

# METHODOLOGY FOR EVALUATING SAFETY AND EFFECTIVENESS UNDER UNUSUAL WORKING CONDITIONS IN INTERNATIONAL WORK ENVIRONMENTS

DOI: 10.2478/czoto-2025-0013

Received: 12/09/2025

Accepted: 28/10/2025

**Helena Fidlerova**<sup>1</sup> – *orcid id: 0000-0002-3426-5803, e-mail: helenafidlerova@stuba.sk*

**Benjamin Abdullah Karl Schmacher**<sup>2</sup>, *e-mail: benjamin.schmacher@team-schmacher.at*

<sup>1</sup>Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, **Slovakia**

<sup>2</sup>Schmacher, Team Schmacher GmbH, **Austria**

**Abstract:** Work environments are becoming increasingly variable and unpredictable, creating new challenges, as unusual working conditions (UWCs), including irregular schedules, spatial disruptions, and procedural or psychosocial instability. These conditions negatively affect the consistency, quality and safety, often exceeding the capacity of conventional risk assessment approaches. This article introduces a practice-oriented methodology designed to dynamically identify and evaluate risks while simultaneously capturing changes in work effectiveness. The framework, based in a literature review and validated with empirical evidence from surveys and observations in international companies, combines SWOT analysis with the DMAIC cycle to support continuous improvement and adaptability to company-specific contexts. By aligning workplace practices with Sustainable Development Goal 8 (SDG8), the study contributes to promoting decent work, safe environments, and sustainable organisational development.

**Keywords:** risk assessment methodology, DMAIC, occupational safety, work effectiveness, Sustainable Development Goal 8 (SDG8)

## 1. INTRODUCTION

Today, many companies operate under unpredictable conditions in the industrial environment. These working conditions may include changes in working hours, fluctuations in workload, irregular environments, and safety problems arising from complex facilities or organisations. Recent studies confirm that intensification of work and the increasing complexity of organisational environments introduce hidden risks that conventional approaches do not adequately capture (Green et al., 2021).

Unusual working conditions negatively influence not only the safety, but also the quality of work and long-term sustainability of organisations. Their consequences include higher accident rates, increased psychological and physical strain, and reduced overall productivity (Meltser et al., 2022; James et al., 2017). At the same time, the concept of Decent Work and Economic Growth under Sustainable Development Goal 8 (SDG 8) emphasizes the need to provide safe, adaptable, and resilient workplaces (Chigbu & Nekhwevha,

2023). Despite this, traditional risk assessment methods, such as Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), or HAZOP, were primarily designed for stable and predictable environments (Card et al., 2012; Stamatīs, 2003; Czajkowska et al., 2021, Mesárosova et al., 2022).

The literature indicates attempts to extend occupational risk assessment using multi-criteria approaches and hybrid models (Gul, 2018; Kvitkina et al., 2023), as well as ergonomic and managerial perspectives (Markova et al., 2023; Hatīar et al., 2018). However, there remains a significant research gap in methodologies that simultaneously assess both risk and work effectiveness in dynamic and unstable environments.

This paper addresses this gap by proposing a practice-oriented methodology for evaluating safety and effectiveness under UWCs. The methodology integrates a structured SWOT (Strengths -Weaknesses-Opportunities-Threats) analysis with continuous improvement principles (DMAIC cycle), and it was validated using empirical evidence from surveys and observations in international companies

Therefore, it is imperative to develop a methodology that recognises and helps identify these changing conditions from a safety perspective, as well as a methodology that maintains work efficiency and minimises risks in the context of the sustainable development goals (SDG) and targets as a part of the Agenda2030.

The paper introduces a methodology developed from a theoretical gap and practical observations, using the SWOT matrix. The methodology to evaluate safety and effectiveness under unusual working conditions was verified in an international company.

The objective of the paper is to address the knowledge gap on unusual working conditions and to present a methodology for unusual working conditions for companies that is intended to reduce the physical and psychological burden on people working in a wide variety of fields in the context of contributing to SDG 8 Decent Work and Economic Growth. Accordingly, the study pursues the following research questions:

*RQ1: To what extent do variables related to the effectiveness of work activities influence overall performance?*

*RQ2: What are the key parameters of risk and effectiveness in work activities, and how can they be evaluated under unusual working conditions?*

In order to assess the correctness of the designed solution, it was necessary to introduce given research questions (RQ):

The paper is structured as follows. Section 2 describes the research methodology, including the rationale for using SWOT analysis. Section 3 presents the results of the SWOT matrix and discusses the methodological framework. Section 4 concludes with implications for practice, links to SDG 8, and directions for further research.

