PROSPECTS FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN OCCUPATIONAL SAFETY AND HEALTH

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Abstract: The rapid development of artificial intelligence (AI) is creating new opportunities for improving occupational safety and health management. Traditional approaches to workplace safety primarily rely on periodic inspections, manual risk assessments, employee training, and the investigation of accidents after they occur. Although these measures remain essential, they may not always provide sufficient opportunities for identifying and preventing hazards in real time. Artificial intelligence offers advanced capabilities for analyzing large volumes of data, identifying potentially dangerous situations, predicting occupational risks, and supporting preventive decision-making. This article examines the prospects for applying artificial intelligence in occupational safety and health, focusing on machine learning, computer vision, intelligent monitoring systems, wearable devices, predictive analytics, and automated safety management. Particular attention is given to applications in construction, manufacturing, mining, and other high-risk industries. The study is based on an analytical review of recent scientific publications and international occupational safety reports. The findings indicate that AI can improve hazard detection, support risk assessment, strengthen safety monitoring, and contribute to more efficient occupational safety management. However, its implementation requires reliable data, technical infrastructure, appropriate regulation, protection of employee privacy, and human supervision. The article concludes that artificial intelligence should be considered a supporting instrument within an integrated occupational safety management system rather than a replacement for professional expertise and human responsibility.

Keywords: artificial intelligence, occupational safety and health, machine learning, occupational risk assessment, computer vision, predictive analytics, workplace monitoring, digitalization, accident prevention, intelligent safety systems

INTRODUCTION. Occupational safety and health are fundamental elements of sustainable economic development, industrial productivity, and social well-being. Ensuring safe working conditions requires the identification of occupational hazards, assessment of potential risks, implementation of preventive measures, and continuous monitoring of workplace conditions. In modern industrial environments, these activities are becoming increasingly complex due to technological development, automation, the expansion of production processes, and the emergence of new occupational risks.

Traditional occupational safety management systems are largely based on scheduled workplace inspections, technical measurements, employee instructions, personal protective equipment, and the analysis of accidents and incidents. Although these measures are indispensable, they may have limitations when dealing with rapidly changing working conditions. For example, a hazardous situation may develop between scheduled inspections, while conventional reporting procedures may not provide immediate information about emerging risks.

The development of artificial intelligence has created new opportunities to address some of these limitations. AI technologies can process information from cameras, environmental sensors, wearable devices, production equipment, and digital records. By analyzing these data, intelligent

systems can identify deviations from normal working conditions, recognize potentially dangerous situations, and provide information that supports preventive decisions.

Artificial intelligence is particularly relevant to occupational safety because many workplace hazards can be identified through observable patterns. These include workers entering restricted areas, failure to use personal protective equipment, unsafe proximity to moving machinery, abnormal environmental conditions, and changes in equipment performance.

Recent scientific research has demonstrated growing interest in applying machine learning and deep learning methods to occupational risk prevention. Armenteros-Cosme et al. (2025), in their systematic review of 61 relevant studies, identified construction, mining, and manufacturing as important areas of application. Computer vision systems based on convolutional neural networks and YOLO models were among the frequently examined approaches.

The International Labour Organization also emphasized the relationship between artificial intelligence, automation, digitalization, and occupational safety in its 2025 report, *Revolutionizing Health and Safety: The Role of AI and Digitalization at Work*. The report highlights the potential of smart monitoring systems and advanced technologies to reduce hazardous exposure while recognizing the emergence of new risks associated with digitalized workplaces.

However, the implementation of AI in occupational safety requires careful consideration. An algorithm may identify a potential hazard, but its prediction does not automatically guarantee that an accident will be prevented. The accuracy of the system, quality of available data, organizational response, and involvement of qualified specialists remain essential.

The purpose of this study is to analyze the current applications and future prospects of artificial intelligence in occupational safety and health, identify its principal technological capabilities, examine implementation challenges, and develop recommendations for integrating AI into modern occupational safety management systems.

MATERIALS AND METHODS. The study employs a theoretical and analytical research approach based on the examination of scientific publications, international reports, and technological developments related to artificial intelligence and occupational safety.

The research methodology includes literature analysis, comparative assessment, classification of AI applications, and examination of organizational and technological factors affecting implementation.

First, recent scientific publications concerning artificial intelligence and occupational risk prevention were reviewed. Particular attention was paid to research on machine learning, deep learning, computer vision, predictive risk modeling, and intelligent workplace monitoring.

