

Assessment of Emerging Risks – is the INCDPM Method, Appropriate for the Assessment of Emerging Risks?

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Abstract. *The rapid evolution of digital technologies has involved a series of important changes throughout society, in everyday life, but also in the evolution of organizations. Organizations' adoption of Industry 4.0 technologies has also given rise to the emergence of new and emerging risks for worker safety and health. These risks reflect the changes in the work environment driven by automation, extended connectivity and the introduction of cutting-edge technologies like the Internet of Things (IoT), data analytics, artificial intelligence, cloud computing and others into the organization's processes. In order to minimize the impact of these digital technologies on workers, it is essential to carry out the procedure of identifying and assessing potential occupational risks before the implementation / introduction of new digital technologies. Identifying risks, clarifying their nature in detail, identifying potential impact and likelihood of materialization, is an essential process for identifying and effectively implementing risk response strategies, ensuring that organizations manage risks in an adaptive and strategic way. Several tools, methods and work methodologies are available to identify, analyze and assess occupational injury and disease risks to which workers are exposed. The purpose of this study is to carry out a careful analysis of the method for assessing the risks of occupational injury and illness elaborated by the National Research and Development Institute for Labor Protection "Alexandru Darabont" from Bucharest, Romania - to identify the limitations and disadvantages of the method, for determine whether it is appropriate for assessing new, emerging risks linked to recently introduced processes and technologies in the context of organizations' integration of digital technologies.*

Keywords: risk assessment, risk identification, digitalisation, emerging risks, occupational health and safety, workplace, I.N.C.D.P.M.

Introduction

Industry 4.0, through the extensive use of digital technologies in all organizational aspects (from smart sensors and the Internet of Things (IoT) to cyber systems or data analysis), brings with it a series of significant and profound transformations that it fundamentally affects how processes are designed, managed and carried out within organizations.

EU-OSHA by including in the list of OSH research priorities the impact of work on digital platforms, the automation of work tasks, remote or hybrid work, the impact of the use of intelligent digital systems, etc., recognizes the importance of addressing issues related to technology in the context of worker health and safety, thus reflecting the changing realities of the modern work environment. EU-OSHA recognizes the complexity and dynamics of changes in the work environment and encourages organizations to adopt strategies to protect the welfare and security

of workers in the face of new challenges (<https://healthy-workplaces.osha.europa.eu/en/about-topic/priority-areas>).

For the proper management of emerging risks in the field of safety and health at work, it is essential that organizations adopt a proactive strategy to identify, analyze and manage all identified risks from the design and implementation phase of technology, products or processes. It is important to continue efforts to identify and manage new and emerging risks to ensure the well-being and safety of workers as the industry evolves and changes (as the transition is made from specialized work to unusual, complex and digitized work tasks).

At the national level, in most fields of activity, the most frequently used method for evaluating the risks linked to occupational injury and illness is the method developed by the "Alexandru Darabonț" National Research and Development Institute for Labor Protection in Bucharest, Romania (I.N.C.D.P.M. method) - I.N.C.D.P.M. ("Institutul Național de Cercetare-Dezvoltare pentru Protecția Muncii" (name used in Romanian) - National Research-Development Institute for Labor Protection).

The I.N.C.D.P.M. method was approved by the Romanian Ministry of Labor and Social Solidarity in 1993. Until this moment, this evaluation method was and is used in most sectors of activity in Romania. However, as a result of the technological evolution, the development of management systems and following the practical application of this evaluation method, a series of gaps were identified. For this reason, I considered it necessary to carry out this study, to carry out additional investigations to identify and centralize the aspects that need to be clarified, in order to adapt this method to be appropriate to current requirements/needs, including in the assessment of emerging risks associated with the use of new digital technologies.

Thus, the following objectives were established for this study:

1. Identifying the limitations and disadvantages of the I.N.C.D.P.M. evaluation method, to determine whether it is appropriate for assessing new, emerging risks associated with new processes and technologies in the context of organizations' integration of digital technologies; identifying the weak points of this method, including in terms of addressing emerging risks;
2. Identifying and proposing a set of strategic measures in order to adapt the I.N.C.D.P.M. assessment methodology, to be adequate in assessing the emerging risks associated with the use of new digital technologies.

