOR A PRACOVNÁ ÚRAZOVOSŤ AKO DETERMINANTY UDRŽATEĽNOSTI PODNIKOV

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Autorky pôsobia na Katedre krízového manažmentu, Fakulty bezpečnostného manažmentu, Žilinská univerzita. Vo svojej vedecko-výskumnej a pedagogickej činnosti sa venujú problematike manažmentu rizík, krízového manažmentu, bezpečnosti a ochrane zdravia pri práci, spoľahlivosti ľudského faktora, stres manažmentu a manažérskych prístupov, procesov a praktík v kontexte tohto článku v prepojení na udržateľnosť a zvyšovanie hodnoty organizácií.

Abstract

Workplace accident rates and human factor reliability are key determinants of business sustainability, as adverse events in the area of occupational safety and health (OSH) directly affect their economic, social, and equitable stability. Although an analysis of statistical data points to a downward trend in fatal workplace accidents during the period under review, certain sectors, particularly construction and industries involving physical labour or the operation of machinery, remain high-risk in the long term. Accidents caused by alcohol consumption pose a particular threat to the sustainable operation of businesses. The aim of this paper is to highlight ways to prevent these workplace accidents through immersive training that simulates the effects of alcohol using simulation goggles. Immersive training appears to be an effective tool for enhancing human factor reliability and represents a

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promising approach to reducing the accident rate through practical training in safe behavior, thereby directly supporting the long-term sustainability of businesses.
Key words: human factor, workpace accident, sustainability, company, prevention

Abstrakt
Pracovná úrazovosť a spoľahlivosť ľudského faktora predstavujú kľúčové determinanty udržateľnosti podnikov, keďže nežiaduce udalosti v oblasti bezpečnosti a ochrany zdravia pri práci (BOZP) priamo ovplyvňujú ich ekonomickú, sociálnu a spravodlivú stabilizáciu. Analýza štatistických údajov síce poukazuje na klesajúci trend smrteľných pracovných úrazov v sledovanom období, avšak vybrané sektory – najmä stavebníctvo a odvetvia spojené s fyzickou prácou či manipuláciou so strojmi – zostávajú dlhodobo rizikové. Osobitnú hrozbu pre udržateľné fungovanie podnikov predstavujú úrazy zapríčinené požitím alkoholu. Cieľom príspevku je poukázať na možnosti prevencie týchto pracovných úrazov prostredníctvom imerzívneho vzdelávania so zameraním na simuláciu účinkov alkoholu pomocou simulačných okuliarov. Imerzívne vzdelávanie sa javí ako efektívny nástroj na posilnenie spoľahlivosti ľudského faktora a predstavuje perspektívnu cestu k znižovaniu úrazovosti prostredníctvom praktického tréningu bezpečného správania, čím priamo podporuje dlhodobú udržateľnosť podnikov.
Kľúčové slová: ľudský faktor, pracovný úraz, udržateľnosť, podnik, prevencia

Introduction

Health protection, occupational safety, and the reduction of accident rates are an integral part of process risk management, which directly determines the long-term sustainability and value of businesses. The effort to streamline processes through human factor management and the prevention of occupational accidents is one of the fundamental determinants of corporate stability. Particular attention should be paid to preventing risky behaviour and accidents caused by alcohol consumption in the workplace, with immersive training using simulation goggles representing an innovative tool for developing a safety culture and verifying it in practice (Hollá et al., 2025; Hudáková et al., 2025).

Adverse events, microtraumas, and serious occupational accidents not only directly disrupt the continuity of business processes, but also give rise to direct and indirect economic losses, reduce the value of human capital, and damage the organisation's reputation. Although long-term statistical indicators show a gradual stabilisation and a downward trend in fatal accident rates, high-risk sectors, particularly construction, manufacturing, and logistics, continue to face a high incidence of incidents caused by human factor failure (Hollá et al., 2025; Kuricová et al., 2025).

One of the most serious consequences of adverse work and working-environment factors on an employee is the occurrence of an occupational accident (Starren et al., 2023). Although reduced work performance need not lead directly to an accident, it can significantly affect an employee's ability to correctly perceive risks, make appropriate decisions, and respond adequately to situations that arise (Heinrich et al., 2021). A further consequence is an increased likelihood of erroneous action, which represents one of the key preconditions for the occurrence of occupational accidents (Reason, 2020). For this reason, the following

section defines the concept of an occupational accident in accordance with the applicable legislation of the Slovak Republic.

