

Towards a robust impact Evaluation of technological innovation Interventions on Occupational Safety and Health

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Abstract: Health and safety interventions implemented in the past often lacked detailed design and rigorous evaluation of their outcomes. Luckily, in recent years, there has been a gradual rethinking of intervention design and evaluation, leading to higher impactful measures in the field. Although much of the literature has focused on evaluating interventions – a crucial phase that not only monitors the success of a specific intervention but has also the potential to generate knowledge for future interventions to improve their design and implementation – most of it remains theoretical and not applied in reality. Therefore, this study aims to show the potential of introducing a national Occupational Safety and Health (OSH) initiative that assesses the multiple impacts of health and safety in the workplace through the evaluation of different interventions, which are not solely focused on OSH improvement, but also on promoting technological innovation through Industry 4.0 solutions. This initiative is part of a portfolio of research projects funded by the Italian National Institute for Insurance against Accidents at Work (INAIL, i.e., in Italian, ‘Istituto Nazionale Assicurazione Infortuni sul Lavoro’), which continuously subsidizes projects in different disciplines to improve workers’ well-being by increasing the global effectiveness of prevention activities. This study presents the initial stages of the initiative, including an analysis of the surrounding environment and the setting up of main variables according to a Programme Theory logic. The Programme Theory will enable the detection of the mechanisms that produce certain effects on the intervention's development. This perspective will help us understand how the success or failure of interventions is reached by studying the potential mechanisms – beneficial and detrimental – that affected the intervention's outcome.

Keywords: Occupational Safety; Occupational Health; Impact; Technological Innovation; Industry 4.0.

I. INTRODUCTION

Occupational Safety and Health (OSH) management has a pivotal role in running a successful business by developing a sustainable work environment. The health and safety of workers should be considered by companies as a pivotal component of their company’s financial success. Fortunately, an increasing number of employers are becoming aware that a healthier workforce costs companies less through lower healthcare costs hence, they increasingly focus on the health and safety needs of their workers by going beyond what is required for compliance and striving for an injury-free and healthy workforce [1]. As stated by Badri

et al. [2]: “A healthy business is now one in which OHS [Occupational Health and Safety] is regarded as an imperative”.

In the past, OSH interventions were not considered a priority for a company. Many organizations have implemented several types of interventions with the purpose to improve productivity, neglecting health and safety interventions, which were seen as a burden rather than added value. Fortunately, things are changing, and an increasing number of companies, recognizing OSH as an integral component of organizational management, are devoting higher attention, and allocating resources to OSH improvement.

The knowledge in this field is rapidly growing, but implementing proper OSH management at an operational level is not always straightforward due to changing technologies and work contexts [3]. OSH faces numerous challenges in the ever-changing work environment, including limited human, economic, and technological resources [4][5]. New methodologies for OSH management and communication are required to keep up with the times [6], where new types of risks continuously emerge, necessitating additional competencies [2][7]. In this context, the chance to continuously monitor risks becomes crucial for the implementation of effective prevention policies [8].

Industry 4.0 is rapidly changing risk management inside companies where Information Communication Technologies (ICTs) and new sensors technologies are crucial to make a breakthrough in the OSH field, by greatly simplifying hazard identification. These improvements imply efficient and real-time communication between workers and information systems. However, few companies, especially among Small and Medium Enterprises (SMEs), are interconnected and this aspect needs to be considered for efficient OSH management. Surprisingly, just a few companies deal with OSH issues and technological advances in Industry 4.0, most of them only focus on new technological solutions driving Industry 4.0, while neglecting how OSH management is affected by this revolution [2]. Thus, when it comes to the evaluation of the impact of technological innovation interventions, the possible (beneficial or detrimental) effects on the health and safety of the workers are not considered.