The research begins with a concise overview of the research methodology, subsequently presenting the outcomes derived from analyzing scientific literature and applying the method in practical terms. The last section is devoted to the presentation of the conclusions resulting from this study, as well as to the proposal of suggestions for a prospective research direction.

Methodology

This study has a theoretical approach. It is based on our own professional experience, the data collected following the practical application of this evaluation method in a very wide area of activity sectors and personal observations related to this research topic.

For this study, in order to identify the relevant research carried out regarding the professional risk assessment method elaborated by I.N.C.D.P.M., a search was carried out in the scientific literature by using the Web of Science - Core Collection and Scopus databases (due to the scientific relevance of these databases).

In order to narrow down the search results, a series of document filtering criteria were applied, using keywords: risk assessment, emerging risks, risk assessment, digitalisation, risk assessment, I.N.C.D.P.M. Regarding the analysis of the limitations and disadvantages of the I.N.C.D.P.M. evaluation method, only 2 publications addressing this topic were identified.

The conclusions obtained from this study formed the basis for identifying and proposing a set of strategic measures in order to adapt the I.N.C.D.P.M. assessment method, to be suitable including for the assessment of emerging risks associated with the use of new digital technologies.

Results and discussion

With the adoption by organizations of the specific technologies of Industry 4.0, the studies conducted indicated that the technological evolution, respectively the integration of digital technologies within the organizational processes (Cioca et al., 2011), involves new "emerging" risks on the security and health of workers, which can lead to occupational disease.

According to the ISO/TS 31050:2023 standard "*Risk management - Guidelines for managing an emerging risk to enhance resilience*", "*emerging risks are characterized by their newness, insufficient data, and a lack of verifiable information and knowledge needed for decision-making related to them*" (<https://www.iso.org/obp/ui/en/#iso:std:iso:ts:31050:ed-1:v1:en>).

In the context of occupational safety and health, new "emerging" risks refer to threats or hazards that may appear unpredictably or evolve over time, having the ability to influence the safety and health of workers. These risks can be generated by different causes, such as:

- the implementation of new technologies in work processes, as a result of the orientation of enterprises towards innovation;
- evolution of work processes, modification of existing technologies, processes, products or services (Moraru, 2023);
- the emergence of new sources of risk, previously unknown;
- changes in the organizational culture of the enterprise (e.g. changes in the work environment, reduction or reorganization of staff activity, emergence of new professions);
- extreme phenomena related to climate change (e.g. extreme temperatures, severe weather events), etc.

The process of identifying and assessing occupational injury and disease risks is an essential aspect of occupational risk management.

Considering the fact that occupational health and safety legislation varies according to the country and the field of activity, a very wide variety of tools and methods are used at the global and national level for the procedure of identifying and evaluating the risks of occupational injury and illness (Rotaru & Cioca, 2024). In 2020, the Royal NLR - Netherlands Aerospace Center made a centralization and a concise overview of 866 methods and techniques that can be used to carry out a safety assessment (Mariken et. al., 2022). Table 1 shows the main tools/methods used for the process of identifying and evaluating occupational risks.

Table 1. The process of identification and assessment of occupational risks – frequently used tools/methods

Hazard identification	Risk analysis	Risk assessment
- brainstorming - structured or semi-structured interviews	- brainstorming - cause-effect analysis (ISHIKAWA diagram)	- root cause analysis - the risk assessment matrix - evaluation of the reliability of the human factor

