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BURNOUT AS AN OCCUPATIONAL SAFETY CHALLENGE IN INDUSTRY 4.0 CONTEXT

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Abstract: *In the Industry 4.0 context, where work is shaped by automation, artificial intelligence, remote work, and digital transformation, burnout is an increased challenge for occupational safety. Employees must adapt to fast-paced technological changes, digital overload, job displacement risks, and evolving skill requirements, all of which contribute to occupational stress and exhaustion. This literature review focuses on the main key factors contributing to burnout as an occupational safety challenge in the Industry 4.0 context and the main prevention and protection measures presented in specialized literature. The findings of this research are applicable to corporate leaders, HR professionals, policymakers, and technology developers, helping them design better strategies to balance technological progress and worker well-being.*
Keywords: *Burnout, Industry 4.0, Occupational safety, Key burnout predictors*

1. INTRODUCTION

Burnout syndrome is a persistent and often misunderstood challenge in modern European workplaces. Recent data indicate that nearly one in five employees in the EU experience exhaustion, a key symptom of burnout. Burnout is characterized by emotional exhaustion, depersonalization, and a reduced sense of personal accomplishment.

Problem Description

The huge negative impact that burnout has on the work and personal lives of professionals affects both the economy and public health of many countries, which led the World Health Organization (WHO) to include this syndrome in the 11th revision of the International Classification of Diseases (ICD-11) as a phenomenon that occurs in the professional context. [1]. In the Industry 4.0 context, where work is increasingly shaped by automation, artificial intelligence, remote work, and digital transformation, burnout is an important challenge for occupational safety. Employees must adapt to fast-paced technological changes, digital overload, job loss risks, and evolving skill requirements, all of which contribute to occupational stress and exhaustion. This literature review focuses on understanding the mechanisms that contribute to burnout in Industry 4.0 workplaces, their organizational impact, and preventive strategies through a systematic literature review.

Application Field

Burnout is a critical issue in various professional fields, particularly those experiencing rapid digital transformation. Industries integrating 4.0 technologies, such as manufacturing, IT, logistics, and healthcare, face increased challenges related to job automation, cognitive workload, and continuous connectivity. The findings of this research are applicable to corporate leaders, HR professionals, policymakers, and technology developers, helping them design better strategies to balance technological progress and worker well-being.

Objectives of research

Our study objectives were to identify the main key factors contributing to burnout as an

occupational safety challenge in the Industry 4.0 context and to identify the main prevention and protection measures presented in specialized literature. In consequences, our literature review was guided by the following research questions:

RQ1. What are the main key factors contributing to burnout as an occupational safety challenge in the Industry 4.0 context?

RQ2. What are the main prevention and protection measures presented in specialized literature?

2. LITERATURE REVIEW METHODOLOGY

A systematic literature review was performed using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology (fig.1) [2]. The review was guided by the research questions: „RQ1. What are the main key factors contributing to burnout as an occupational safety challenge in the Industry 4.0 context?" and „RQ2. What are the main prevention and protection measures presented in specialized literature?"

Database selection

To answer these questions and to ensure a good coverage of academic publications, a search was conducted, using a combination of keywords, in the main databases such as Web of Science and Scopus, along with reputable publishers including IEEE, Elsevier, Wiley, Springer, and Taylor & Francis [3].

Keywords selection

The next stage of the analysis focused on selecting relevant keywords, a very important step in identifying the scientific papers that approach burnout as an occupational safety challenge in the Industry 4.0 context.

Guided by the research objectives, the keyword selection process aimed to capture the key themes and emerging trends regarding the burnout in the industries that are most impacted