## **2. METHODOLOGY OF RESEARCH**

The research process presented in the flow chart is structured into two interconnected phases that reflect the theoretical and empirical dimensions (Figure 1). The initial part consisted of a literature review of existing literature and practice. This review identified gaps in theory and practice. The second phase was empirical, based on a survey in international companies and direct workplace observation.

The research process is shown in Figure 1. First, a literature and practice review identified gaps in theory and application. Second, we conducted an empirical study (survey in international companies and direct workplace observation). The following methods were used to address the analytical aspects of the study: literature review and analysis, observation,

survey methods (questionnaires, etc.), data evaluation and SWOT analysis including SWOT matrix. In a broader sense, methods such as expert interviews, focus group discussions, experiments, meta-analyses, etc. may also be useful.

The results of the SWOT analysis are summarised in Table 1. The Developing (SO) quadrant emphasises innovation, improvement and market position. Catching up on (WO) refers to communication, employee health, and digitalisation. Safeguarding (ST) includes customer solutions, workplace culture, and managing challenges. Avoiding (WT) focusses on competitiveness, staff qualification, and business pressure.

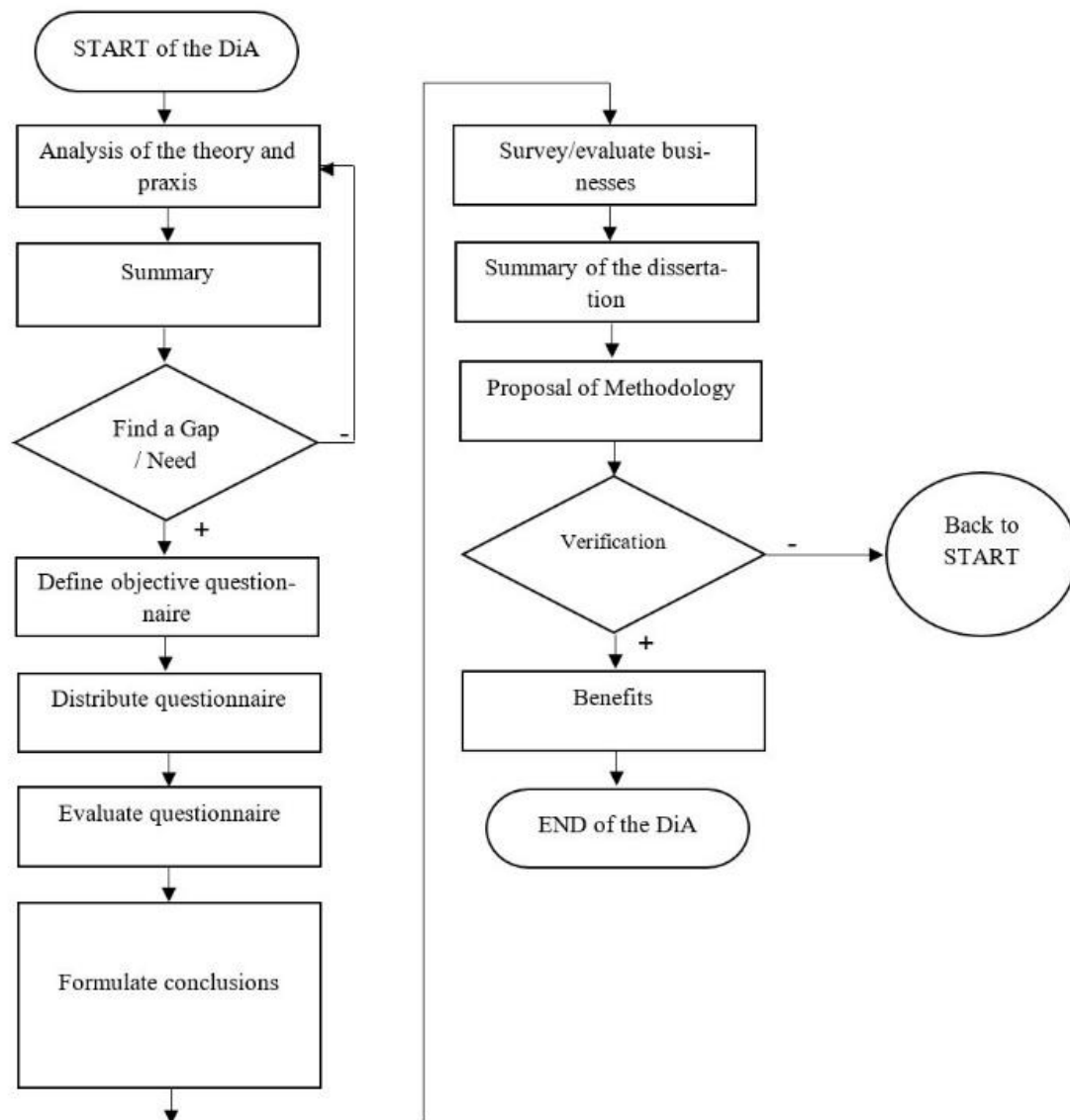


Fig. 1. Flow chart of the research process (drawn by the authors)

SWOT analysis was applied to evaluate strengths, weaknesses, opportunities, and threats in relation to unusual working conditions. This approach provided a structured overview of internal and external factors affecting company performance and safety. Table 1 summarises the impact areas, where the SO quadrant emphasises innovation and market leadership, the WO quadrant highlights communication, employee health and digitalisation, the ST quadrant refers to customer solutions and workplace culture, and the WT

quadrant stresses competitiveness, staff qualification, and coping with demanding activities.

Table 1  
SWOT impact areas

| Developing<br>STRENGTHS/OPPORTUNITIES                                                                                                                                                                                                                               | Catching up on<br>WEAKNESSES/OPPORTUNITIES                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Developing innovative practices<br>Further, develop, recognise, and exploit solutions for all persons involved.<br>Secure the pioneering position on the market through rapid handling of the process                                                               | Increase communication performance, and thus raise awareness.<br>Focus on the health of the entire staff.<br>Digitise internal communication (APP) and avoid inconvenience                                                                                   |