In this context, the Italian National Institute for Insurance against Accidents at Work (INAIL, i.e., in Italian, ‘Istituto Nazionale Assicurazione Infortuni sul Lavoro’) has funded a national OSH initiative to assess the multiple impacts of health and safety in the workplace through the evaluation of different interventions, primarily technological innovation interventions promoting Industry 4.0 solutions. This initiative is part of a portfolio of research projects aiming to improve OSH prevention strategies and provide companies with effective tools for OSH management.

In this work, we will emphasise the importance of proper evaluation of interventions by setting the stage for the Italian national initiative development and showing how it is going to be developed to meet its objectives.

Therefore, it follows that *Section II*, according to the literature, will underline the importance of building interventions that can be properly evaluated and will propose a supporting theory, the Programme Theory, as an effective method for evaluating interventions; *Section III* will describe the context in which this work was born and will state the aim of the research; *Section IV* will show the early stages of development of this initiative; finally, *Section V* will conclude and set the next steps of the research.

II. THEORETICAL BACKGROUND

OSH interventions are embedded in a complex and ever-changing context, at the working and organizational, economic, and technological levels [4]. Consequently, understanding the effective strategies to enhance workplace interventions and workers' well-being is one of the primary challenges faced by researchers and practitioners. Predicting the actual effectiveness of interventions remains difficult [9], as variables come into play and the success of interventions is affected by them. Therefore, variables affecting the actual intervention development should be identified and controlled in advance and having a clear understanding of the mechanisms and context that determine the outcomes would provide reasonable assurance of intervention success [10].

There are many factors affecting the effectiveness of organizational interventions that should be considered in the design and implementation of OSH interventions: the characteristics of the individuals or target groups, the features of the intervention itself and the broader organisational and cultural context in which the intervention is implemented [11,12]. For example, as outlined by Nielsen [13], smaller organizations can benefit more from individual-level interventions, while larger firms from organizational-level interventions, related to broader structural and cultural issues.

OSH interventions must consider the different aspects of the context, such as the industry, culture, and organizational structure. It results clear that a ‘one size fits all’ approach to these interventions is not effective, due to the specific context of implementation [14]. Furthermore, the factors involved are multiple and varied in nature and can have sometimes positive or negative effects on the phenomenon. The intervention context is essential to study how choices in intervention development led to changes in the outcomes [15]. Another important aspect of evaluating interventions is to

understand the cause-effect links that lead to a given outcome. These relationships are identified in the literature as ‘mechanisms’, which can be for example determined by people’s actions and behaviours [16].

While much literature deals with multi-faceted interventions influenced by multiple factors, a good part of the literature still focuses just on the outcomes of interventions, without analysing contextual factors [17]. Moreover, the inadequate understanding of contextual factors identifies gaps in the evaluation of interventions’ effectiveness at the organisational level [17][18]. Interventions are designed with defined objectives and actual practical activities, but long-term assessment of the results is often lacking, and there are no or few indicators to monitor their success [20]. It is not enough to say whether the intervention worked or not at the end of the implementation, but how it will work after a while has to be controlled. By properly evaluating interventions over time, it is possible to design better interventions in the future [21]. Designing, implementing, and evaluating are, indeed, the three phases of OSH interventions that should be equally considered for the effective development of each of them; in addition, the third phase enhances above all the design of the following ones.

Different theories have been applied by researchers from the general development of interventions up to the specific evaluation of OSH interventions. It is common knowledge that each theory provides a different approach for the analysis of interventions and none of them is without criticism. Therefore, combinations of theories may be applied to support better analysis. In the OSH field, several researchers have been using the Programme Theory to describe different types of intervention, as it is deemed an efficient tool to understand the complexity of the phenomenon. Similarly, this work applies the Programme Theory to study and consequently assesses the multiple OSH impacts of past interventions for technological innovation that are going to be evaluated for the development of the previously mentioned Italian OSH initiative funded by INAIL. Further details on this theory are provided below.

A. The Programme Theory

The Programme Theory is widely used in various fields, including that of OSH, to understand the cause-effect relations of an intervention. The Programme Theory is a framework that describes how a program should work and what are the

expected results. A program is defined as a set of organized activities or interventions supported by resources aimed at achieving a specific outcome [22].