Second, AI applications were classified according to their main functions in occupational safety management. These included hazard identification, risk prediction, monitoring of personal protective equipment, ergonomic assessment, environmental monitoring, and emergency prevention.

Third, the possibilities of applying AI technologies in different industrial sectors were examined. Construction, manufacturing, mining, and other high-risk activities were considered because of their exposure to complex occupational hazards.

Fourth, the advantages and limitations of intelligent safety systems were evaluated. The analysis considered data quality, algorithm reliability, employee privacy, cybersecurity, organizational readiness, and the importance of human supervision.

The methodological framework also incorporated the principles of ISO 45001:2018 and the International Labour Organization's ILO-OSH 2001 guidelines. These frameworks provide a foundation for integrating technological solutions into established occupational safety management processes.

The research is analytical and literature-based. It does not present experimental measurements, original industrial datasets, or field-test results. The conclusions and recommendations are derived from the synthesis of existing scientific findings and international occupational safety principles.

RESULTS. The analysis identified several major directions in which artificial intelligence can contribute to the development of occupational safety and health management.

Intelligent Identification of Workplace Hazards. One of the most promising applications of artificial intelligence is the automated identification of hazardous workplace conditions.

Computer vision systems can analyze images and video streams obtained from workplace cameras. Using deep learning algorithms, these systems can recognize workers, machinery, protective equipment, restricted areas, and potentially dangerous interactions between people and equipment.

For example, in construction environments, an AI-based monitoring system can be designed to identify situations in which workers enter hazardous zones, approach unprotected edges, or perform activities without required personal protective equipment.

In manufacturing facilities, computer vision can support the detection of unsafe proximity to moving machinery, unauthorized access to restricted areas, and deviations from established safety procedures.

The YOLO family of object-detection models and convolutional neural networks are among the technologies examined in recent occupational risk prevention research. Their application makes it possible to analyze visual information and identify objects or conditions associated with workplace hazards.

However, the reliability of such systems depends on camera positioning, image quality, lighting conditions, visibility, and the diversity of training data. Therefore, AI-based detection should be validated under the actual environmental conditions in which it will operate.

Predictive Assessment of Occupational Risks. Traditional risk assessment generally evaluates existing hazards and estimates their potential consequences. Artificial intelligence expands this approach by analyzing historical and real-time information to identify patterns associated with increased risk.

Machine learning algorithms can process information about previous accidents, equipment failures, working conditions, employee activities, and environmental measurements.

By examining these relationships, intelligent systems can identify combinations of factors that may indicate an increased probability of an incident.

For example, an AI-based system in a manufacturing enterprise may analyze equipment vibration, temperature changes, operating duration, and maintenance records. Unusual patterns can indicate possible equipment malfunction and the need for technical inspection.

In construction, predictive analytics can support the identification of high-risk activities by examining information about weather conditions, work schedules, equipment operation, and previous safety incidents.

It is important to distinguish between identifying risk patterns and accurately predicting individual accidents. AI models provide estimates based on available data and cannot guarantee that a particular incident will occur.

Consequently, predictive assessment should complement conventional risk assessment procedures and professional safety expertise.

Automated Monitoring of Personal Protective Equipment. Personal protective equipment plays an essential role in protecting employees against occupational hazards. However, the effectiveness of protective equipment depends on its correct selection, condition, and use.

Artificial intelligence can support the monitoring of personal protective equipment through computer vision technologies.

For example, image-recognition systems can be trained to identify safety helmets, protective vests, gloves, safety footwear, and other visible protective equipment in designated working areas.

In construction projects, such systems can help safety specialists identify situations in which workers enter specific zones without the required protective equipment.

In industrial environments, intelligent monitoring can be adapted to recognize certain types of protective equipment and provide notifications when expected safety conditions are not observed.

Nevertheless, camera-based systems cannot reliably verify every aspect of protection. They may recognize the presence of a helmet but cannot always determine whether it is correctly fitted, undamaged, or appropriate for the specific hazard.

Therefore, automated monitoring should be combined with workplace inspections, employee training, and professional assessment.

Application of Artificial Intelligence in Ergonomic Risk Assessment. Ergonomic hazards are associated with repetitive movements, awkward working postures, excessive physical effort, and prolonged exposure to uncomfortable working conditions.

Artificial intelligence can contribute to ergonomic assessment by analyzing body movements and working postures using computer vision and wearable sensors.

For example, motion-analysis systems can examine the position of the back, arms, shoulders, and legs during specific work activities. The collected information can help identify repetitive or potentially harmful movement patterns.