| Safeguarding<br>STRENGTHS/THREATS                                                                                                                                                                                                                                   | Avoiding<br>WEAKNESSES/THREATS                                                                                                                                                                                                                               |
| Develop solutions for customers, suppliers, and clients in the area of communication.<br>Compensate for the lack of skilled workers on the labour market through a good working atmosphere.<br>Positively shape challenging activities with variety in the business | Stay one step ahead of the competition by raising the profile of the company.<br>Compensate for the lack of qualification of the staff through targeted training and further education.<br>Focus on the pressure of the business with challenging activities |

Source: authors

To further validate the proposed methodology, a questionnaire survey was conducted both in the pilot company and in international companies in the renovation industry. The identical instrument, with the same questions, blocks, and criteria, was distributed and collected. In total, more than 100 responses were received. The majority of the respondents were male (~70%), in the 30 to 50 age group, and with more than 5 years of company affiliation (~70%). Most were employed in technical or back-office positions.

The survey was focused on work in the restoration sector and the broader field of natural disaster repair covered variables relevant to both research questions, such as risk perception, physical and mental strain, and workplace environmental parameters (illumination, noise, vibrations, microclimate, dust, and harmful substances).

These data complement the findings of the pilot company and provide a broader empirical basis for the methodology, ensuring its applicability in different organizational contexts.

### 3. RESULTS AND DISCUSSION

This section presents the results of the SWOT matrix, the international company survey and methodological implications for work in unusual working conditions.

#### 3.1. SWOT matrix

The results of the analysis confirm that unusual working conditions (UWCs) significantly affect the perception of work risks and the efficiency of work processes. The application of SWOT analysis provided a structured overview of internal and external factors. The experts assigned a rating and weight to each factor, which made it possible to determine its relative importance. The weighted score showed that the strengths and opportunities quadrant (SO), in particular innovation, continuous improvement, and the ability to secure a pioneering position in the market, is the most decisive. These factors clearly strengthen competitiveness and adaptability in a dynamic environment. Similarly, the strengths and

threats quadrant (ST) emphasises stability through customer-oriented solutions, a supportive workplace culture, and the ability to manage complex projects. On the other hand, the Weaknesses and Opportunities (WO) quadrant highlights communication, health initiatives and digitalization as key areas requiring improvement, while the Weaknesses and Threats (WT) quadrant highlights challenges related to skill levels, competitive pressures and the ability to cope with stress (Table 2).

