International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

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ARTICLE TITLE	THE ROLE OF ALGORITHMS IN APPLYING OCCUPATIONAL RISK ERGONOMICS TO ACHIEVE "LOST SAFETY" ACCORDING TO ULRICH BECK'S MODEL
ARTICLE INFO	Sali Mohammed. (2025) The Role of Algorithms in Applying Occupational Risk Ergonomics to Achieve "Lost Safety" According to Ulrich Beck's Model. *International Journal of Innovative Technologies in Social Science*. 2(46). doi: 10.31435/ijitss.2(46).2025.3537
DOI	https://doi.org/10.31435/ijitss.2(46).2025.3537
RECEIVED	06 April 2025
ACCEPTED	06 June 2025
PUBLISHED	14 June 2025
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THE ROLE OF ALGORITHMS IN APPLYING OCCUPATIONAL RISK ERGONOMICS TO ACHIEVE "LOST SAFETY" ACCORDING TO ULRICH BECK'S MODEL

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ABSTRACT

This research examines the role of algorithms and artificial intelligence techniques in enhancing occupational safety across various work environments. It focuses on how these algorithms are utilised to analyse and predict occupational risks with greater accuracy, thereby contributing to the reinforcement of preventive measures and the reduction of accidents. The study also addresses the challenges associated with the application of these technologies, such as data heterogeneity and the capacity to predict emerging risks. Furthermore, the research discusses the significance of Ulrich Beck's model in deepening the understanding of social risks and its practical applications in the field of occupational safety. In conclusion, the research presents a set of recommendations to improve occupational safety through the effective integration of algorithms and modern technologies.

KEYWORDS

Algorithms, Occupational Safety, Artificial Intelligence, Occupational Risks, Ulrich Beck's Model

CITATION

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Introduction.

The environment surrounding economic institutions today is a dynamic one, characterised by continuous and rapid change. It encompasses a variety of factors and components related to business activity sectors according to a well-defined and directed economic trajectory. This situation has led to the emergence of the principle of influence and mutual impact, with new dimensions marked by interaction and shared outcomes and objectives. This has manifested in the rise of numerous risks that now pose a genuine threat to the structure of various institutions, necessitating the search for effective and efficient methods capable of anticipating, detecting, and addressing risks according to a scientific methodology grounded in the utilisation of knowledge and science. In this context, artificial intelligence is considered one of the modern technologies that enables the search for and use of information in ways that ensure the swift and dynamic management of risks affecting the activities of institutions.

Algorithms and artificial intelligence techniques have become advanced tools that are increasingly relied upon across various fields, including occupational safety. These technologies contribute to improving the assessment of occupational risks in diverse work environments, thereby facilitating the implementation of early preventive measures. In light of the current challenges related to workplace safety, this research focuses on how companies and institutions can benefit from intelligent algorithms to reduce risks and enhance safety levels. The study also addresses the application of Ulrich Beck's model to understand social risks and approaches to managing them using technological tools.

Problem Statement and Main Research Question

The central issue revolves around how algorithms and intelligent technologies can be utilised to enhance occupational safety in complex work environments, which are experiencing an increase in risks and safety-related challenges. The main research question posed by this study is: How can occupational safety be developed through the effective use of algorithms and artificial intelligence techniques?

Hypotheses

The first hypothesis: Algorithms and artificial intelligence techniques can significantly contribute to improving occupational safety by providing accurate and effective solutions for risk assessment in work environments.

The second hypothesis: The application of algorithms and intelligent technologies may encounter significant challenges related to variable and inconsistent data, which affects their accuracy and effectiveness in risk assessment.

Definition of Study Concepts and Sociological Approach

- **Occupational safety**: This system aims to establish a safe and suitable working environment for both workers and their tools in the workplace. This is achieved by providing preventive services and precautions that ensure the protection of individuals from occupational risks, such as workplace injuries and occupational diseases that may result from performing specific tasks. It also seeks to protect machines and equipment through continuous and regular maintenance, which contributes to maintaining production efficiency for a more extended period (Harairia, 2017). Thus, occupational safety is the set of measures and precautions taken to ensure the safety of workers in work environments, including the prevention of accidents and injuries.
- **Ergonomics**: This field is considered one of the applied sciences in which engineers, psychologists, and planners contribute. It focuses on the design of equipment, machines, devices, and products, as well as the adaptation of the physical conditions surrounding work. Such adaptation is based on the knowledge of the sensory capabilities or perceptual abilities of the worker and their capacity for learning and comprehension. Thus, it is the art of dealing with the human element (Al-Maaytah, 2007). Ergonomics is defined as the science that prepares the physical conditions surrounding work in a manner that suits human sensory and perceptual abilities and aligns with their psychological, motor, and physical capacity for learning. It aims to achieve comfort, safety, and satisfaction within the work environment (Al-Wahab, 2022).
- **Algorithms**: Algorithms are a series of ordered, clear, and executable steps designed to achieve a specific goal and lead to a defined result (Firan, 2021).