This theory can be particularly useful when evaluating complex interventions, such as OSH interventions. The development of the Programme Theory is a step-by-step process, which involves identifying the problem to be addressed, determining the target population, specifying the components of the intervention, and articulating the expected results [23]. The Programme Theory answers the question of how and why an intervention works, and finds the causal links between the mechanism released by an intervention and the intended outcomes, i.e., people’s responses to programme activities [15].

The Programme Theory links potential interventions and implementation activities with an overall goal of improvement through a schematic representation of hypothesised and highlighted cause-effect relationships [24]. The aim is to clarify how a programme is expected to work, looking at key results and finding their interpretation; the focus is on the implemented activities, their effects, and their alignment with the goals, i.e., the expected results [25].

The Programme Theory has been identified as a useful tool for the planning, execution, and evaluation of quality improvement interventions. According to Birckmayer and Weiss [24], the benefits of using this theory include:

- advantages for programme planning and modification;
- benefits for the growth of knowledge of human behaviour and behaviour change;
- advantages for planning and carrying out the evaluation of the specific programme.

Therefore, the Programme Theory can be useful for summative evaluation, as it can help to identify the underlying reasons why an intervention is successful in producing the desired outcomes or not [23].

This theory is closely linked to the realist evaluation concept introduced by Pawson [25], who based the evaluation process of interventions on the three main elements: context, mechanisms, and outcomes (CMO). It is indeed relevant to add a critical realist paradigm in the evaluation of interventions [27]. Specifically, our work refers to Pedersen et al. [16], who applied the realist evaluation in the OSH

research field and contextualized the three elements, the CMO detailed below, in the OSH environment.

1. **Context:** The context is defined as a structure that influences outcomes, both formally and informally. Formal (external) structures include national and global entities, such as the financial market and national laws, while local (internal) structures include company size, formal organisation, production pressure, and technical issues. Relevant informal structures include internal or external company rules or norms that may influence the outcome. It is crucial to assess the environment in which the intervention takes place; an initiative that is successful in one specific context will not necessarily be successful in a different context. Context factors are crucial for understanding the efficiency of interventions.
2. **Mechanism:** Mechanisms are defined as relevant personal characteristics of the main actors or their relationships. These actors, who have significant decision-making authority for the intervention, may be internal or external to the company. Examples of mechanisms are intrapersonal relationships, role behaviour, level of motivation in the project and trust between key actors and employees that influence outcomes.
3. **Outcomes:** The outcomes generated are highly dependent on contextual factors and mechanisms and the relationship between them. They can be categorised as positive or negative, expected, or unexpected.

As discussed in the article of Pedersen et al. [16], the context, mechanisms, and outcomes provide insight into why an intervention works or does not work and under which specific conditions it is most efficient. The CMO configuration represents these three factors, and Figure 1 below makes understandable the connections between them.

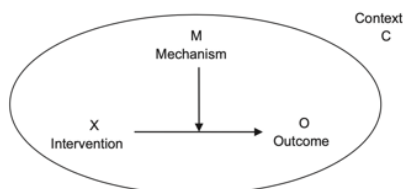


Figure 1. Context, mechanism, and outcome (CMO) configuration, from Pedersen et al. [16]

III. RESEARCH CONTEXT AND AIM

A. Context

The work here presented is part of a larger research initiative funded by INAIL, which continuously finances research projects from different disciplines to improve the well-being of workers and increase the overall effectiveness of prevention activities.

The research initiative started in April 2023 has the overarching objective to assess the impact of interventions in the OSH field, promoting technological innovation, particularly in SMEs, by developing suitable tools for causal analysis and long-term monitoring of the effects resulting from the development of these interventions. An integrated model of operational tools for the evaluation of different types of interventions is not available on the market and this initiative originated exactly from that, i.e., providing a wide range of users – companies in the industrial sector – effective tools for the evaluation of interventions.