Table 2  
SWOT matrix with ratings and weights

|            | Activity                                                                                              | Rating | Weight | Weighted score | Impact |
|------------|-------------------------------------------------------------------------------------------------------|--------|--------|----------------|--------|
| <b>SO1</b> | Developing innovative practices                                                                       | 5      | 0.6    | 3              | high   |
| <b>SO2</b> | Further develop, recognise, and exploit solutions for all persons involved                            | 5      | 0.6    | 3              | high   |
| <b>SO3</b> | Secure the pioneering position on the market through rapid handling of the process                    | 4      | 0.7    | 2.8            | high   |
| <b>WO1</b> | Increase communication performance and thus raise awareness                                           | 3      | 0.3    | 0.9            | low    |
| <b>WO2</b> | Focus on the health of the entire staff                                                               | 4      | 0.2    | 0.8            | low    |
| <b>WO3</b> | Digitise internal communication and avoid inconvenience                                               | 5      | 0.4    | 2              | high   |
| <b>ST1</b> | Develop solutions for customers, suppliers, and clients in the communication                          | 5      | 0.6    | 3              | high   |
| <b>ST2</b> | Compensate for the lack of skilled workers on the labour market through a good working atmosphere     | 4      | 0.5    | 2              | high   |
| <b>ST3</b> | Positively shape challenging activities with variety in the business                                  | 4      | 0.4    | 1.6            | medium |
| <b>WT1</b> | Stay one step ahead of the competition by raising the profile of the company                          | 5      | 0.3    | 1.5            | medium |
| <b>WT2</b> | Compensate for the lack of qualification of the staff through targeted training and further education | 4      | 0.1    | 0.4            | low    |
| <b>WT3</b> | Focus on the pressure of the business with challenging activities                                     | 4      | 0.2    | 0.8            | low    |

Source: authors

These findings support RQ1, as they argue that variables such as communication, employee health, and workplace culture have a direct impact on work effectiveness. They also contribute to RQ2, as they identify measurable parameters of effectiveness and risk that can be systematically assessed within the proposed methodology.

### 3.2 Survey in international companies

To broaden the empirical basis of the methodology, the responses of the respondents working in international companies in the reconstruction industry ( $N = 104$ ) were analysed. The sample consisted exclusively of respondents aged 30–50, of whom more than 70% were male and almost 70% had more than five years of experience in the company. The majority of participants were technicians or back office employees with practical work experience.

The survey was focused on the risk perception analysis, which shows that more than half of the respondents (53.8%) considered their work to be risk-free, while 21.2% reported technical risks and 25.0% health-related risks. Regarding perceived stress, 76% reported a low or insignificant level, 16% a disturbing stress, and 8% an unusual level that prevents further work. The assessment of environmental parameters such as lighting, noise, vibration, microclimate, dust, and harmful substances showed that most conditions were evaluated as optimal or acceptable, with only 1–4% of respondents identifying unusual or disturbing values.

The hypotheses assumed independence between professional experience and risk perception, tested at a significance level of  $\alpha = 0.05$ . Since the test statistic exceeded the critical chi-square value, the null hypothesis was rejected, confirming that professional experience significantly influences the perception of occupational risks. The chi-square test confirmed a statistically significant relationship between years of professional experience and perception of occupational risks ( $\chi^2(6) = 22.65$ ,  $p < 0.001$ , Cramér's  $V = 0.33$ ), which indicates a medium association. Less experienced workers tended to report physical strain, while more experienced workers emphasised mental load and long-term health concerns (Figure 2).

The results underline the need to combine objective and subjective perspectives. Although most environmental parameters were rated as optimal or permissible, workers still perceived health, communication, and stress-related issues as relevant. This confirms the need for a methodology that links risk assessment with effectiveness evaluation in a dynamic way.

The combined SWOT and survey results also support the integration of continuous improvement principles (DMAIC). Classifying work into physical, mental, and risk-intensive categories ensures that both technical parameters (e.g., illumination, noise, vibrations) and human factors (e.g., training, perception of strain, workplace culture) are considered.

### 3.3 Methodological implications

The design of the proposed methodology is guided by the generally accepted principles of assessing work efficiency (OUTPUT/INPUT) and risks associated with work under unusual working conditions (UWCs). The aim is to provide a structured, step-by-step procedure that can be applied in practice. The methodology integrates several basic elements: systematic data collection on the actual state of implementation, analysis and classification of activities, selection of relevant assessment methods, and establishment of standard values for indicators describing UWCs. Clear objectives and predefined analytical steps are essential to ensure comprehensibility for plant managers and to support its practical application.