Hazard identification	Risk analysis	Risk assessment
- direct observations (dynamic risk assessment) - checklist - scenario analysis - cause-effect analysis (ISHIKAWA diagram) - preliminary risk / hazard analysis - analysis of protection levels (LOPA) - SWOT analysis	- the structured technique "What if ..." (SWIFT) - analysis of failure modes and effects (FMEA) - root cause analysis - multicriteria analysis of the decision (MCDA) - analysis of protection levels (LOPA) - event tree method - the decision tree method - hazard and operability study (HAZOP) - Heinrich's pyramid - business impact analysis	- the preliminary risk analysis method (PHA) - analysis of failure modes and effects (FMEA) - Bow-Tie analysis - Monte Carlo simulation method - Bayesian statistics and Bayesian systems - multicriteria analysis of the decision (MCDA) - the INCDPM method for assessing occupational injury and illness risks - the decision tree method - sequential analysis of events (ETA) - hazard and operability study (HAZOP)

Source: Authors' own research (Moraru, 2023; Mariken et al., 2022).

It has also been observed that digitalization reduces the risk of injury to workers, but generates new risks that, over time, can lead to occupational illness. The generic identification of risks specific to Industry 4.0 was carried out following an analysis of several digital solutions integrated within organizations (intelligent digital systems, work automation and robotics, remote or hybrid work, artificial intelligence, work on digital platforms). These digital solutions were selected and analyzed considering that they are the most frequently implemented. Figure 1 summarizes the main occupational injury and disease risks specific to Industry 3.0. and Industry 4.0 (Milea & Cioca, 2024).

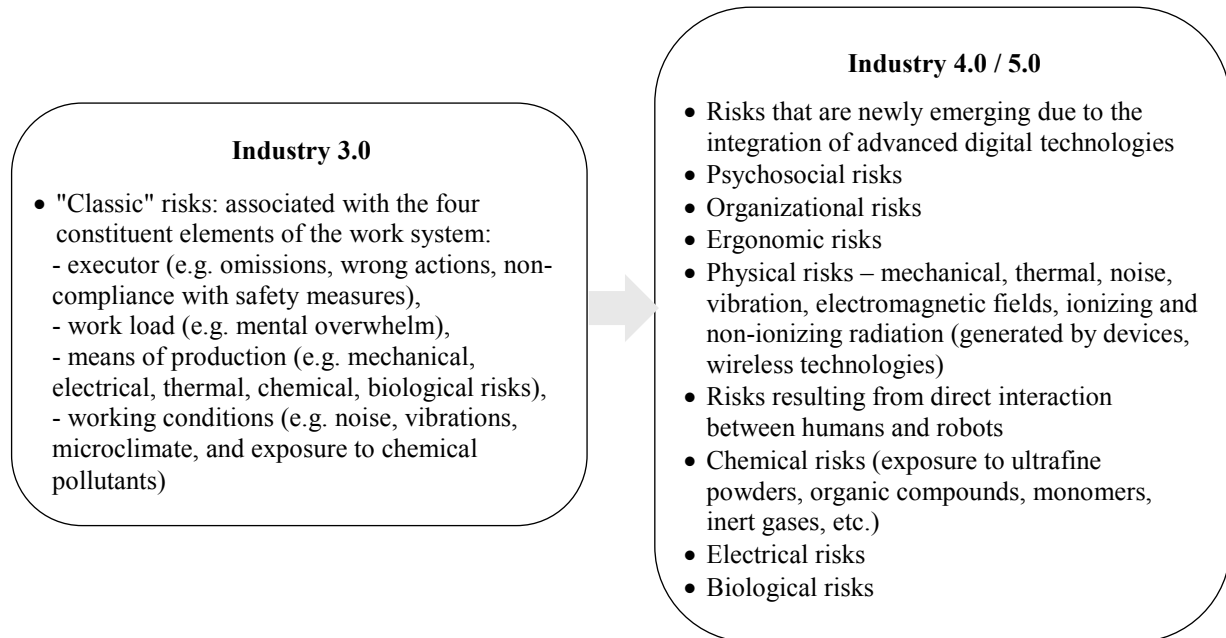


Figure 1. Specific risks within the contexts of Industry 3.0 and Industry 4.0

Source: Adaptation after (Milea & Cioca, 2024).