As also stated in the literature, the possibility of properly evaluating interventions will determine two cascading effects:

- An immediate (short-term) effect as it will be possible to evaluate interventions by analysing their positive and negative effects on the target beneficiaries, and to implement corrective actions during the process in order to realign to the established targets, and
- A global (long-term) effect because knowing their impact it will be possible to improve future interventions and the process of resource allocation among a portfolio of potential interventions as it will be clear the impact generated by each of them.

The following *Table I* presents a summary of the goals and potential benefits, in the short and long term of the described initiative.

TABLE I. THE GOALS AND POTENTIAL SHORT AND LONG-TERM EFFECTS OF THE INITIATIVE

Goals	Short-term effects	Long-term effects
Identification of OSH and technological innovation interventions	Increasing knowledge about the impact of Industry 4.0 interventions on OSH	Improvement of future interventions, setting targeted goals
Identification of the most effective interventions in terms of OSH	Immediate improvement of intervention, implementing corrective action to re-aligning with the established goal	Reduction of occupational injuries and illnesses, and increasing company's productivity
Creation of an integrated model of operational tools for the evaluation of different types of interventions	Improved and targeted monitoring of the interventions	

This initiative addresses an extremely new and complex issue, which is to understand how the resources used in technological innovation intervention can generate a certain impact, among others on OSH. One of the objectives of this initiative is indeed to combine OSH with productivity, two topics that have been historically treated separately. Financial incentives might have a crucial role in increasing both productivity and workplace health and safety.

Another relevant issue will be determining whether clear cause-and-effect relationships exist, as it might be challenging to establish the exact mechanisms through which long-term improvements in health and safety are generated. The effects can be multiple and varied, not necessarily connected with linear cause-and-effect relationships.

A further critical point would arise from the complexity of the study, which will challenge the reliability of the analysis conducted. Therefore, micro-level analysis of interventions will be avoided in favour of a higher level to ensure the generalizability of the results in other contexts. Consequently, one of the major outcomes of this project will be to provide guidance on which information should be monitored once an intervention is implemented. Companies will have a clear indication of which should be a set of minimum information to collect for an effective impact evaluation of the interventions.

In conclusion, this research is crucial as it offers important insights into the connection between OSH and technological innovation, especially in the context of Industry 4.0.

B. Aim

Considering the larger objective of this initiative, funded by INAIL, this research work focuses on the initial stages of the initiative by targeting the broader issue of intervention evaluation and proposing a method to evaluate OSH interventions through the Programme Theory. The Programme Theory will help to identify and analyse the context, key variables, and causal mechanisms determining the outcome of past analysed interventions. Starting from this analysis a set of tools, capable of clarifying the contextual factors and critical causal mechanisms, will be derived and will be the first step toward the definition of the integrated model for intervention evaluation, the final aim of the broader initiative.

IV. EARLY RESULTS AND PLANNED OUTCOMES

This first phase of the initiative will require collecting a series of companies' past interventions, not specifically OSH interventions, primarily for technological innovation that had also an indirect impact on the OSH of the company. Most of the data in this initial phase will be collected from interviews and surveys of companies that have been involved in the last few years in various activities held by an Italian Competence Centre, which is generically an infrastructure dedicated to training and knowledge transfer to different types of end-users. The considered Competence Centre is specifically dealing with companies willing to implement new Industry 4.0 solutions. Various kinds of interventions promoted by the Italian Competence Centre for Industry 4.0 innovation will be therefore considered, mainly depending on the way companies got in touch with such Competence Centre by:

- Physically visiting it;
- Participation in webinars;
- Participation in training courses;
- Requesting consultancy projects.

Interviews and surveys with the interested companies will gather relevant information for the evaluation of past interventions implemented by them via the support of the mentioned Competence Centre. The information-gathering process will collect data on the type of intervention, the expected outcome, how it was developed, and its actual results and effects. Subsequently, links between the

components of the intervention and the outcome will be outlined, thus finding causal relationships, and affecting factors through the use of the Programme Theory.