Aim and methodology

According to current research in the field of OSH and ergonomics, the reliability of the human factor in both managerial and operator processes represents a critical pillar of ESG strategy and of the social dimension of business sustainability. The presence of alcohol and other addictive substances in the workplace constitutes a particularly significant determinant of process risk management, as it fundamentally reduces cognitive abilities, extends reaction time, and increases risk tolerance. As a means of preventing such failures, innovative educational methods are coming to the fore, primarily immersive training using simulation goggles. This approach enables an experiential simulation of the sensory and motor impairments caused by alcohol, thereby effectively shaping safety awareness and reinforcing a risk culture directly within the process practice of businesses.

The aim of this paper is to highlight ways of preventing these occupational accidents through immersive training focused on simulating the effects of alcohol using simulation goggles. In order to achieve this aim, the study applied methods including empirical research using exploratory methods based on specialist literature and the results of previous research, observation, analysis of selected data, and synthesis for the purpose of formulating new findings. Applying this methodology made it possible to build a comprehensive framework describing the relationships between human failure under the influence of alcohol, the management of process risks in OSH, and the overall long-term sustainability of businesses. Immersive training thus appears to be an effective tool for strengthening human factor reliability and represents a promising route towards reducing accident rates through practical training in safe behaviour.

Analysis of occupational accident trends

One of the most serious consequences of adverse work and working-environment factors on an employee is the occurrence of an occupational accident. Although reduced work performance need not lead directly to an accident, it can significantly affect an employee's ability to correctly perceive risks, make appropriate decisions, and respond adequately to situations that arise. A further consequence is an increased likelihood of erroneous action, which represents one of the key preconditions for the occurrence of occupational accidents. For this reason, the concept of an occupational accident needs to be defined more precisely below, in accordance with the applicable legislation of the Slovak Republic. An occupational accident is defined as “a damage to health caused to an employee in the performance of work duties or in direct connection therewith, independently of his or her will, by a short-term, sudden, and violent action of external influences” (Act No. 311/2001, § 195, para. 2). In Slovakia, occupational accidents are divided into:

- recorded occupational accidents,
- registered occupational accidents,
- serious occupational accidents involving severe damage to health, and
- serious occupational accidents resulting in death (Employer Procedures, 2024).

For the purposes of this paper, we will focus solely on fatal occupational accidents. A fatal occupational accident (FOA) is an occupational accident that results in the death of an employee. It represents the most serious consequence of a failure in occupational safety and health (Serious Injury to Health, 2021; Act No. 124/2006).