A set of rules or instructions used to process data in order to reach specific outcomes.

- **Artificial Intelligence**: Copeland and Proudfoot define artificial intelligence as the process of developing computer systems capable of performing tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and translation (Boubaha, 2022). Artificial intelligence is thus a modern technology aimed at simulating human capabilities through automated systems that can make decisions based on data.
- **Occupational Risks**: Occupational risks are all factors that affect the safety and health of workers as a result of hazardous or harmful agents. These risks are linked to all workplace conditions and can lead to the deterioration of workers' health, making it necessary for employers to address them in order to ensure workers' safety (Khira, 2024).
- **Lost Safety**: Lost safety is defined as the condition in which the work environment does not adhere to optimal occupational safety and health standards, thereby leaving gaps that may pose risks to workers. Through algorithms, these gaps can be accurately analysed and addressed with proactive measures that contribute to improved safety. "Comprehensive and clear social facts will continue to be provided through big data, shedding light on the processes and indicators of profound self-insecurity in the modern era. These processes range from self-destruction to self-awareness, as well as intense cultural and social critique and processes of reflection" (Beck, 2006). The concept of lost safety refers to the gap between the current state of occupational safety and the ideal level required in the work environment. This disparity reflects a deficiency in the implementation of safety and security measures, exposing workers to risks and health problems. Achieving lost safety necessitates an accurate understanding of these risks and their causes. The use of algorithms and artificial intelligence techniques is considered an effective tool for analysing these gaps and continuously reducing occupational risks.

1. The Importance of Studying the Role of Algorithms in Applying Occupational Risk Ergonomics

Studying the role of algorithms in applying occupational risk ergonomics is a fundamental element for achieving occupational safety in work environments. With the continuous advancement of artificial intelligence technologies, algorithms have become a primary tool for analysing and assessing risks with high precision, thereby contributing to the enhancement of worker safety and the reduction of occupational accidents. Moreover, the analysis of available risk-related data and the accurate identification of influencing factors have become possible through algorithms, enabling the prediction and avoidance of risks before they occur.

2. Ulrich Beck's Model in Predicting Occupational Hazards

We live in a global society full of risks, but not all decisions necessarily lead to unpredictable outcomes. The concept of "risk management societies" means that we exist in a state of alignment with circumstances, where the possibility of controlling the side effects and risks resulting from decision-making has become doubtful. Here, new knowledge plays a role in transforming incalculable risks into calculable risks, which leads to the emergence of new phenomena that are difficult to comprehend. This compels us to reflect on risks, and with this reflection on uncertainty, it becomes necessary for the first time to define interruption in the present, thus requiring a reshaping of our perception of society and concepts associated with sociology (Beck, 2006).

The concept of the risk society, formulated by the German sociologist Ulrich Beck, constitutes a comprehensive theoretical framework that reflects the nature of the current era. Beck indicates that the complexities of the current situation necessitate a reconsideration of the language of social sciences to develop more suitable concepts for understanding the reality of the world in which we live (Rachidi & Karima, 2020).

Ulrich Beck's model is considered a fundamental reference in occupational risk management, as it focuses on assessing lost safety and adopting a holistic view of risks in work environments. This model is based on the premise that risks can emerge even in the absence of obvious incidents, thereby necessitating the use of algorithms for practical data analysis. The model promotes the utilisation of artificial intelligence to achieve innovative solutions to various risks.

The principles of this model revolve around the classification and assessment of risks, as well as the comprehensive analysis of lost safety. This requires the integration of algorithms to process large datasets and to analyse psychological, social, and organisational factors that may influence the level of safety in work environments.

3. Algorithms and Artificial Intelligence Techniques

Algorithms and artificial intelligence techniques are fundamental pillars in enhancing occupational safety. By rapidly and efficiently analysing data, algorithms can accurately identify risks and provide innovative solutions to mitigate them. Technologies such as deep learning and big data analytics can play a vital role in offering strong and precise insights into how risks can be reduced.

3.1. Definition of Algorithms

Definition of Algorithm: The term dates back to the ninth century CE and refers to Jaafar ibn Musa Al-Khwarizmi, the Arab scholar renowned for his achievements in mathematics and astronomy. He was the first to establish the principles of algebra and arithmetic, which are the algorithms now associated with electronic computer programming (Firan, 2021).

Algorithms are a series of mathematical and logical procedures used to solve problems and make decisions. Algorithms vary in type and include traditional algorithms, such as search and sorting algorithms, and evolutionary algorithms that rely on mechanisms of evolution to find optimal solutions. These types are primarily used to enhance occupational safety by processing data and analysing risks in work environments.