The goal is to define the main variables that have characterized the intervention and that led to a specific outcome, thus determining its success or failure. A range of valuable information can be gathered from the sample of companies under consideration to get a general overview of the intervention.

In the end, starting from the CMO configuration of the Programme Theory, an extensive framework has been hypothesized, as described in *Table II*, which includes the type of information that we are going to ask companies for an effective ex-post evaluation of the interventions implemented by/with the Competence Centre for new Industry 4.0 solutions. In fact, the adoption of innovative technologies such as the Internet of Things (IoT), artificial intelligence, and robotics into industrial processes can lead to a decrease in hazardous human activities and increase the use of automation and robotics [28]. It is therefore evident how these interventions impact significantly OSH and specifically the work environment, helping to reduce physical, and mechanical risks, and most of them, to improve the ergonomics of the workers.

As a final remark, it is important to say that the selection of interviewees will be pivotal for this first part of the analysis because their expertise will be decisive for the accuracy of the data gathered on interventions and the proper identification of related mechanisms and contextual factors.

TABLE II. THE FRAMEWORK, ACCORDING TO A PROGRAMME THEORY LOGIC, FOR AN EX-POST-

1.	2.	3.	4.
Environment	Contextual Factors	Goals	Activities
5.	6.	7.	8.
Mechanism	Output	Outcome	Non-achieved Results
INTERVENTION EVALUATION			

V. CONCLUSION AND FUTURE DEVELOPMENTS

The evaluation of OSH and technological innovation of Industry 4.0 interventions is a highly relevant and novel topic. The evaluation of both health and safety aspects is rare in the literature [29],

hence this represents a further added value of the proposed research.

This research faces many challenges and aims to give a wider knowledge of the topic, researching the key factors to consider for an adequate evaluation of the interventions. The use of Programme Theory makes it possible by identifying causal links between the intervention and the outcome and understanding the mechanisms that produce certain effects. It is hence possible to understand the factors influencing the success or failure of interventions and take accordingly corrective actions during implementation. Knowledge of successful mechanisms will finally lead to better designing of future interventions.

A combination of theories is always possible and, in this case, would support a better evaluation of the interventions and determine stronger outcomes from the analysis. The Translation Theory will help in the generalizability of the results [30], by supporting the process of ‘translation’ of knowledge *between interventions* from one context to another. This theory fits the intervention to the real context by addressing the limitations related to the change of the original setting and assesses the effects in the short, medium, and long-term time. Furthermore, this theory can be used to analyse the process of translation *within the intervention* from ‘research-to-practice-to-impact’ and the approaches, barriers and facilitators and context (i.e., social, political, organizational) found in this process. Therefore, it enables more dynamic monitoring of interventions, providing a better understanding of the phenomenon over time and strengthening the overall analysis.

A future step of the research will go through the combination of *qualitative* but also *quantitative* analyses. These analyses will start from different sets of data and will follow different logic and procedures, which will increase the complexity of the study but will certainly provide a stronger, holistic, evaluation of the interventions. The major challenge will be making the results of the two analyses comparable.

In conclusion, we presented the early developments of an Italian national initiative with the primary intent to show the potential of introducing such an innovative initiative that assesses the multiple impacts of health and safety in the workplace through the evaluation of different – not only OSH – interventions.