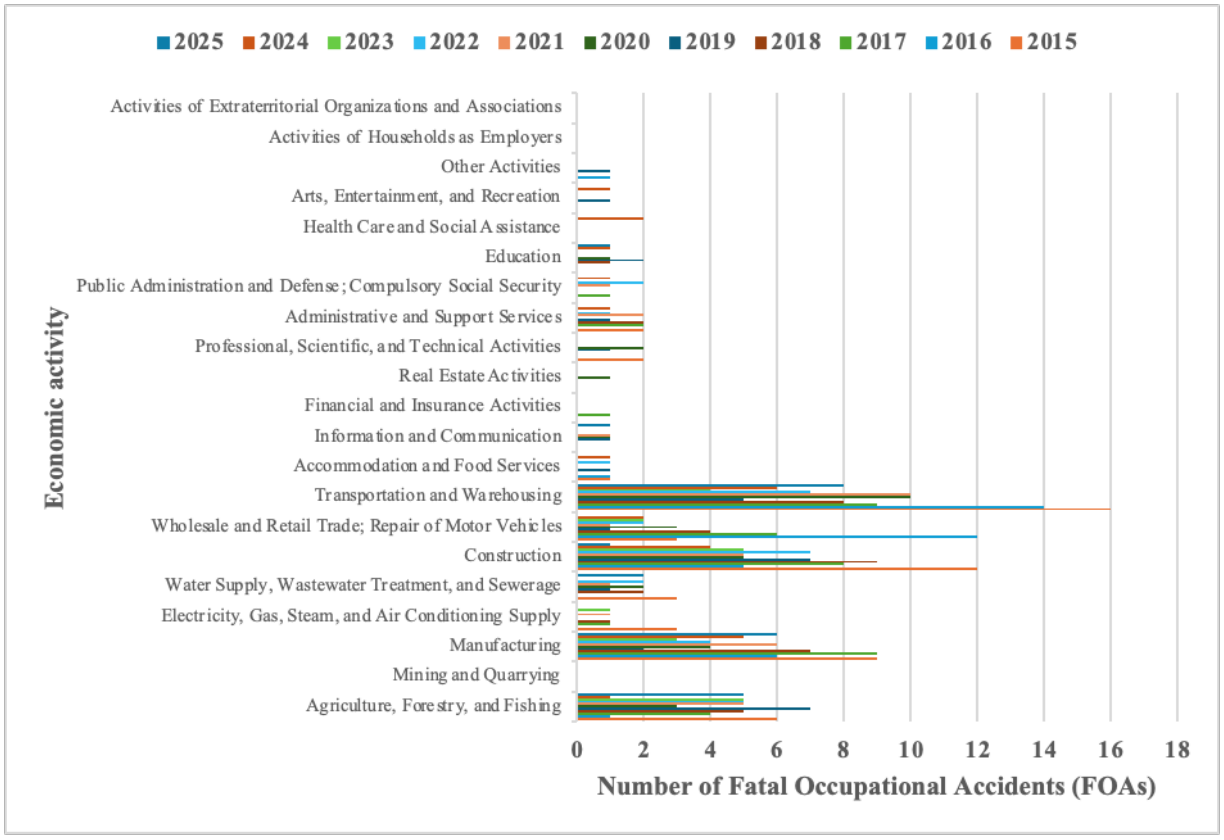

Figure 1 – Trend in the number of FOAs in Slovakia, 2015-2025
Source: Analysis of Occupational Accidents, 2026; Beňadiková, 2026

Overall, the analysed data indicate a downward trend in the number of FOAs over the period under review (Fig. 1). Since 2015 there has been a gradual decline, and by the end of the period, in 2025, 24 FOAs were recorded. In terms of sectoral structure, the highest incidence of FOAs was recorded, over the long term, in the transportation and storage sector, which remained among the highest-risk sectors in terms of occupational safety throughout the entire period under review. In 2015 and 2016, 16 and 14 FOAs respectively were recorded in this sector, representing some of the highest values recorded in the analysed dataset. Cumulatively, the transportation and storage sector thus reached the highest number of FOAs among all the sectors monitored. A significant share of FOAs was also identified in the construction sector. In 2015, 12 FOAs were recorded in this sector. Over the period under review, however, a marked decline can be observed, with only 1 FOA recorded in 2021. A relatively high number of FOAs was also recorded in the manufacturing sector. The number of recorded cases fell from 9 in 2015 to 6 in 2025, pointing to a slight improvement in occupational safety in this sector. The analysed data also show that, throughout the entire period under review, no FOAs were recorded in the mining and quarrying sector, in activities of households as employers, or in activities of extraterritorial organisations and bodies.

At the same time, it is essential to highlight the importance of human factor reliability, which represents a person's ability to perform work activities safely, correctly, and consistently even under changing working-environment conditions. The level of human factor reliability is influenced by a number of factors, such as professional knowledge, practical skills, experience, psychological and physical condition, fatigue, stress, and the quality of the working environment. Their mutual interaction significantly affects the likelihood of human error, and thus the risk of an occupational accident.

The analysis of FOA trends points to their multifactorial nature, with technical, organisational, and environmental factors, as well as the human factor itself, all contributing to their occurrence. From the perspective of designing effective preventive measures, it is therefore essential to identify the causes that led to the occupational accident. In this section, the causes of occupational accidents are classified, in accordance with the applicable legislation of the Slovak Republic, into three basic groups according to the party responsible: causes on the part of the employer, causes on the part of the employee, and other causes. In the practice of investigating occupational accidents, one primary (root) cause is generally identified, representing the immediate determinant of the accident. Causes (Decree No. 500/2006 Coll.; Horňák et al., 2019; Beňadiková, 2026):