Research findings in scientific literature have highlighted the concern among occupational safety and health experts about the influence of new digital tools on the physical and mental well-being of workers, given the complexity and variability of issues associated with the intensive use of technology in the modern work environment.

To minimize the impact on workers, it is essential to carry out the procedure of identifying and evaluating potential occupational risks before the implementation / introduction of new digital technologies. Identifying risks, clarifying their nature in detail, identifying potential impact and likelihood of materialization, is an essential process for identifying and effectively implementing risk response strategies, ensuring that organizations manage risks in an adaptive and strategic way (Ivascu & Cioca, 2019)(Costantino et al., 2021).

The method for assessing professional risks elaborated by the "Alexandru Darabonț" National Research-Development Institute for Labor Protection from Bucharest (the I.N.C.D.P.M. method) is a comprehensive and structured method of risk analysis, which is based on the detailed analysis of the work system, examining each aspect of the system separately (executor, tools/equipment, workload, and working conditions) to fully identify all risk factors involved.

In order to identify risk factors within the analyzed system, the method relies on employing predefined checklists. Subsequently, each identified risk factor is individually examined, and the quantification of risk is performed by integrating the severity and frequency of the potential consequences, resulting in a partial risk level. The overall risk level of the examined system is determined through the application of a weighted average of the partial risk levels. (Pece & Dăscălescu, 1998). Through this approach, a more detailed and accurate assessment of the impact and probability of each identified risk is obtained.

Figure 2 summarizes and presents the stages of this evaluation method, as well as the tools utilized for work.

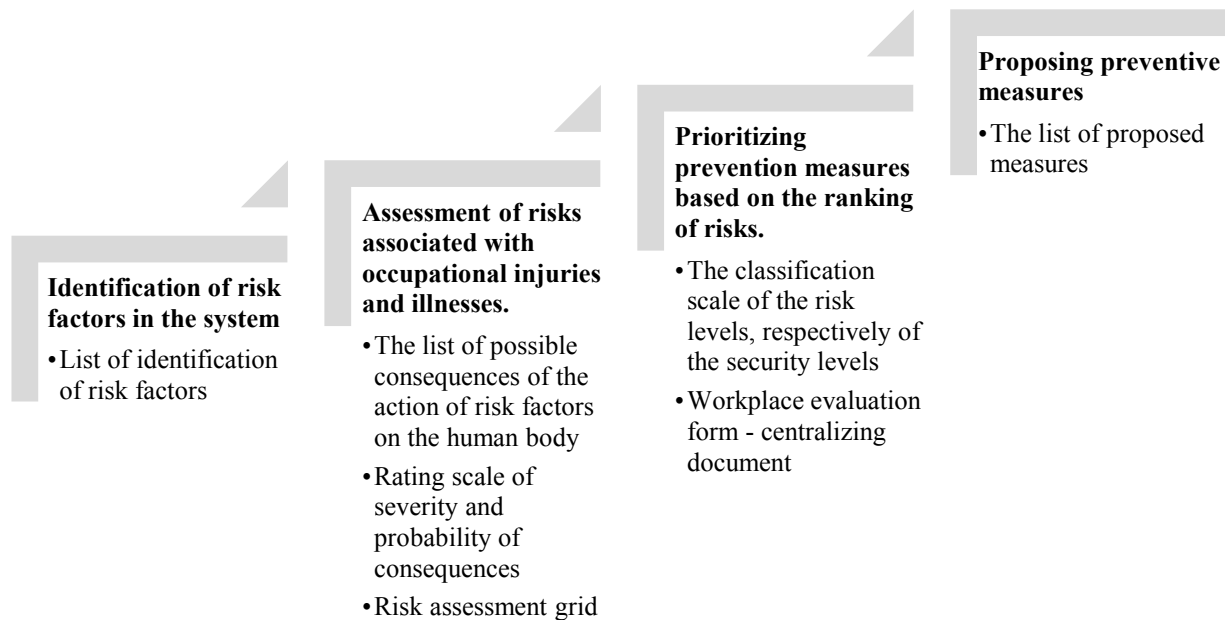


Figure 2. The stages of the I.N.C.D.P.M. method and working tools used

Source: Adaptation after (Pece & Dăscălescu, 1998).