3.2. Types of Algorithms

Algorithms can be divided into two categories:

a. **Computational Algorithms**: These are algorithms that deal with mathematical and arithmetic operations. If a mathematical calculation is not accompanied by a sequence in performing its operations—from input to output or problem-solving—it cannot be classified as a mathematical process.

b. **Non-Computational Algorithms**: These are the most widely used algorithms. Additionally, some algorithms are employed for text processing, data storage and retrieval, as well as for managing databases and supporting decision-making in various daily aspects. An example of such algorithms is the spelling check algorithm, which is non-computational by nature (Firan, 2021).

4. Methods for Improving Occupational Safety Using Algorithms

Algorithms are powerful tools for analysing occupational risks and identifying weak points within the system. By employing algorithms, the overall performance of safety systems can be enhanced, and innovative solutions can be provided to reduce accidents and minimise risks. For instance, algorithms can be used to analyse data from previous incidents and identify root causes, which leads to a reduction in future accidents.

4.1. Genetic Algorithms

Computer programmes that simulate biological processes are vital tools for analysing problems in evolutionary systems. Research that simulates the process of natural selection relies on tracking the sequence of events and is routinely used to find practical solutions for improvement and problem-solving. Genetic algorithms belong to a broader class of evolutionary algorithms, as they generate multiple solutions to problems through techniques inspired by natural evolution and its associated ecosystems. These algorithms mainly rely on the intelligent exploitation of random search and use basic techniques to solve problems optimally (Nafissa & Nasr Eddine, 2023).

Genetic algorithms are based on the principles of evolution and heredity to find optimal solutions. These algorithms are highly effective in analysing and predicting risks, as they can determine appropriate preventive measures based on the available data. Due to their capacity for continuous optimisation, genetic algorithms are utilised to improve occupational safety systems and to reduce accidents and injuries in industrial work environments. Genetic algorithms are considered a method for solving mathematical and engineering problems, as they are based on simulating the process of gene reproduction in living organisms.

4.2. Practical Applications of Algorithms in Achieving Occupational Safety

There are numerous practical applications of algorithms in enhancing occupational safety. Through the analysis of data related to workplace accidents and occupational injuries, algorithms can provide effective preventive solutions. For example, algorithms can be used to analyse risks in work environments such as manufacturing or construction, where they help to improve safety procedures and reduce accidents.

5. Applications of Artificial Intelligence in Occupational Risk Assessment

5.1. The Role of Artificial Intelligence in the Occupational Environment:

Artificial intelligence is considered one of the most significant achievements of the human mind in the last decades of the twentieth century. It is a branch of modern computer science that aims to develop software technologies enabling machines to perform tasks and derive conclusions in a manner that, although limited, simulates human cognitive processes. This field centres on studying the characteristics of human intelligence and partially replicating them. Artificial intelligence relies on analysing the complex mental processes undertaken by the brain during thought, then translating them into computational operations that make it easier for computers to address complex problems. The primary objective is to enable devices to imitate certain aspects of human intelligence, allowing them to solve problems and make decisions using a logical and organised approach. Artificial intelligence has achieved tangible success, moving beyond academic research to practical use in business, delivering notable efficiencies across a wide range of applications (Brarama, 2024).

5.2. The Role of Artificial Neural Networks in Occupational Risk Management

Artificial neural networks have increasingly become a vital tool in the field of economic risk management for institutions, due to their ability to process vast amounts of data, learn from it, and subsequently provide accurate predictions based on identified patterns. The following are some of the key roles they play in this context:

- **Risk Prediction**: Artificial neural networks are distinguished by their ability to analyse large volumes of historical data to forecast future events, such as market fluctuations or financial crises. For example, they can predict changes in stock prices or assess economic risks based on previous financial data (Brarama, 2024).
- **Pattern Analysis**: Neural networks enable the identification of hidden patterns within data, which contributes to the detection of potential risks. For instance, they can uncover patterns indicative of fraud or any abnormal deviations in financial operations (Brarama, 2024).
- **Crisis Management**: Neural networks contribute to the development of predictive models that assist organisations in making effective and rapid decisions during crises. They can also forecast the trajectory of a crisis and provide early recommendations to mitigate its impact.
- **Financial Situation Analysis**: Neural networks are capable of studying financial data and key performance indicators of institutions, thereby helping to identify potential weaknesses and propose solutions that contribute to improving the financial situation.

- **Investment Portfolio Management**: Neural networks rely on analysing market trends and economic indicators to design advanced investment strategies, which support the optimisation of asset allocation and the reduction of potential risks that may affect investment portfolios.
- **Operational Risk Identification**: This has become possible thanks to neural networks, which possess a remarkable ability to accurately analyse operational data in order to identify risks that may affect the daily workflow, such as technical issues and logistical complexities. Through their capacity to process vast amounts of data and recognise complex patterns, this technology provides practical tools to enhance risk management plans and support the economic security of institutions (Brarama, 2024).