- **On the part of the employer (codes 1–7):**
  1. Defective or unfavourable condition of the source of the accident (not the workplace). This cause covers technical deficiencies in machinery, equipment, tools, or materials, such as machine failures, hidden material defects, or a damaged, slippery, or contaminated surface of the accident source. These are cases in which the source of the accident was not in a safe condition and the employer failed to ensure its removal or repair.
  2. Missing or inadequate protective devices and safeguards. This includes accidents caused by the absence or ineffectiveness of protective devices. The employer also bears responsibility where work was carried out without protective measures with his or her knowledge or consent.
  3. Non-assigned, inadequate, or unsuitable personal protective equipment. These are cases in which the employer failed to provide the employee with adequate personal protective equipment or provided equipment of inadequate quality or unsuitable for the given type of work. This may also include personal protective equipment that had lost its effectiveness due to wear.
  4. Unfavourable condition or defective layout of the workplace or access routes (even where the workplace itself is the source of the accident). This group includes accidents caused by a cluttered, untidy, or poorly organised workplace, or by the poor technical condition of floors, access routes, or work areas.
  5. Deficiencies in lighting and visibility, and adverse effects of noise, vibration, and harmful air on the workplace or access routes. This cause covers unfavourable working-environment conditions such as insufficient or glaring lighting, noise, vibration, harmful gases, dust, or unsuitable temperature conditions.
  6. Incorrect organisation of work. This includes organisational deficiencies such as unsuitable work procedures, poor coordination of work, irregular supply of

materials, or an inappropriate allocation of work tasks. An accident is also considered to fall within this category where it results from the consumption of alcoholic beverages or other addictive and psychotropic substances, if the employer had an objective opportunity to prevent the employee from working under their influence but failed to fulfil this obligation. In such a case, responsibility for the occurrence of the occupational accident is transferred to the employer.

7. Failure to become familiar with the conditions for safe work, and lack of qualification. These are cases in which the employee was not properly trained or did not have the necessary qualifications, knowledge, or induction training.

- **Arising from the conduct of the employee (codes 8–10):**
  8. The use of dangerous work procedures or methods, including acting without authorisation, against instructions, prohibitions, or orders, and remaining in an area of danger. These are cases in which the employee knowingly violated safety regulations, procedures, or prohibitions, carried out activities without authorisation, remained in an area of danger, or worked under the influence of alcohol or other addictive substances.
  9. Removal or non-use of prescribed safety devices and protective measures. This includes situations in which the employee wilfully removed or failed to use safety devices that were functional, available, and whose use was mandatory.
  10. Non-use or incorrect use of personal protective equipment. These are cases in which the employee, despite having been issued with suitable personal protective equipment, failed to use it or used it incorrectly.
- **Other causes** that cannot be unambiguously attributed to either the employer or the employee (codes 11–14):
  11. Endangerment by other persons. This includes accidents caused by the actions of other persons, for example by a disturbance, dangerous behaviour, or a breach of regulations by a third party. Neither the employer nor the employee was at fault in these cases.
  12. Deficiencies in an individual's personal prerequisites for the proper performance of work (e.g. lacking physical prerequisites, sensory deficiencies, unfavourable personal characteristics, and acute psychophysiological states). These are cases caused by sudden illness, physical indisposition, or another unforeseen condition of the employee that was not caused by a breach of regulations.
  13. Endangerment by animals or natural elements. This covers accidents caused by animals or by forces of nature.
  14. Undetermined causes. This category is used in cases where the cause of the occupational accident cannot be unambiguously established.

This classification of the causes of occupational accidents shows that their occurrence is conditioned by the interplay of several factors, which may originate on the part of the employer, the employee, or their mutual interaction. Identifying the decisive cause of an occupational accident is therefore an essential precondition for adopting effective preventive

measures and eliminating similar events in the future. A specific group of occupational accidents comprises cases in which the investigation demonstrated that the injured employee was, at the time of the accident, for example under the influence of alcohol. This fact is generally verified by means of a breath test or other objective methods for determining the presence of alcohol in the employee's body, carried out immediately after the accident.