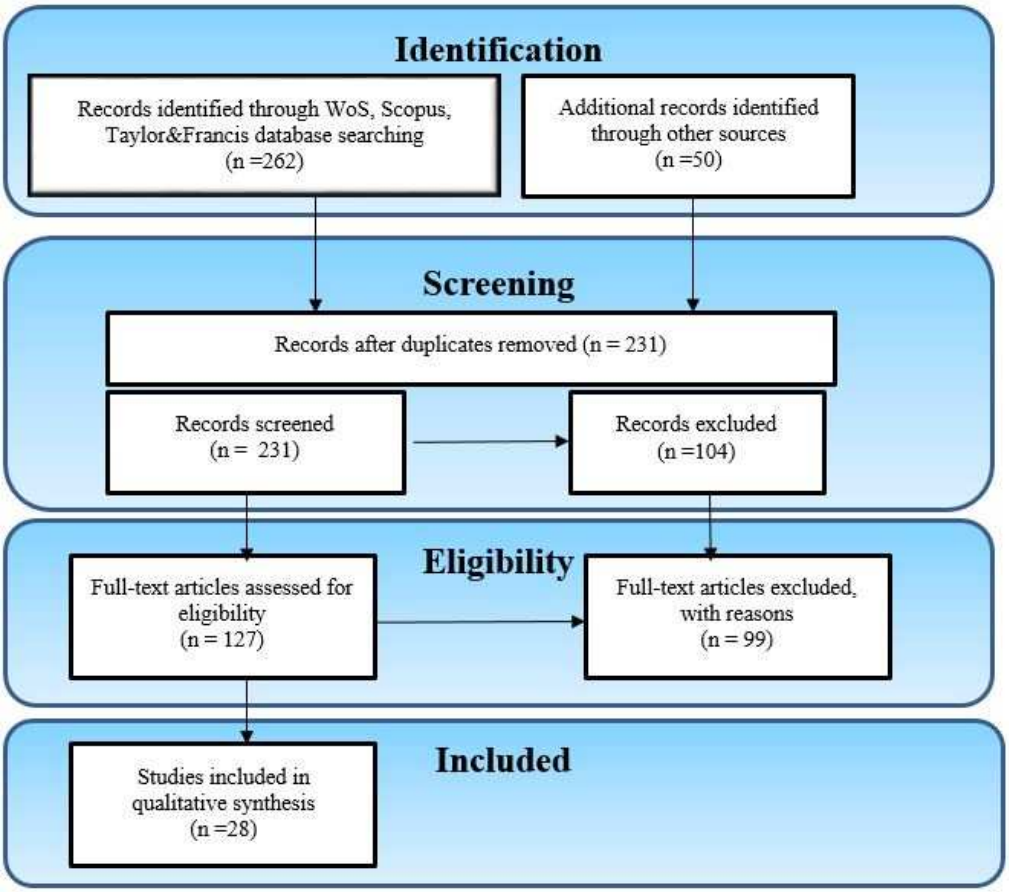

Fig. 1. PRISMA flow diagram

by Industry 4.0 advancements: IT, manufacturing, logistic. We used a series of keyword combinations systematically structured using Boolean operators (AND and OR). We also followed the specific syntax of each database to ensure comprehensive data retrieval. The AND operator was used to link keywords within the same category, while OR connected keywords across different categories.

In Scopus database, for example, we used the search engine syntagma: [TITLE-ABS-KEY] (burnout AND occupational safety AND workers AND Industry 4.0) [OR] [TITLE-ABS-KEY] (health AND safety AND burnout AND workers AND Industry 4.0).

In Web of Science we used the search engine syntagma: [TOPIC] (burnout workers in Industry 4.0) [OR] [TOPIC] (occupational safety for workers in Industry 4.0). [TIMESPAN] the las ten years 2015-2025

This method facilitated the inclusion of both singular and plural forms of terms, maximizing the retrieval of relevant publications. The search was designed to identify articles in which the specified keywords appeared in the title, abstract, or document metadata, ensuring the selection of the most relevant studies for our analysis.

Inclusion and exclusion criteria

*Inclusion Criteria***:** To ensure the relevance and accessibility of the selected literature, only publications written in English were considered. Additionally, to reflect the most recent advancements and research trends, the analysis was limited to studies published within the last 10 years. This time frame allows for a comprehensive review of current findings while maintaining historical context where necessary.

Exclusion Criteria: Publications that did not meet the language requirement, specifically those written in languages other than English, were excluded to maintain consistency and facilitate broader accessibility.

Furthermore, articles that were not openly accessible were omitted to ensure unrestricted availability of the reviewed studies. Additionally, conference papers and book chapters were excluded, as they often lack the rigorous peer-review process of journal articles.

3. RESULTS AND DISCUSSION

The study selection process began with the identification of 262 records from database searches; an additional 50 records were identified through other sources. After removing duplicates, and applied all our inclusion and exclusion criteria, we obtained 28 articles.