In manufacturing and warehouse operations, AI-supported ergonomic monitoring may help identify activities involving frequent lifting, twisting, bending, or repetitive movements.

Wearable sensors can also collect information about physical activity and movement patterns. When appropriately designed and used with employee consent, these devices can support the assessment of ergonomic conditions.

The main advantage of such technologies is their ability to provide more continuous information than occasional manual observations. However, ergonomic assessment must account for individual differences, work tasks, medical confidentiality, and the limitations of sensor-based measurements.

Intelligent Environmental Monitoring. The working environment has a direct influence on employee health and safety. Temperature, humidity, noise, dust concentration, toxic gases, oxygen levels, and ventilation conditions can create occupational risks when they exceed acceptable limits.

AI can be integrated with environmental sensors to analyze these parameters and identify potentially dangerous changes.

For example, in mining operations, intelligent monitoring systems can process information from gas detectors, temperature sensors, and ventilation equipment. Unusual combinations of measurements can generate warnings that require immediate investigation.

In chemical production facilities, AI-supported monitoring may help identify abnormal gas concentrations or changes in process conditions.

In agricultural activities, environmental sensors and predictive systems can support the monitoring of temperature, humidity, and potentially hazardous exposure conditions during chemical treatment operations.

These systems are particularly valuable when continuous environmental monitoring is required. Nevertheless, AI-based analysis must not replace certified measuring instruments, legally required monitoring procedures, or established emergency alarm systems.

Artificial Intelligence in Occupational Safety Education. Artificial intelligence also creates opportunities to improve occupational safety education and professional training.

Traditional safety training often relies on lectures, printed instructions, presentations, and periodic knowledge assessments. Although these methods remain important, digital technologies can make learning more interactive and adaptable.

AI-supported educational platforms can analyze students' assessment results, identify areas of insufficient knowledge, and provide learning materials based on individual needs.

Virtual reality combined with intelligent learning systems can create simulated workplace environments in which students practice identifying hazards and responding to emergency situations.

For example, architecture and construction students can explore a virtual construction site, identify unsafe conditions, examine evacuation routes, and evaluate the placement of safety barriers.

AI-based chatbots can also support access to occupational safety information, provide explanations of regulations, and help learners prepare for knowledge assessments. However, their responses must be checked against authoritative legislation, technical standards, and professional guidance.

The integration of AI into occupational safety education can therefore contribute to developing a preventive mindset among future engineers, architects, construction specialists, and industrial employees.

Automated Analysis of Accidents and Near-Miss Events. The analysis of occupational accidents is essential for identifying the causes of injuries and preventing similar incidents.

In many organizations, accident investigation records are stored in separate documents and databases. Artificial intelligence can help process this information and identify recurring patterns.

Natural language processing technologies can analyze incident reports, inspection records, and employee observations to identify frequently reported hazards and common contributing factors.

Machine learning can also be applied to structured information concerning the type of work, equipment involved, environmental conditions, and incident characteristics.

Near-miss reporting is particularly important because it provides information about hazardous situations that did not result in injury but could have caused serious consequences.

By analyzing such reports, AI-supported systems can help safety specialists identify recurring problems and prioritize preventive actions.

However, the quality of the results depends on the completeness and accuracy of incident records. Organizations must encourage transparent reporting and avoid using automated analysis as a mechanism for unfairly blaming individual workers.

Future Development of Integrated Intelligent Safety Systems. The future of artificial intelligence in occupational safety is closely associated with the integration of multiple technological systems.

An integrated intelligent safety system may combine workplace cameras, environmental sensors, wearable devices, equipment-monitoring systems, digital records, and predictive analytical tools.

Such a system could provide safety specialists with a more comprehensive understanding of workplace conditions.

For example, information from cameras may indicate that a worker is operating in a restricted area, while wearable sensors and environmental monitoring devices provide additional information about the surrounding conditions.

By combining these data sources, an AI system may identify situations requiring further investigation or preventive intervention.

The future development of intelligent safety systems will depend on the ability to combine different data sources, improve algorithm transparency, protect employee privacy, and ensure compatibility with established safety management procedures.

DISCUSSION. The research findings demonstrate that artificial intelligence has significant potential to improve occupational safety management. Its main contribution lies in expanding the ability of organizations to collect, process, and interpret information about workplace conditions.

Traditional safety management frequently depends on periodic inspections and retrospective accident analysis. AI-supported technologies can provide additional opportunities for continuous monitoring and earlier identification of potentially hazardous situations.