Statistical analysis shows that FOAs in which the injured employee was shown to have consumed alcohol occur repeatedly in Slovakia, particularly in sectors characterised by a high proportion of physical labour, work performed in an external environment, or the operation of machinery and technical equipment. The trend in the number of FOAs in which the investigation confirmed that the injured employee had consumed alcohol shows a fluctuating course over the period 2015–2025, although a slightly downward trend can be observed over the long term. The highest number of cases was recorded in 2015, when six alcohol-related FOAs were recorded. In subsequent years, the number of such cases remained at lower levels, with a marked decline recorded towards the end of the period under review. In 2024 and 2025, one alcohol-related FOA was recorded in each year. In terms of sector, the highest number of alcohol-related FOAs was recorded in construction, where a total of 17 cases were recorded over the period under review. Construction thus recorded the highest number of FOAs among all the sectors monitored and represents the highest-risk sector in terms of the occurrence of alcohol-related occupational accidents. Individual cases of alcohol-related FOAs were also recorded in agriculture, forestry, and fishing; manufacturing; electricity, gas, steam, and air-conditioning supply; water supply, sewerage, and waste management; wholesale and retail trade; real estate activities; education; and transportation and storage. Compared with construction, however, these involved substantially lower numbers of cases. A common feature of these sectors is the performance of work activities involving the operation of machinery and technical equipment, the handling of materials, or work carried out in an environment with an elevated level of occupational risk. In the remaining sectors monitored, no FOA in which the injured employee was shown to have consumed alcohol was recorded between 2015 and 2025 (Beňadiková, 2026).

Prevention of occupational accidents using simulation goggles

Employers are increasingly drawing attention to the growing incidence of factors that can negatively affect employees' work performance and safe behaviour. Significant causes of incidents and occupational accidents also include incorrect organisation of work, which may itself result from the consumption of alcoholic beverages or other addictive and psychotropic substances. The occurrence of an occupational accident may also be caused by excessive fatigue, sleep deprivation, psychological strain, or a combination of several forms of work-related and non-work-related burden. These factors significantly reduce the ability to correctly perceive risks, slow down reaction time, and impair movement coordination, decision-making, and situational awareness, thereby increasing the likelihood of occupational accidents and serious safety incidents. One of the tools for preventing occupational accidents is training of employees, i.e. of the human factor. Modern approaches to education, including in the field of OSH, are gradually shifting from the passive transfer of information towards experiential and interactive forms of learning. Immersive training carried out using simulation goggles

represents a preventive tool aimed at raising safety awareness, developing human factor reliability, and eliminating risky behaviour. Through experiential learning, it enables a better understanding of the consequences of reduced psychomotor capacity for safe work performance, thereby supporting more effective prevention of occupational accidents. Simulation goggles can also be used in the preparation of students or in the training of employees in the field of OSH. These simulation goggles serve as an innovative tool for simulating selected effects and are used mainly for educational purposes and in prevention.

Immersive training represents an educational approach based on creating realistic, interactive, and experiential learning situations in which the participant actively performs tasks and gains practical experience through direct interaction with a simulated environment or simulation technologies. Immersive training carried out using simulation goggles represents a preventive tool aimed at raising safety awareness, developing human factor reliability, and eliminating risky behaviour. Through experiential learning, it enables students and employees to better understand the consequences of reduced psychomotor capacity for safe work performance, thereby supporting more effective prevention of occupational accidents.

Simulation goggles can also be used in preparing students or in training employees in the field of occupational safety and health (Fig. 2). These simulation goggles serve as an innovative tool for simulating selected effects and are used mainly for educational purposes and in prevention. As part of prevention activities, goggles simulating mild alcohol impairment, severe alcohol impairment, as well as drug use and fatigue, can be used.

Figure 2 – Goggles simulating a low level of alcohol impairment, corresponding to a blood alcohol concentration of 0,4 – 0,6 ‰
Source: Drunk Busters Low Level Impairment Goggles, 2026

Simulation goggles primarily affect the user's (student's or employee's) visual and motor functions and are not capable of fully simulating the complex effects of alcohol, addictive substances, or fatigue on the human body. Despite this limitation, they represent a suitable tool within immersive and experiential training aimed at preventing risky behaviour in the workplace.

While carrying out the model tasks, students and employees are generally still capable of rational thinking and assessing situations; however, despite retaining this cognitive capacity, a demonstrable deterioration in the accuracy of the activities performed, a reduction in performance, and an increased error rate can be observed. This discrepancy between subjectively retained control and objectively impaired performance represents the key educational effect of simulation training, enabling participants to better understand the impact of reduced psychomotor capacity on occupational safety.

As part of prevention, during training and instruction in work activities, goggles simulating the following can be used:

- the effects of alcohol (intoxication at various blood alcohol levels),
- a state of intoxication combined with impaired lighting conditions,
- a state resulting from drug use or medication overdose,
- a state resulting from the use of ecstasy,
- a state resulting from the use of marijuana,
- the effects of sleep deprivation, i.e. fatigue caused by lack of sleep.