Novelty and research niche

The limited number of identified articles (28) in comparison to other fields reflects the novelty of this research domain. This finding suggests that while there is a growing interest in the topic, it remains underdeveloped, highlighting the need for further research.

The analysis of the reviewed studies indicates a growing interest within the scientific community in this topic. Notably, 70% of the research has been conducted in the last three years, highlighting a significant acceleration in academic engagement. This suggests that researchers are recognizing the urgency and relevance of the subject, likely driven by advancements in technology, evolving workplace dynamics, and emerging challenges associated with Industry 4.0.

The increasing volume of recent studies also reflects greater interdisciplinary collaboration, as experts from fields such as occupational psychology, human resource management, engineering, and digital transformation explore the implications of burnout and workplace stress [4].

In the reviewed studies we identified a series of key factors (called in this paper burnout predictors) contributing to burnout in Industry 4.0:

- Automation-related job insecurity and fears of workforce displacement [5].
- Digital overload and constant connectivity, leading to blurred work-life boundaries [6].
- High cognitive demands due to continuous learning and adaptation to new technologies [7].
- Reduced human interaction and increased isolation in remote and AI-driven work settings [8].
- Work intensification due to real-time monitoring and algorithmic management [9].

We analyzed these burnout predictors in three areas that will be most impacted by Industry 4.0: manufacturing, logistics, and IT [10].

Manufacturing Sector:

The integration of Industry 4.0 technologies in manufacturing, particularly robotic process automation (RPA), AI-driven production lines, and IoT-based efficiency tracking, will introduce new sources of stress and burnout among workers [11].

One of the primary concerns is job insecurity, as automation increasingly replaces manual tasks, leading to mental fatigue and anxiety about long-term employment stability [12]. Workers must also frequently reskill to keep pace with evolving technologies, adding additional pressure. Furthermore, real-time data analytics and AI-driven monitoring systems enforce strict efficiency targets, creating high-pressure production schedules with minimal downtime [13].

Employees will face continuous productivity demands, which can lead to physical and mental exhaustion [14]. The requirement to monitor and oversee automated systems may reduce physical labor but introduces cognitive fatigue, as workers must remain highly attentive to prevent errors in complex, fast-moving environments.

IT sector

The IT sector, at the forefront of Industry 4.0, faces significant burnout risks due to the intense cognitive demands, rapid technological changes, and an always-on work culture [15].

A major contributor to burnout is the high cognitive load required for continuous problem-solving, debugging, and software development. IT professionals must frequently adapt to new technologies, which adds to mental exhaustion and stress [16]. The fast-paced nature of the industry, combined with frequent software updates and evolving cybersecurity threats, demands constant learning and adaptation, increasing pressure on workers.

Additionally, IT roles are characterized by an "always-on" culture, where extended working hours, remote work, and immediate response demands contribute to digital burnout. Many employees struggle to disconnect after work, leading to work-life imbalance and chronic stress [17].

Further exacerbating burnout is job insecurity caused by outsourcing and automation. With the rise of AI-driven coding tools and cloud-based IT services, professionals worry about long-term job stability, increasing anxiety and workplace dissatisfaction.

Remote work, while offering flexibility, has also led to increased isolation among IT professionals. Reduced face-to-face interaction diminishes social support, increasing emotional exhaustion and feelings of disengagement.

An example of how workers in IT can be affected is the 2017 WannaCry ransomware attack. Infecting over 200,000 systems globally and severely disrupting critical infrastructure, particularly in healthcare, the attack's rapid spread exposed serious vulnerabilities, largely due to delayed system updates and insufficient preparedness [18].

A crucial yet often overlooked aspect of the incident was the immense cognitive burden on cybersecurity personnel tasked with managing the crisis. These employees faced overwhelming mental demands, as they were forced to analyze threats, implement countermeasures, and mitigate damage in real time, all while working under extreme urgency and high-stakes pressure. The relentless nature of the attack, coupled with prolonged working hours, intensified fatigue and increased the likelihood of errors, further complicating response efforts. This event highlighted the critical need for proactive cybersecurity strategies, including automating patch management to reduce human workload and enhancing resilience training to better equip cybersecurity teams for high-pressure scenarios.

Logistic sector

The logistics sector will undergone rapid transformation in the Industry 4.0 with the adoption of AI-driven logistics optimization, real-time tracking, and automated performance monitoring. While these technologies improve efficiency, they also contribute to heightened workplace stress and burnout [19].