A detailed presentation of this evaluation method was not included in this study, the study being focused on identifying the limitations and disadvantages of this method.

Following the rigorous analysis and practical application by the authors of this method for evaluating the risks associated with occupational injuries and illnesses elaborated by I.N.C.D.P.M. Bucharest in a wide area of activity sectors (food industry, automotive industry, textile industry, wood industry, manufacturing of paper and paper products, trade, health, etc.), a number of limitations and disadvantages have been identified:

- a) The evaluation method is not applicable for all fields of activity, considering the fact that: each field of activity is different; is subject to specific regulations and standards; presents unique characteristics, with specific work equipment, technologies and processes; involves unique and specific risks, etc. In complex or interdisciplinary fields of activity, the application of this evaluation method is not adequate/sufficient for all their specific aspects.
- b) The method has a subjective character (Băbuț & Moraru, 2017):
 - The results obtained from the occupational injury and disease risk assessment process may differ between different analysis teams or assessors. These variations may be possible, being influenced by several aspects, such as: a different interpretation or perception of risks, depending on the evaluators' experience, their technical knowledge, context and other factors; different access to information and data sources, which can influence the risk identification and assessment process; different approaches to risk analysis (use of own experience, intuition, mathematical models, etc.) which can lead to varied outcomes, etc.;
 - The analysis and evaluation team must classify each risk identified according to the severity of the consequences and the probability of their occurrence, in one of the classes of severity, respectively of probability. This estimate can be quite difficult to achieve. For the calculation of the probability of occurrence of the estimated consequences, it is necessary to choose the right method according to the situation, and it is also necessary to use a sufficiently large and representative data set;
- c) The identification list of risk factors is insufficiently detailed, i.e. it does not include risks specific to all fields of activity (for example, it does not include risks specific to activities in the chemical environment). This is because each industry has its own unique characteristics, requirements and challenges, and the associated risks can vary considerably between industries.
- d) The identification list of risk factors does not include new, emerging risks associated with new processes and technologies used, within the framework of organizations incorporating digital technologies. For example, it does not include risk factors such as:
 - psychosocial risks associated with reduced social interaction, reduced interpersonal contact, direct contact with colleagues or the employer (in the case of remote or hybrid workers); psychosocial risks generated by the feeling of insecurity, job insecurity;
 - psychosocial risks due to changes in work tasks, automation or semi-automation of some technological operations, due to increased interaction with digital systems, etc. (Ramos et al., 2022);
 - the tendency to intensify work in the case of workers who carry out their activity remotely or hybrid (in a workplace other than the one organized by the employer);
 - "techno addiction" as a result of the tendency to use digital technologies excessively (Cazan, 2020);
 - "technostress" - a form of stress associated with the utilization of digital technologies, manifested in the case of workers through feelings of anxiety, frustration, skepticism, etc. (Dragano & Lunau, 2020);