VI. REFERENCES

- [1] Fox, M.A., Spicer, K., Chosewood, L.C., Susi, P., Johns, D.O. and Dotson, G.S. (2018). Implications of applying cumulative risk assessment to the workplace. *Environment International*, 115, 230–238. <https://doi.org/10.1016/j.envint.2018.03.026>
- [2] Badri, A., Boudreau-Trudel, B. and Souissi, A.S. (2018). Occupational health and safety in the Industry 4.0 era: A cause for major concern? *Safety Science*, 403–411. <https://doi.org/10.1016/j.ssci.2018.06.012>
- [3] Podgórski, D., Majchrzycka, K., Dąbrowska, A., Gralewicz, G. and Okrasa, M. (2017). Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the Internet of Things technologies. *International Journal of Occupational Safety and Ergonomics*, 23(1), 1–20. <https://doi.org/10.1080/10803548.2016.1214431>
- [4] Micheli, G.J.L. and Cagno, E. (2010). Dealing with SMEs as a whole in OHS issues: Warnings from empirical evidence. *Safety Science*, 48(6), 729–733. <https://doi.org/10.1016/j.ssci.2010.02.010>
- [5] Rodrigues, M.A., Sá, A., Masi, D., Oliveira, A., Boustras, G., Leka, S. and Guldenmund, F. (2020). Occupational Health & Safety (OHS) management practices in micro- and small-sized enterprises: The case of the Portuguese waste management sector. *Safety Science*, 129. <https://doi.org/10.1016/j.ssci.2020.104794>
- [6] Ajayi, A., Oyedele, L., Davila Delgado, J.M., Akanbi, L., Bilal, M., Akinade, O. and Olawale, O. (2019). Big data platform for health and safety accident prediction. *World Journal of Science, Technology and Sustainable Development*, 16(1), 2–21. <https://doi.org/10.1108/wjstsd-05-2018-0042>
- [7] Zwetsloot, G., Schmitt-Howe, B. and Nielsen, K.T. (2020). Success factors for OSH implementation. Opening the black box of OSH realization. *Policy and Practice in Health and Safety*, 18(2), 196–210. <https://doi.org/10.1080/14773996.2020.1786994>
- [8] Asadzadeh, A., Arashpour, M., Li, H., Ngo, T., Bab-Hadiashar, A. and Rashidi, A. (2020). Sensor-based safety management. *Automation in Construction*, 133. <https://doi.org/10.1016/j.autcon.2020.103128>
- [9] Fridrich, A., Jenny, G.J. and Bauer, G.F. (2015). The context, process, and outcome evaluation model for organisational health interventions. *BioMed Research International*, 2015. <https://doi.org/10.1155/2015/414832>
- [10] Vitrano, G., Micheli, G.J.L., Sala, G., Guglielmi, A., De Merich, D., Campo, G. and Pellicci, M. (2021). A programme theory evaluation of initiatives to support health and safety improvement: an Italian cross-sectional study. In *Proceedings of the XXVI Summer School Francesco Turco – Industrial Systems Engineering*. AIDI.
- [11] Nielsen, K. and Miraglia, M. (2017). What works for whom in which circumstances? On the need to move beyond the ‘what works?’ Question in organizational intervention research. *Human Relations*, 70(1), 40–62. <https://doi.org/10.1177/0018726716670226>
- [12] Vitrano, G., Micheli, G.J.L., Guglielmi, A., De Merich, D., Pellicci, M., Urso, D. and Ipsen, C. (2023). Sustainable Occupational Safety and Health Interventions: A Study on the Factors for an Effective Design. *Safety Science*, 166, 106249. <https://doi.org/10.1016/j.ssci.2023.106249>
- [13] Nielsen, K. (2017). Organizational occupational health interventions: What works for whom in which circumstances? *Occupational Medicine*, 67(6), 410–412. <https://doi.org/10.1093/occmed/kqx058>
- [14] Karanikas, N., Khan, S.R., Baker, P.R.A. and Pilbeam, C. (2022). Designing safety interventions for specific contexts: Results from a literature review. *Safety Science*, 156. <https://doi.org/10.1016/j.ssci.2022.105906>
- [15] Blamey, A. and Mackenzie, M. (2007). Theories of change and realistic evaluation: peas in a pod or apples and oranges? *Evaluation*, 13(4), 439–455. <https://doi.org/10.1177/1356389007082129>