The systematic review conducted by Armenteros-Cosme et al. (2025) identified 61 relevant studies and demonstrated growing research interest in predictive occupational risk modeling. The review found that computer vision and deep learning were frequently applied in construction, mining, and manufacturing.

However, the availability of promising technological applications should not be confused with proven reductions in occupational injuries. Jetha et al. (2025), in their systematic review, identified 1,255 potentially relevant publications, but only two studies met their eligibility criteria for evaluating measurable effects on worker injury or illness. The authors concluded that the evidence was still insufficient to recommend widespread implementation of AI-based occupational safety tools without further evaluation.

This distinction is important for the scientific assessment of artificial intelligence. A system may demonstrate high accuracy in recognizing objects or identifying patterns in a dataset, but this does not necessarily establish that its use reduces the number of workplace accidents.

The practical effectiveness of AI depends on several interconnected factors. First, the system must receive reliable and representative data. Second, its algorithms must be validated under real working conditions. Third, the organization must have procedures for responding to warnings and identified risks. Fourth, employees and safety specialists must understand the purpose and limitations of the technology.

Another important issue concerns privacy and employee rights. Continuous camera monitoring and wearable sensors may create concerns about personal data collection, excessive surveillance, and the use of information for purposes unrelated to safety.

Therefore, organizations should establish clear rules regarding data collection, storage, access, retention, and use. Employees should be informed about monitoring systems, and worker representatives should be involved in decisions concerning their implementation.

The use of AI also introduces new occupational risks. Increased digital monitoring may contribute to psychological pressure, reduced autonomy, and excessive reliance on automated decision-making. In addition, technical failures, inaccurate predictions, and cybersecurity incidents may create additional safety challenges.

The International Labour Organization's 2025 report emphasizes that digitalization and automation can improve workplace safety but also require new preventive policies and adaptive risk management.

Based on these findings, the application of artificial intelligence in occupational safety should follow several principles:

- AI systems should support, not replace, qualified occupational safety specialists.
- Risk prevention should remain based on the hierarchy of controls.
- AI algorithms should be tested and validated before operational use.
- Employees should participate in the design and implementation of monitoring systems.

- Personal data should be protected through transparent policies.
- AI-generated warnings should be connected to clear procedures for corrective action.
- The effectiveness of implemented technologies should be evaluated using measurable safety indicators.

For Uzbekistan, the application of artificial intelligence in occupational safety offers opportunities for modernization in construction, mining, energy, manufacturing, agriculture, and transport. Universities can contribute to this process by developing educational programs that combine occupational safety, engineering, digital technologies, and data analysis.

In particular, architecture and construction students should become familiar with AI-supported hazard identification, BIM-based safety planning, intelligent monitoring, and digital risk assessment. These competencies can help future specialists incorporate safety considerations into the design and construction process.

Thus, the most promising direction is not the replacement of existing occupational safety systems with artificial intelligence, but their gradual transformation into integrated, data-supported, and preventive management systems.

CONCLUSION. Artificial intelligence represents an important technological direction for the future development of occupational safety and health. Its application creates opportunities to improve hazard identification, risk assessment, environmental monitoring, accident analysis, and professional safety education.

The study leads to the following conclusions.

First, artificial intelligence can improve the identification of workplace hazards through computer vision, intelligent sensors, and automated monitoring systems.

Second, machine learning and predictive analytics can support the identification of risk patterns and help occupational safety specialists prioritize preventive measures.

Third, AI-supported monitoring can contribute to improving the use of personal protective equipment and identifying potentially unsafe working practices.

Fourth, wearable technologies and intelligent analytical systems can support ergonomic assessment and the monitoring of workplace environmental conditions.

Fifth, artificial intelligence can improve occupational safety education through adaptive learning platforms, intelligent assessment systems, and virtual simulations.

Sixth, AI-based analysis of accident and near-miss reports can help organizations identify recurring hazards and develop more effective preventive strategies.

At the same time, the implementation of artificial intelligence requires reliable data, technical validation, employee participation, cybersecurity, privacy protection, and professional supervision. Current scientific evidence does not yet establish that all AI-based safety applications consistently reduce occupational injuries and illnesses. Therefore, their effectiveness must be evaluated through carefully designed practical studies.

In conclusion, the future of occupational safety will increasingly depend on the integration of human expertise, engineering solutions, digital technologies, and intelligent analytical systems. Artificial intelligence should be developed as a supporting component of a comprehensive occupational safety management system, with the ultimate objective of preventing accidents, protecting human health, and creating safer working environments.

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