- ergonomic risks generated by improper organization of the workplace (Drăghici & Căruțașu, 2020);
 - risks arising in the case of carrying out activities in unfavorable atmospheric conditions (in the case of work on digital platforms);
 - risks generated by human-machine interaction (Lindholm et al., 2020; Abdrakhmanov et al., 2022);
 - physical risks (thermal, noise, vibrations, electromagnetic fields, radiation) generated by devices, by wireless technologies;
 - chemical risks (exposure to ultrafine powders, organic compounds, etc.);
 - violation of workers' right to confidentiality, to privacy, due to the growing trend of monitoring the workplace, monitoring the activity of workers (Abdrakhmanov et al., 2022), etc.
- e) The classification of workplaces according to the value of the overall risk level, calculated based on the calculation formula specific to the method, may differ from the human perception of the specific risks. Thus, a workplace less exposed to risks, with a low probability of producing consequences on the human body and of small or negligible gravity, may have a higher global risk level than another workplace more exposed to risks (Băbuț & Moraru, 2017);
- f) Existing practices have indicated that analysis and assessment teams, as well as persons responsible for occupational safety and health duties within organizations, focus their attention on the management of occupational risks that have been classified according to the risk/safety level classification scale, in a low (3) to maximum (7) risk level, neglecting risks in a very low (2) or minimal (1) risk level. Thus, the list of proposed measures, in most cases, does not include measures for the management of these identified risks. The lack of adequate management of all occupational risks, including those initially classified in severity classes with small or negligible consequences, or with a very rare or extremely rare probability of producing consequences, is likely to lead to their evolution over time, generating secondary effects or more significant consequences for the well-being and safety of workers;
- g) The evaluation method elaborated by I.N.C.D.P.M. Bucharest does not integrate the criteria outlined in the occupational health and safety management system according to the EN ISO 45001:2018 / EN ISO 45001:2023 standard – an important aspect that will ensure that the risk assessment within the organization is complete and that all aspects of employee health and safety are adequately addressed.

After evaluating the chosen method, a series of strategic measures was formulated that we recommend to be analyzed in order to adapt this method to the current legislative and management requirements. These improvement measures/recommendations were summarized in Table 2:

Table 2. Recommendations for improving the method elaborated by I.N.C.D.P.M. Bucharest

Stage	Recommendations for improving the method
	1. Adaptation of the evaluation method to be more flexible and adaptable / applicable in as wide an area as possible of fields of activity, by taking into account the specifics of each field of activity, taking into account its unique characteristics and the particularities of the risks involved; by considering the objectives and desired results, the level of complexity, the available resources, the cultural and organizational context.

Stage	Recommendations for improving the method
	2. Involvement in the assessment process and relevant stakeholders (from IT, information security, HR and other key people) who can bring a more comprehensive perspective on the risks associated with new digital technologies.
Identification of risk factors	3. Updating the identification list of risk factors, by including new, emerging risks linked with the new processes and technologies used, within the framework of organizations incorporating digital technologies; the possibility of rapid inclusion of new emerging risks and its adaptation according to the specifics of new technologies. This aspect involves: - consulting specialists and professionals in the respective field to identify and assess specific risks and their implications; - examining previous incidents in the field to identify trends in terms of risks and their impact; - regularly reviewing and updating the list of risk factors to reflect changes in the economic environment, in regulations or in other conditions that could affect the risks associated with the field of activity; - the possibility of rapid inclusion of new emerging risks and its adaptation according to the specifics of new technologies, etc.
Assessment of risks associated with occupational injuries and illnesses.	4. To reduce the variations that may occur in the evaluation of occupational injury and disease risks by different review teams or assessors, it is essential to establish a clear methodology, use standardized tools and techniques (these will help to ensure consistency between risk assessments); 5. Identification / development of a simple and objective method for fitting the identified risk factors into a class of probability of occurrence of an event, to be used when relevant statistical data sets are not available, for the calculation of the probability.
Ranking of risks and establishing prevention priorities	6. In order to clarify the anomaly that occurs when classifying workplaces according to the value of the global risk level, some specialists have proposed the method of improving the evaluation method by equalizing the number of identified risk factors for all evaluated workplaces. Thus, it is recommended to eliminate the risk factors with a partially low risk level or to add a number of hypothetical risk factors, with a risk level equal to 1 (Băbuț & Moraru, 2017).
Proposing preventive measures	7. The adopting by organizations of a proactive approach to occupational risk management, by dealing with all identified risks, including those initially classified as having low or negligible consequences, or with a very rare or extremely rare probability of consequences, to prevent their evolution over time and the generation of more significant consequences on the safety and health of workers; 8. Periodic re-analysis / updating of the professional risk management process, taking into account the fact that they can evolve over time due to the change / evolution of technologies, work processes, environmental conditions, etc.
	9. Incorporating the requirements of the occupational health and safety management system outlined in the EN ISO 45001:2023 standard, into the evaluation method developed by I.N.C.D.P.M. Bucharest. This aspect is necessary: - to ensure the organization's compliance with the relevant legislation and regulations; - for the creation of a coherent and efficient framework for occupational health and safety management; - to establish specific occupational health and safety objectives; - for the continuous improvement of performance in the field of occupational health and safety by monitoring and regularly reviewing the management system, etc. thus contributing to the improvement of workers' working conditions and the reduction of occupational risks.
	10. Integration of digital technologies in the evaluation process: - predictive analysis, to identify patterns and trends based on existing data, which can help anticipate and prevent future risks; - artificial intelligence, for the automation of risk assessment processes, thus reducing the dependence on human assessment and possible associated errors;