The process begins with data collection from multiple sources, including company documentation, internal surveys, and direct observation. Based on these inputs, work activities are classified into three main categories: physical work, mental work and hazardous/risky

work. For each category, key parameters of working conditions are identified and compared with normative values. Depending on the assessment, the process ends or continues with further analysis until the classification is complete.

Figures 2, 3 and 4 illustrate this approach in more detail. Figure 2 presents the general framework of the methodology, which integrates both efficiency and risk assessment.

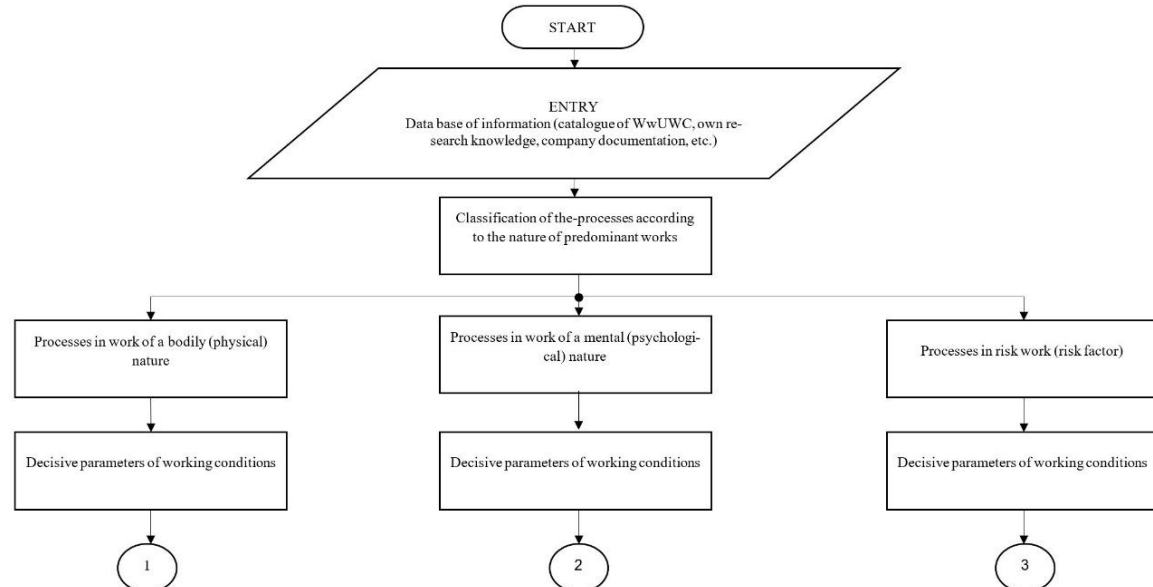


Fig. 2 Framework of the proposed methodology for evaluating safety and effectiveness under unusual working conditions "START" (authors).

Figure 3 shows the first level of classification, where work processes are divided into physical, psychological, and hazardous categories. Figure 4 illustrates how the assessment continues within each category, for example, by examining muscle tension, duration of workload, or environmental stress during physical work. Therefore, the methodology allows for a structured assessment of unusual working conditions and a dynamic link between risk assessment and efficiency analysis.