The incorporation of simulation goggles into practical training makes it possible to create realistic model situations, to support the development of an organisation's safety culture, and to increase employees' individual awareness of the consequences of reduced work capacity. During training, simulation goggles primarily affect visual perception and motor coordination, whereas actual intoxication also affects higher cognitive functions, decision-making, behavioural inhibition, attention, and judgement. Their significance therefore lies not in the exact reproduction of neuropsychological processes, but in supporting experiential learning, developing safety awareness, and fostering discussion of the risks associated with performing work under the influence of factors causing reduced work capacity. The greatest benefit can be expected when this is combined with expert instruction, workplace risk analysis, practice of correct work procedures, and subsequent reflection on the experience gained, which strengthens the transfer of the knowledge acquired into real working practice.

The implementation of simulation goggles in training and human-factor development within OSH and occupational accident prevention should be based on a risk analysis of the specific job position and on identifying the activities in which reduced work capacity could significantly affect occupational safety. Training and practical exercises should be carried out through model situations that replicate the real work tasks of the given job position as closely as possible, with all activities taking place in a controlled and safe environment under the professional supervision of an instructor. Work tasks must be carried out in accordance with a safe working procedure and using all the protective work equipment assigned for the given job position. While the work task is being carried out, the instructor records the correctness of the procedure, any errors, and, where applicable, the time taken to complete the task. During training with simulation goggles, employees gain first-hand experience of impaired visual perception, movement coordination, and spatial orientation.

From a methodological perspective, training or practice in work activities using simulation goggles can be carried out in the following steps:

1. **Introductory preparation and briefing**. Participants are familiarised with the aim and course of the training, the conditions of its implementation, the safety principles, and the method of using the simulation goggles. This step also includes an explanation of the work task and the criteria for its correct performance.
2. **Performance of the reference work task**. The specified work task is carried out without the simulation goggles in order to record the baseline manner and level of its performance under standard conditions.

3. **Performance of the work task with the simulation goggles**. The same or a comparable work task is repeated using the simulation goggles. The participant is able to directly experience the changes in visual perception, coordination, orientation, and the ability to perform the work activity safely under the simulated conditions of reduced capacity.
4. **Professional reflection and error analysis**. The course of the task performed is evaluated, and any errors, risky behaviour, and potentially dangerous situations are identified. This step also includes a comparison of performance with and without the simulation goggles, and a discussion of the possible consequences of a worker's reduced capacity for occupational safety.
5. **Repeat performance of the work task and consolidation of knowledge**. The work task is repeated without the simulation goggles, with the conscious application of the knowledge gained during the training and the professional reflection. This final step is aimed at reinforcing the principles of safe working behaviour, increasing risk awareness, and supporting the transfer of the experience gained into the real working environment.

During the performance of work tasks, a training procedure designed in this way makes it possible to compare employees' performance, supports experiential learning, and facilitates the transfer of the experience gained into real working practice. From an economic perspective, simulation goggles represent a cost-effective tool for supporting OSH training, with the acquisition price of a single pair of goggles being approximately €180, which is relatively low compared with the potential costs associated with occupational accidents or a loss of work performance. A significant benefit of this aid is that it can be used repeatedly in induction, periodic, and specialised OSH training, as well as in practical training of employees across multiple occupations. Its long service life and minimal operating costs increase the economic efficiency of the investment and allow it to be used over several training cycles without the need for additional financial input. From the perspective of preventive strategies, the implementation of simulation goggles can be regarded as an investment that supports the development of a safety culture, raises risk awareness, and fosters the adoption of safe behaviour through experiential learning.

Conclusion

Based on the analysis carried out, it can be stated that the number of alcohol-related FOAs shows an overall downward trend over the period under review. Despite this favourable development, every such case represents a serious failure in occupational safety and health with fatal consequences. The marked concentration of these accidents in the construction sector highlights the need for the consistent enforcement of the prohibition on working under the influence of alcohol, the systematic implementation of preventive measures, and the strengthening of controls over compliance with occupational safety requirements by both employers and employees themselves. At the same time, it underlines the importance of educational and training activities aimed at eliminating risky behaviour, which can make a significant contribution to reducing the likelihood of occupational accidents. This paper

demonstrates the possibilities in the field of education and building a risk culture through immersive education – the use of simulation goggles to model the effects of alcohol. It thereby provides a specific, verifiable tool for practical, experiential training of employees and managers alike in the field of OSH.

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