Stage	Recommendations for improving the method
	- digital modeling and simulation technology, to create virtual scenarios and assess the impact of different risks in a controlled environment; - digital platforms for collaboration and communication, to facilitate the exchange of information between different teams and departments involved in the risk assessment process; - other digital tools.
	11. Integrating tools and indicators to measure risk management performance over time. This helps to evaluate the effectiveness of the adopted strategies and measures and to adjust them if necessary.
	12. Documenting and reporting assessment results in a clear and accessible way to facilitate understanding and communication of risks and prevention measures (response plans) - integration of the evaluation method into a software program specialized in risk management, which includes tools for documenting, evaluating and reporting risks.

Source: Authors' own research.

By addressing these measures/recommendations, the occupational risk assessment method can provide a solid framework for managing emerging risks associated with digital technologies in an efficient and adaptive way.

Conclusions

Technological innovation involves a series of rapid and continuous technological changes; involves a number of opportunities and benefits toward the sustainable development of organizations, but also significant challenges, which must be properly addressed, through a constant review of well-established practices and activities, to guarantee the organization's ability to adjust and prosper in an ever-evolving environment.

The contribution made by this study consists in:

1. Critical analysis of the I.N.C.D.P.M. evaluation method, to identify limitations and disadvantages; to identify the weaknesses of this method in terms of its accuracy, relevance, applicability and effectiveness, including in terms of addressing emerging risks;
2. Proposing a set of strategic measures in order to adapt the I.N.C.D.P.M. assessment method, for its improvement and optimization, to be adequate in the assessment of emerging risks associated with the use of new digital technologies.

These theoretical contributions aim to provide a more comprehensive understanding of the I.N.C.D.P.M. evaluation method, thereby contributing to the development and evolution of this method, including knowledge and practices in the field of risk assessment.

The introduction of new digital technologies, including robots, artificial intelligence, automation and other digital solutions, may introduce various new risks to the health and safety of workers. In this context, it is essential to evaluate the potential influence of these technologies on the safety and health of workers; it is essential identifying new and emerging health and safety hazards in a timely manner to ensure they are effectively managed.

Thus, it is necessary to re-analyze and update the methods as well as the tools used to identify and assess professional risks, by taking into account the new, emerging risks that have appeared in the context of incorporating digital solutions. Also, for a correct approach to these risks, it is necessary to analyze and take into account the following aspects:

- It is essential to anticipate the potential effects of new technologies and identify emerging hazards before they become concrete threats (for example by using simulation tools, which are an effective method to assess and anticipate working conditions or interactions in a work

environment) (Costantino et al., 2021). By implementing proactive strategies by organizations, appropriate preventive measures can be taken and processes can be optimized, before facing real situations, to minimize the impact on workers and avoid possible negative consequences;

- It is also very important to analyze the risks that can result from the interconnection of the digital technologies used. The simultaneous use of several technologies can lead to a cumulative impact, either in the sense of increasing efficiency or in the sense of creating new risks.

Future research directions:

We recommend further studies to develop robust systems (advanced models and methods) that address the specific challenges associated with the identification, assessment and management of occupational risks in the context of the integration of technological solutions. This could lead to significant improvements in security and occupational risk management in various application environments.

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