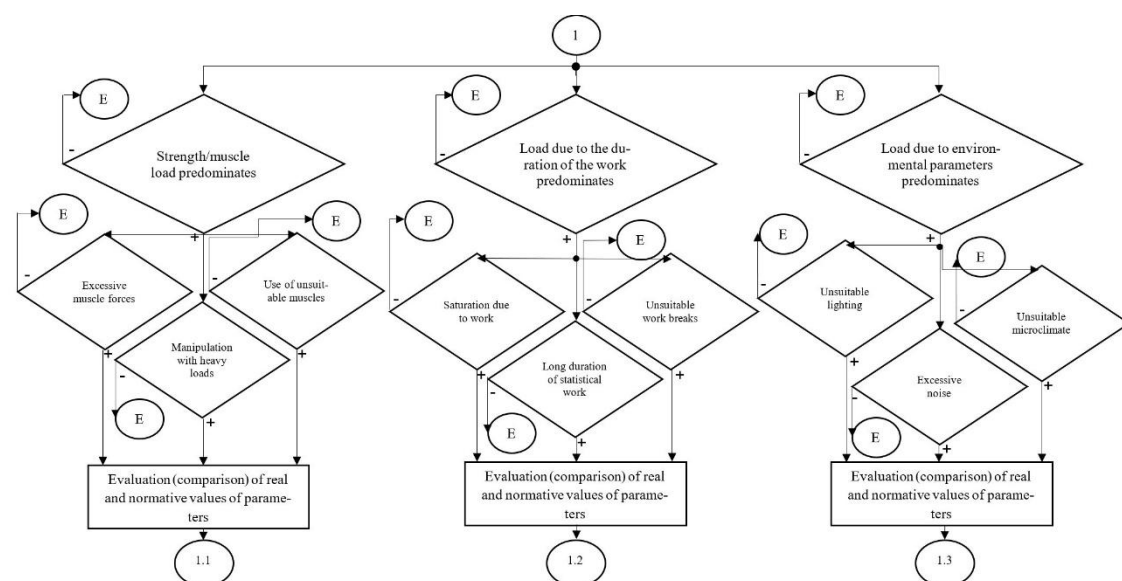


Fig.3 First-level classification of work processes into physical, mental and risk-intensive categories (authors)

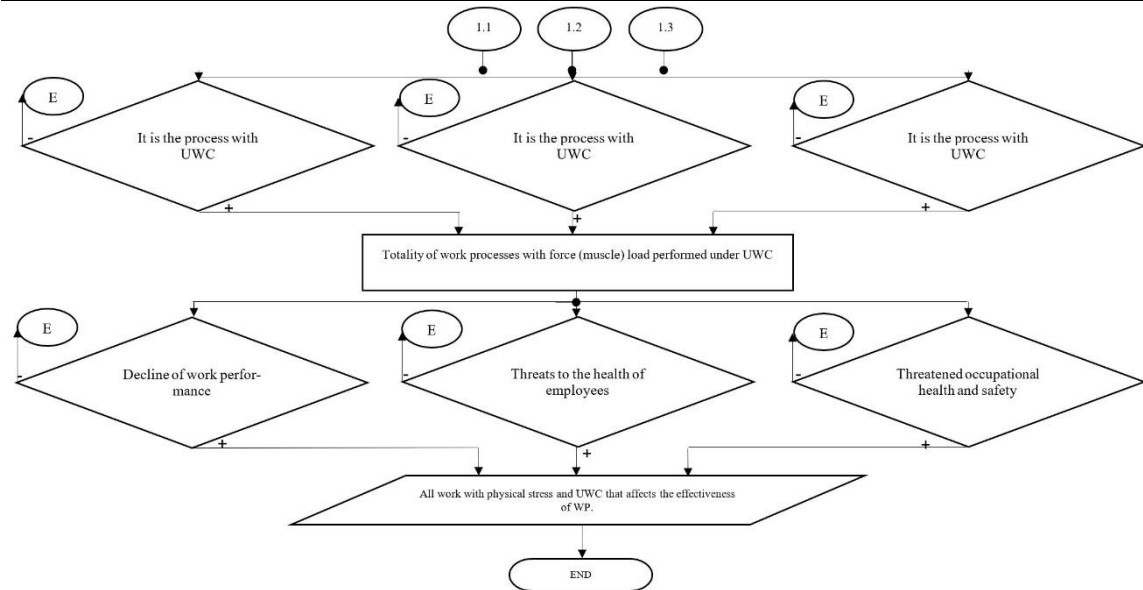


Fig. 4 Detailed assessment steps for physical work under UWCs (muscle/load, duration, environmental stress) (authors)

This study contributes both theoretically, by integrating SWOT and DMAIC in the context of UWCs, and practically, by providing a step-by-step framework for managers. Compared to recent works (Jia et al., 2025; Patalas-Maliszewska et al., 2025), this research offers an integrative and practice-oriented methodology.

The presented methodology for evaluating safety and effectiveness under unusual working conditions was validated through both theoretical insights and empirical evidence from surveys and observations in international companies, ensuring robustness and applicability.

#### 4. CONCLUSION

This study demonstrates that unusual working conditions have a significant impact on the health, performance, and sustainability of the working environment of employees. The methodological approach considered takes into account various factors including, but not limited to, the physical environment, work organisation, social and economic aspects and psychosocial conditions. Similarly, the proposed methodology is intended to be available for further development and adaptation in other specific sectors. The paper clearly states its contribution, limitations, and directions for further research, aligning with common scientific evaluation criteria and ensuring both transparency and replicability.