A major stressor in logistics is the continuous demand for real-time tracking and AI-driven route optimization, which places constant pressure on employees to meet just-in-time delivery expectations [20]. The need for instantaneous decision-making and strict workforce monitoring systems leads to reduced

Table 1

Severity levels of key burnout predictors

Burnout Predictor	Manufacturing	IT	Logistics
Job Insecurity	**Value assigned: 8** (High, due to automation replacing manual labor)	**Value assigned: 6** (Moderate, due to AI coding tools)	**Value assigned: 7** (High, automation of warehouse and transport jobs)
Digital Overload	**Value assigned: 5** (Moderate, increasing use of IoT and data analytics)	**Value assigned: 9** (Very high, IT professionals face constant digital demands)	**Value assigned: 6** (Moderate, logistics tech but less constant exposure)
High Cognitive Demands	**Value assigned: 7** (High, workers must continuously upskill to use automation)	**Value assigned: 10** (Very high, rapid digital evolution and complex problem-solving)	**Value assigned: 5** (Moderate, needs operational adjustments but less mental strain)
Isolation	**Value assigned: 4** (Low, still significant human-machine interaction)	**Value assigned: 7** (High, many remote workers and coding tasks)	**Value assigned: 3** (Low, logistics often involves teamwork)
Work Intensification	**Value assigned: 9** (Very high, real-time monitoring, productivity targets)	**Value assigned: 5** (Moderate, workload peaks but flexibility exists)	**Value assigned: 8** (High, fast-paced environment with real-time tracking)

autonomy, making workers feel micromanaged and psychologically stressed.

Additionally, the sector is characterized by long shifts, repetitive tasks, and physically demanding work. Employees in warehousing, transportation, and distribution centers often endure high-paced order fulfillment processes, increasing the risk of both physical and mental exhaustion. These conditions are further exacerbated by seasonal workload fluctuations, where demand surges create unpredictable work conditions, leading to burnout and decreased well-being [21].

Severity levels of key burnout predictors

Based on scientific literature, industry reports, and observed trends in how Industry 4.0 is shaping workplace dynamics, we assigned severity levels to key burnout predictors. The values assigned (on a scale of 1 to 10, where 1 = low impact and 10 = very high impact) are estimated based on sector-specific challenges (table 1).

The bar chart represents the severity levels of key burnout predictors in Industry 4.0, across three major sectors: Manufacturing, IT, and Logistics (fig.2). The predictors analyzed are:

- Job Insecurity - Fear of job loss due to automation and AI.
- Digital Overload - Continuous exposure to digital tools, emails, and notifications.
- High Cognitive Demands - The mental effort required to learn and adapt to new technologies.
- Isolation - Reduced human interaction due to remote work, automation, or AI-driven processes.
- Work Intensification - Increased workload due to algorithm-driven efficiency and real-time monitoring

Burnout Prevention Strategies in Industry 4.0

To mitigate burnout in digitalized work environments, companies must adopt proactive strategies tailored to each industry's unique challenges [25]. Below are listed burnout prevention measures based on sector-specific stressors identified in our previous analysis (table 2).

General burnout prevention strategies across industries are as follows: work-life balance policies, mental health support, smart workload management, leadership training for burnout awareness, ergonomic and digital well-being practices [22], [26 - 27].

These findings are relevant to the scientific community, as they highlight how research on burnout in Industry 4.0 points to a shifting research focus, moving from traditional burnout models toward technology-driven stressors, automation-related job insecurity, and digital overload.

