



# Ecosystem perspective for effective occupational safety and health interventions: A cross-national expert study

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## ABSTRACT

With the intent to promote lasting workplace interventions for the health, safety, and well-being of workers, this study focuses on supporting the development of Occupational Safety and Health (OSH) interventions, with particular attention to the processes and actors involved. Inspired by the circular ecosystem's principles, the concept of ecosystem in OSH introduces a new perspective into discussions on OSH interventions. This perspective deepens understanding of the underlying dynamics contributing to intervention outcomes. This research adopts a qualitative, exploratory design, structured around expert engagement in two phases: first, exploratory interviews aimed at gathering insights on past OSH interventions; and second, a focus group with the same experts, where initial findings were used as a foundation to collectively discuss and refine strategies for improving intervention effectiveness.

Based on the mixture of OSH and ecosystems knowledge, the findings are derived by interpreting data according to the intervention development phases—design, implementation, evaluation, and follow-up—and the five elements of circular ecosystems—value, actors, data materials and flows, circular activities and strategies, and governance. A framework is determined to interpret the diverse aspects, including contextual factors and drivers, influencing intervention development and its long-term effectiveness. The ecosystem perspective proposed is intended to provide scholars with a fresh approach to intervention development and clear guidelines for practitioners to create successful, long-lasting interventions through the ecosystem perspective.

## 1. Introduction

Occupational Safety and Health (OSH) management is pivotal in running successful businesses and developing a sustainable work environment. Badri et al. (2018, p.404) write: "A healthy business is now one in which OHS (Occupational Health and Safety) is regarded as an imperative." Regardless of the sector or the territorial area, OSH is a primary concern for organizations, which increasingly recognize the importance of integrating OSH into their management systems. However, while the knowledge in this field is rapidly expanding, putting OSH into practice is a complex task (Hasle et al., 2014). OSH is increasingly challenged by evolving and complex factors (e.g., human-technology interactions, an aging workforce, and the growing frequency of extreme weather events), each of which contributes to the emergence of new and often interrelated risks. Addressing these challenges requires the development of new competencies, adaptive strategies, and interdisciplinary approaches to effectively protect and promote OSH in rapidly changing work environments (Dyregborg et al.,

2022). Consequently, organizations must remain vigilant and adapt to meet the ongoing challenges of OSH in the modern world (Badri et al., 2018; Zwetsloot et al., 2020).

Effective interventions are a leading priority, especially in companies struggling to manage health and safety in the workplace (Dyregborg et al., 2022; Nielsen et al., 2024). In this context, an "intervention" refers to a planned set of actions—often organizational, technical, behavioral, or policy-based—designed to prevent injuries and diseases from occurring in the working environment by improving the safety, health, and well-being of employees. What truly matters is the real-world impact of these interventions and their ability to foster safer, healthier work environments (Dyregborg et al., 2022). In this sense, the effectiveness of interventions can be assessed through OSH performance, understood as a qualitative or quantitative measure of the outcomes of all activities aimed at improving workers' health, safety, and well-being in both the short and long term.

Understanding the environment where interventions are set and implemented is crucial to ensuring their success (Fridrich et al., 2015). In

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this regard, the literature has investigated the multifaceted aspects—including contextual factors, drivers, barriers, and mediating and moderating factors—influencing the effectiveness of interventions (Cagno et al., 2016; Graham et al., 2024; Masi and Cagno, 2015; Micheli et al., 2018). Some studies, inspired by the realist analysis (Pawson, 2006), have focused on the mechanisms that drive intervention outcomes (Masi and Cagno, 2015; Pedersen et al., 2012), while others have studied the combined effect of contextual factors and mechanisms on improving the working environment (Hasle and Limborg, 2006; Micheli et al., 2018). Micheli et al. (2018) investigated the mediating and moderating factors behind the success or failure of OSH interventions comprehensively by evaluating a range of techno-organizational interventions.