Since this methodology has been designed for companies in the national or international sector, as well as for family or strategically managed sectors, these documents and basic knowledge are also integrated into practice and training. In international companies, the basics in the areas of risk, operations management, efficiency, effectiveness, and of course physical strain are already integrated into the training programme. There, not only is the theory taught, but also the mastery in practice is discussed based on case studies where this methodology has to be applied. For this reason, one of the pilot companies decided to expand the “Team Schmacher Academy” programme to include training courses such as risk management, operations management, communication, stress management, etc. This allows the teaching and implementation of this methodological process



in its entirety, which strengthens the overall success at every level of the company. The proposed framework offers actionable guidance for managers and practitioners by linking risk assessment directly with effectiveness evaluation under dynamic work conditions.

The methodology design takes into account several factors such as the physical environment, work organisation, social and economic aspects and psychosocial conditions, which are integral to achieving the Sustainable Development Goals and promoting decent work as part of the 2030 Agenda. By aligning workplace practices with Sustainable Development Goal 8 (SDG 8), the study supports the creation of safer, more resilient, and sustainable work environments. Despite being empirically validated mainly in the restoration industry, the methodology is adaptable and should be tested across other sectors in future research. Emerging trends in workplace design and management are expected to prioritise adaptability, employee well-being and the integration of smart technologies. At the same time, sustainable human resource management emphasises employee well-being, development and engagement as key factors for organisational satisfaction and resilience (Vranakova et al., 2024, Qamar et al., 2024, Schmacher et al., 2024). From an environmental perspective, Huk and Kurowski (2021) emphasise the importance of factors in the context of corporate social responsibility (CSR) at work. Veselovska et al. (2020) point out that the elimination of specific risks is essential for strengthening CSR according to international standards.

Based on the findings of this study, future research will focus on the evolving impact of technological advances in the future on working conditions, possible risks, and the organisational environment. As noted by Paulikova et al. (2022), new technologies, particularly in the area of human–robot collaboration, have considerable potential to improve occupational safety and improve product quality. Similarly, Khazieva et al. (2024) emphasise that integrating knowledge management systems with artificial intelligence can generate synergistic effects in optimising work processes and strengthening organisational resilience. Compared to recent studies, this research offers a more integrated and sector-adaptable methodology that bridges theory and practice in addressing unusual working conditions. While Jia et al. (2025) explore the psychological effects of AI in the workplace and Patalas-Maliszewska et al. (2025) focus on safety in human–robot collaboration, this study uniquely combines physical, psychosocial, and organisational factors into a unified framework applicable across industries. Furthermore, unlike Sajko et al. (2021) and Toso et al. (2025) who concentrate on CSR and AI-driven sustainability respectively, the present methodology provides a practical training model that embeds these principles into company-wide operations and strategic development. This holistic approach reinforces the novelty and practical relevance of the findings.

## ACKNOWLEDGEMENTS

This article is part of the research project VEGA no. 2/0013/24 ‘*Acceptance and use of innovations 4.0 in relation to cognitive gains and load in the context of sustainable development goals*’ and based on results of successfully finished project *SDG4BIZ*.

## REFERENCES

- Card, A.J., Ward, J.R., Clarkson, P.J., 2012. *Beyond FMEA: The structured what-if technique (SWIFT)*. Journal of Healthcare Risk Management, 31(4), 23–29. DOI: 10.1002/jhrm.20101
- Chigbu, B.I., Nekhwevha, F., 2023. *Exploring the concepts of decent work through the lens of SDG 8: Addressing challenges and inadequacies*. Frontiers in Sociology, 8, 1266141. DOI: 10.3389/fsoc.2023.1266141