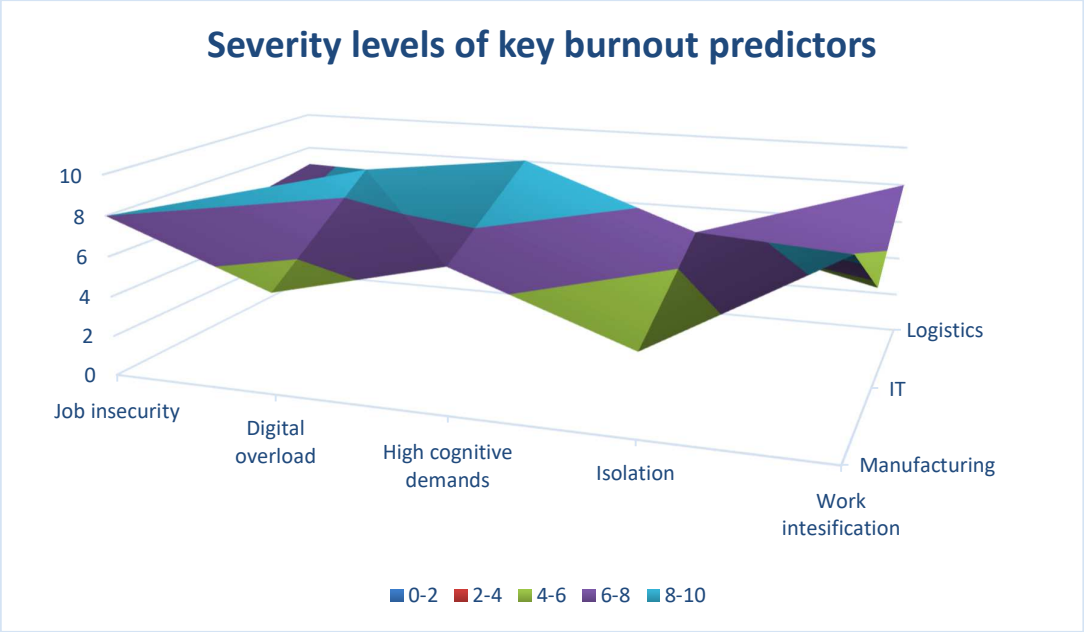

Fig. 2. Severity levels of key burnout predictors

Table 2

Industry-Specific Burnout Prevention Strategies

Industry	Issue Addressed	Challenges	Solutions
Manufacturing sector	Automation-related stress and work intensification	- Job insecurity due to automation. - High work intensification from real-time AI monitoring and productivity tracking. - Physical and cognitive strain from interacting with robotic systems	➔ Reskilling and upskilling programs - Invest in human-machine collaboration training to help workers adapt to AI-driven production lines. - Offer certification programs in digital literacy and smart manufacturing to increase job security. ➔ AI-Integrated workload balancing - Implement predictive maintenance AI to prevent sudden workload spikes and unrealistic productivity expectations. - Rotate workers between automated and manual tasks to prevent monotony and physical fatigue. ➔ Automated ergonomic monitoring - Wearable sensors to monitor worker fatigue and recommend breaks. - Use adaptive robotics that adjust to human movement patterns, reducing strain on operators.
IT sector	Managing digital overload, isolation, and cognitive demands	- Extreme digital overload and always-on work culture. - High cognitive strain from rapid tech advancements. - Remote work-induced isolation.	➔ Work-Life balance regulations for remote teams - Encourage asynchronous work policies to prevent digital burnout. - Implement AI-driven work prioritization to reduce unnecessary meetings and notifications. ➔ Automated stress monitoring - Use AI-driven well-being analytics to track signs of exhaustion and recommend breaks.

			- Provide mental health chatbots for real-time emotional support. ➔ Human-centric AI integration - Use AI to automate repetitive coding tasks, allowing IT professionals to focus on creative problem-solving. - Provide continuous learning support through AI-based adaptive learning modules to reduce cognitive strain. ➔ Hybrid work models with in-person collaboration •Organize on-site team-building events to strengthen social connections and combat isolation. •Foster co-working space partnerships for remote employees who need a structured environment.
Logistics sector	Coping with real-time tracking, performance monitoring, and workload fluctuations	- High-pressure environment due to real-time AI tracking and optimization. - Strict performance metrics create stress and reduce autonomy. - Long shifts and unpredictable workload fluctuations.	➔ Shift flexibility and task rotation - Introduce predictive shift scheduling AI to balance workloads efficiently. - Rotate workers across different tasks to reduce monotony and fatigue. ➔ Employee autonomy in decision-making - Empower logistics workers to adjust their schedules dynamically based on real-time traffic or warehouse conditions. - Implement AI-based real-time feedback loops that focus on improvement rather than punishment. ➔ Fatigue monitoring and recovery programs - Use wearable technology to track worker fatigue levels and automatically adjust shift recommendations. - Provide dedicated rest areas and recovery breaks for long-haul drivers and warehouse staff. ➔ Ergonomic enhancements in logistics workspaces - Design AI-assisted exoskeletons to reduce physical strain in warehouses. - Use automated vehicle routing AI to minimize unnecessary workload surges.