Artificial intelligence is considered one of the fundamental tools in occupational risk assessment. By applying artificial intelligence techniques such as machine learning and deep learning, hazardous patterns are analysed more quickly and accurately, contributing to the identification of potential incidents and the reduction of injuries and losses. These applications are not limited to heavy industries but also extend to fields such as healthcare and transport.

6. The Role of Ergonomics in the Prevention of Occupational Risks

Ergonomics seeks to prevent occupational risks by establishing preventive measures to limit the spread of occupational hazards in work environments, due to the severe effects they have on workers' health, including numerous workplace accidents and occupational diseases, which may cause total or partial disability, and sometimes even result in death and loss of life. In addition, there are the high costs borne by institutions as a result of the compensation required. The following are the preventive measures:

- Periodic assessment of occupational risks in order to diagnose and evaluate the frequency of exposure and the degree of severity, thereby enabling the implementation of preventive measures to minimise them.
- Designing workplaces according to ergonomic standards to provide workers with healthy working conditions, the highest levels of well-being, and the adoption of healthy physical postures that avoid acute joint positions, which may damage joints and muscles.
- Regular maintenance of machines and work equipment.
- Carrying personal protective equipment, which must be ergonomically designed according to workers' body dimensions and the characteristics of the activities performed.
- Training workers regarding the nature of occupational hazards they are exposed to in their work and how to deal with them, as well as training on the use of personal protective equipment, which can reduce the severity of risks. This training is in addition to the instruction workers must receive from the employer on correct working procedures.
- Careful selection of machines and production tools based on their safety features.
- Organising working hours properly, including work and rest periods, so that rest times allow workers to recover their physical fitness and reduce workload.
- Continuous communication in the field of worker safety and security.
- Establishing a comfortable, lively, and friendly working environment, which reduces the psychological pressures experienced by workers (Oubrahim & Mohamed, 2023).

7. Current and Future Challenges

Despite the significant progress achieved by algorithms in enhancing occupational safety, there are still many challenges that remain. One of the most prominent challenges is improving the ability of algorithms to predict rapidly changing risks in work environments, especially in industries undergoing continuous technological transformations. In the future, research will continue to focus on developing more advanced algorithms to increase the effectiveness of risk assessment.

Current challenges include enhancing the adaptability of algorithms to rapidly changing environments, as well as addressing inconsistent data and ensuring the quality of collected data. In the future, artificial intelligence is expected to be more deeply integrated into occupational risk assessment, particularly with the increasing use of innovative robotics technology, which can be employed to monitor risks in real time.

8. Findings

This research highlights the vital role of algorithms in enhancing occupational safety through artificial intelligence applications. These technologies have a significant impact on reducing occupational risks and creating a safer work environment. As research and development in this field continue, we will be able to improve further the ability to predict risks and take appropriate preventive measures quickly and efficiently.

Efforts must continue to be directed towards developing algorithms and technologies that contribute to creating a safe working environment and to strengthening collaboration among academics, practitioners, and the industrial sector to achieve these objectives.

The study has shown that modern algorithms and artificial intelligence can play a significant role in improving the safety of work environments by enhancing the ability to predict risks and providing proactive solutions. Although some challenges remain, such as the lack of consistent data, advances in this technology open up broad prospects for reducing accidents and injuries in workplaces.

Conclusions

Relying on artificial intelligence as a fundamental element in risk management strategy has become an urgent necessity in light of the accelerating and increasingly complex environmental changes. This situation has intensified uncertainty and increased the likelihood of risks occurring. Artificial intelligence is characterised by its capacity for learning, understanding, and problem-solving, which enhances optimal decision-making. Intelligent systems, through their high effectiveness and efficiency in risk analysis—both quantitative and qualitative—have contributed to establishing rules for knowledge distinction and mechanisms of reasoning. This, in turn, has enhanced understanding and improved methods of addressing risks more efficiently.

Ergonomics plays a vital role in the prevention of occupational risks within institutions by conducting regular assessments and implementing appropriate preventive measures. It has become essential to focus on these aspects, especially given the widespread nature of risks in various work environments, where workers face dangerous conditions that threaten their physical and psychological health, potentially leading to serious occupational injuries, diseases, or even death. Therefore, all institutions must attach great importance to this process and provide all necessary material, technical, and human resources to ensure its success. It is also necessary to monitor and evaluate the extent to which the implemented preventive measures are being applied, with an emphasis on identifying the risks faced by the institution.

The use of algorithms and artificial intelligence in occupational safety represents a significant step towards achieving safer work environments. Despite current challenges, these technologies contribute to providing innovative solutions that help reduce accidents.

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