- Czajkowska, A., Ingaldi, M., 2021. *Structural failures risk analysis as a tool supporting corporate responsibility*. Journal of Risk and Financial Management, 14(4), 187. DOI: 10.3390/jrfm14040187
- Gul, M., 2018. *A review of occupational health and safety risk assessment approaches based on multi-criteria decision-making methods and their fuzzy versions*. Human and Ecological Risk Assessment, 7, 1723–1760. DOI: 10.1080/10807039.2018.1424531
- Green, F., Felstead, A., Gallie, D., & Henseke, G., 2021. *Working still harder*. ILR Review, 75(2), 458–487. DOI: 10.1177/0019793920977850
- Hatlar, K., Fidlerová, H., Sakál, P., 2018. *Ergonomic programs based on the HCS model 3E as integral part of sustainable CSR strategy*. In New Trends in Process Control and Production Management. CRC Press, pp. 169–174. DOI: 10.1201/9781315163963-34
- Huk, K., Kurowski, M., 2021. *The environmental aspect in the concept of corporate social responsibility in the energy industry and sustainable development of the economy*. Energies, 14(18), 5993. DOI: 10.3390/en14185993
- James, S.M., Honn, K.A., Gaddameedhi, S., Van Dongen, H.P.A., 2017. *Shift work: Disrupted circadian rhythms and sleep—Implications for health and well-being*. Current Sleep Medicine Reports, 3(2), 104–112. DOI: 10.1007/s40675-017-0071-6
- Jia, J., Ning, X., Liu, W., 2025. *The consequences and theoretical explanation of workplace AI on employees: a systematic literature review*. Journal of Digital Management, 1(14). DOI: 10.1007/s44362-025-00016-3
- Khazieva, N., Pauliková, A., Chovanová, H. H., 2024. *Maximising Synergy: The Benefits of a Joint Implementation of Knowledge Management and Artificial Intelligence System Standards*. Machine Learning and Knowledge Extraction, 6(4), 2282–2302. DOI: 10.3390/make6040112
- Kvitkina, M., Pushenko, S., Staseva, E., 2023. *The method of assessing occupational risk based on the materials of a special assessment of working conditions*. E3S Web of Conferences, 381, 01090. DOI: 10.1051/e3sconf/202338101090
- Markova, P., Homokyova, M., Prajova, V., Horvathova, M., 2023. *Ergonomics as a tool for reducing the physical load and costs of the company*. MM Science Journal, 2023(5). DOI: 10.17973/MMSJ.2023\_12\_2023132
- Meltser, A.V., Yakubova, I.S., Erastova, N.V., Kropot, A.I., 2022. *Assessment of occupational a priori health risk at the workplace*. Hygiene and Sanitation, 101(10), 1195–1199. DOI: 10.47470/0016-9900-2022-101-10-1195-1199
- Mesarosova, J., Martinovicova, K., Fidlerova, H., Hrablik Chovanova, H., Babcanova, D., Samakova, J., 2022. *Improving the level of predictive maintenance maturity matrix in industrial enterprise*. Acta Logistica, 9(2), 183–193. DOI: 10.22306/al.v9i2.292
- Patalas-Maliszewska, J., Łosyk, H., Dudek, A., 2025. *Improving safety in human–robot collaboration towards sustainable production in Industry 5.0*. Journal of Intelligent Manufacturing. DOI: 10.1007/s10845-025-02676-4
- Paulikova, A., Chovancova, J., Blahova, J., 2022. *Cluster modeling of environmental and occupational health and safety management systems for integration support*. International Journal of Environmental Research and Public Health, 19, 6588. DOI: 10.3390/ijerph19116588
- Qamar, F., Afshan, G., Rana, S.A., 2024. *Sustainable HRM and well-being: Systematic review and future research agenda*. Management Review Quarterly, 74, 2289–2339. DOI: 10.1007/s11301-023-00360-6
- Sajko, M., Boone, C., Buyl, T., 2021. *CEO Greed, Corporate Social Responsibility, and Organizational Resilience to Systemic Shocks*. Journal of Management, 47(4), 957–992. DOI: 10.1177/0149206320902528
- Schmacher, B., Fidlerova, H., 2024. *Methods for evaluating and classifying work conditions according to risks and effectiveness*. In MMK 2024. Magnanimitas, Hradec Králové, Czech Republic, pp. 879–887. ISBN 978-80-87952-41-2.
- Stamatis, D.H., 2003. *Failure Mode and Effect Analysis: FMEA from Theory to Execution*. ASQ Quality Press, Milwaukee, WI, USA. ISBN 0873895983.

- Tosetto, D., Zangiacomi, A., Nettleton, D.F., Perin, G., Fornasiero, R., 2025. *Leveraging AI Data Analytics Methodology for Social Sustainability of Working Environments: An Integrated Framework*. In *Hybrid Human-AI Collaborative Networks*, IFIP AICT 770, pp. 500–519. DOI: 10.1007/978-3-032-05673-3\_30
- Veselovska, L., Zavadsky, J., Zavadska, Z., 2020. *Mitigating bribery risks to strengthen the corporate social responsibility in accordance with the ISO 37001*. *Corporate Social Responsibility and Environmental Management*, 27(4), 1972–1988. DOI: 10.1002/csr.1909
- Vraňáková, N., Stareček, A., Babel'ová, Z.G., 2024. *Evaluation of HRM processes digitalisation by different genders*. *Entrepreneurship and Sustainability Issues*, 12, 333–347. DOI: 10.9770/e3652964232