Preventing burnout in Industry 4.0 requires a combination of technological solutions and human-centered workplace policies. While automation and AI increase efficiency, they must be integrated to support, not replace, human workers [23].

Organizations that prioritize digital well-being, skill development, and flexible work policies will be the most resilient in the face of Industry 4.0 transformations [24].

4. LIMITATION, FUTURE RESEARCH

This study has several limitations related to the selection of industries taking into consideration. It focused only on IT, manufactures and logistics as sectors affected by burnout. Other sectors, as health, educations are also affected by burnout and their potential impact remains underexplored. Another limitation is the reliance on English-language

papers, which may exclude research published in other languages. This could lead to an incomplete perspective of burnout as occupational safety challenge in Industry 4.0 context. Future studies should consider multilingual sources to capture a more diverse range of findings.

Although the study acknowledges certain limitations, it also emphasizes the relatively novelty of this research domain. The limited number of identified articles (28) in comparison to more established fields reflects the early stage of scholarly exploration in this area.

This finding suggests that while there is a growing interest in the topic, it remains underdeveloped, highlighting the need for further research. Expanding contributions in this field would not only enhance theoretical frameworks but also provide practical insights, supporting the development of more effective strategies and applications.

Future research should further explore the intersection of Industry 4.0 and burnout, particularly regarding the burnout prevention strategies. The integration of burnout mitigation measures in diverse industrial 4.0 contexts remains an open challenge.

5. CONCLUSION

Our study focused on the main key factors contributing to burnout as an occupational safety challenge in the Industry 4.0 context and the main prevention and protection measures presented in specialized literature in the IT, manufactures and logistics sectors. The key factors analyzed were: Job Insecurity, Digital Overload, High Cognitive Demands, Isolation and Work Intensification.

In the manufacturing sector, the Work Intensification factor is very high (due to real-time monitoring, productivity targets) followed by Job Insecurity, which is also high, due to automation replacing manual labor. This is a case of logistic sector also, where Work Intensification and Job Insecurity are high due to automation of warehouse and transport jobs and fast-paced environment with real-time tracking. In the IT sector, Digital Overload and High Cognitive Demands factors are very high due to rapid digital evolution and complex problem-solving.

Preventing burnout in Industry 4.0 requires a combination of technological solutions and human-centered workplace policies. While automation and AI increase efficiency, they must be integrated to support, not replace, human workers. Organizations that prioritize digital well-being, skill development, and flexible work policies will be the most resilient in the face of Industry 4.0 transformations.

These findings help shape the future research agenda for Industry 4.0, underscoring the necessity of interdisciplinary collaboration that merges technological innovation with occupational health and safety considerations.

As Industry 4.0 continues to evolve, it is essential to explore how emerging technologies can be leveraged not only to enhance productivity but also to mitigate workplace risks and improve overall well-being. This calls for a holistic research approach that brings together experts from engineering, ergonomics, occupational health, and social sciences to develop comprehensive strategies that ensure both efficiency and worker protection in the digital era.

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Burnoutul ca provocare la siguranța ocupațională în contextul industriei 4.0

În contextul Industriei 4.0, unde munca este modelată de automatizare, inteligență artificială, muncă la distanță și transformare digitală, epuizarea profesională (burnout) reprezintă o provocare sporită pentru siguranța ocupațională. Angajații trebuie să se adapteze la schimbările tehnologice rapide, la supraîncărcarea digitală, la riscurile de pierdere a locurilor de muncă și la cerințele de competențe în continuă evoluție, toate acestea contribuind la stresul și epuizarea ocupațională. Această analiză a literaturii de specialitate se concentrează pe principalii factori cheie care contribuie la epuizarea profesională ca provocare pentru siguranța ocupațională în contextul Industriei 4.0 și pe principalele măsuri de prevenire și protecție prezentate în literatura de specialitate. Rezultatele acestei cercetări sunt aplicabile liderilor corporativi, specialiștilor în resurse umane, factorilor de decizie politică și dezvoltatorilor de tehnologie, ajutându-i să conceapă strategii mai bune pentru a echilibra progresul tehnologic și bunăstarea lucrătorilor.

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