- [16] Abildgaard, J.S., Nielsen, K., Wählin-Jacobsen, C.D., Malmsten, T., Christensen, K. B. and Holtermann, A. (2020). ‘Same, but different’: A mixed-methods realist evaluation of a cluster-randomized controlled participatory organizational intervention. *Human Relations*, 73(10), 1339–1365. <https://doi.org/10.1177/0018726719866896>
- [17] Pedersen, L.M., Nielsen, K.J. and Kines, P. (2012). Realistic evaluation as a new way to design and evaluate occupational safety interventions. *Safety Science*, 50(1), 48–54. <https://doi.org/10.1016/j.ssci.2011.06.010>
- [18] Vitrano, G., Micheli, G.J.L., Guglielmi, A., De Merich, D., Pellicci, M. and Sala, G. (2022). An explorative study setting a national supportive system of near-miss management for the Italian industrial sector. In *Proceedings of the XXVII Summer School Francesco Turco – Industrial Systems Engineering*. AIDI.
- [19] Biron, C. and Karanika-Murray, M. (2014). Process evaluation for organizational stress and well-being interventions: Implications for theory, method, and practice. *International Journal of Stress Management*, 21(1), 85–111. <https://doi.org/10.1037/a0033227>
- [20] Bamberger, M., Tarsilla, M. and Hesse-Biber, S. (2016). Why so many “rigorous” evaluations fail to identify unintended consequences of development programs: How mixed methods can contribute. *Evaluation and Program Planning*, 55, 155–162. <https://doi.org/10.1016/j.evalprogplan.2016.01.001>
- [21] Olsen, K., Legg, S. and Hasle, P. (2012). How to use programme theory to evaluate the effectiveness of schemes designed to improve the work environment in small businesses. *Work*, 41(1), 5999–6006. <https://doi.org/10.3233/WOR-2012-0036-5999>
- [22] Breuer, E., Lee, L., De Silva, M. and Lund, C. (2015). Using theory of change to design and evaluate public health interventions: A systematic review. *Implementation Science*, 11(1), 63. <https://doi.org/10.1186/s13012-016-0422-6>
- [23] Rogers, P.J. (2008). Using programme theory to evaluate complicated and complex aspects of interventions. *Evaluation*, 14(1), 29–48. <https://doi.org/10.1177/1356389007084674>
- [24] Reed, J.E., McNicholas, C., Woodcock, T., Issen, L. and Bell, D. (2014). Designing quality improvement initiatives: the action effect method, a structured approach to identifying and articulating programme theory. *BMJ Quality and Safety*, 23(12), 1040–1048. <https://doi.org/10.1136/bmjqs-2014-003103>
- [25] Birckmayer, J. D. and Weiss, C.H. (2000). Theory-based evaluation in practice: What do we learn? *Evaluation Review*, 24(4), 407–431. <https://doi.org/10.1177/0193841X0002400404>
- [26] Pawson, R. (2006). *Evidence-based policy. A realist perspective*. Sage Publications, London.
- [27] Micheli, G.J.L., Cagno, E. and Riggio, N. (2019). Comparing programme theory and intermediaries’ views: assessment of OSH programmes in Italy. In *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, 1183–1187. <https://doi.org/https://doi.org/10.1109/IEEM44572.2019.8978934>
- [28] Zorzenon, R., Lizarelli, F.L. and Daniel, D.B.A. (2022). What is the potential impact of Industry 4.0 on health and safety at work? *Safety Science*, 153. <https://doi.org/10.1016/j.ssci.2022.105802>
- [29] Micheli, G.J.L., Famé, S. and Vitrano, G. (2022). A holistic view and evaluation of health and safety at work: Enabling the assessment of the overall burden. *Safety Science*, 156. <https://doi.org/10.1016/j.ssci.2022.105900>
- [30] Schulte, P.A., Cunningham, T.R., Nickels, L., et al. (2017). Translation research in occupational safety and health: A proposed framework. *American Journal of Industrial Medicine*, 60(12), 1011–1022. <https://doi.org/10.1002/ajim.22780>