Despite this growing body of research, OSH practitioners may struggle to recognize these influencing factors, often due to biases formed from prior experiences (Baril-Gingras et al., 2006; Noy et al., 2015; Teufer et al., 2019; Verbeek, 2018). As a result, even the most promising interventions may fail to deliver benefits if poorly communicated or inappropriately implemented (Vitrano et al., 2023). To be effective and long-term value, interventions require a network of engaged, informed, and coordinated actors, including OSH professionals, company managers, workers and their representatives, policymakers, and territorial or institutional bodies. Their collaboration is essential across all phases of intervention development: design, implementation, and evaluation (De Merich et al., 2022; Nielsen et al., 2024; Vitrano et al., 2024).

Based on this understanding, this study intends to enhance the effectiveness of OSH interventions by focusing on the processes and actors involved in their development, aiming to promote effective, lasting workplace interventions for the health, safety, and well-being of the workers by advancing OSH research toward more theoretical and strategic perspectives, exploring ways to continuously improve its management at a system level, and in turn, strengthening OSH interventions at an operational level.

To support this approach, the ecosystem concept is introduced as a theoretical lens. An ecosystem, in this context, is understood as a dynamic system that persists over time and seeks a stable balance over time, where all actors—such as corporate stakeholders, territorial institutions, and governance bodies—are aware of their roles and act not only in their own interest but for the collective well-being and sustainability of the system. This perspective emphasizes the need for integrated management of processes over time, including the design, implementation, and evaluation of OSH interventions at both organizational and national levels.

As such, the next Section 2 explores the relevance of introducing a new perspective, the ecosystem concept, in this current discussion of interventions' effectiveness in OSH. Then, in Section 3, the methods are detailed. Section 4 describes the results, and Section 5 discusses the findings, defining a framework to interpret the diverse aspects influencing intervention development. Finally, Section 6 offers conclusions, limitations, and future research directions.

## 2. The ecosystem perspective and aim of the study

The introduction of a theoretical perspective can bring value to the discussion of OSH interventions' effectiveness, diving into the underlying aspects that contribute to their success or failure.

In this study, the ecosystem concept is adopted as a particularly relevant lens; although it is not yet widely established in OSH literature (Hasle et al., 2017; Rocha, 2010; Vitrano and Micheli, 2024; Zwetsloot et al., 2020), it offers a systemic view that helps understand how diverse actors and processes interact and explain the conditions supporting the long-term effectiveness of OSH interventions (Dyreborg et al., 2022). The ecosystem is an extensive concept, discussed in many disciplines, and therefore, for the following analysis, a selection of relevant

ideas was considered with a particular focus on industrial and circular ecosystems.

Industrial ecosystems arose from the industrial ecology field that centers on the various stages of production processes for goods and services, with a perspective that mimics natural systems and emphasizes resource conservation and reuse (Valenzuela-Venegas et al., 2016). This approach enabled the characterization of manufacturing complexes as industrial ecosystems. Jacobides et al. (2018, p.1) state that ecosystems are “interacting organizations, enabled by modularity, not hierarchically managed, bound together by the non-redeployability of their collective investment elsewhere.” Moreover, Adner (2016, p.40) viewed the ecosystem as an “alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize.” These ecosystems typically involve complementarities and dependencies among the participating individuals. Thus, only together can they achieve complete value creation through a systems-level architecture (Adner and Kapoor, 2010; Kapoor and Lee, 2013) with “varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled” (Jacobides et al., 2018, p.10). Comparable logic and principles apply when developing OSH interventions where the interaction and alignment with actors are crucial, and no hierarchical structure and mechanisms of complementarities and dependencies exist (Hasle and Sørensen, 2011; Vitrano and Micheli, 2024).

Industrial ecosystems (Lowe and Evans, 1995) work well with linear models—take, make, and waste; however, they tend to disregard the sustainability of their operations (Aminoff et al., 2017). Linear models are less effective than circular ones—make-remake-use-return—owing to inefficiencies in resource utilization (Tate et al., 2019). Therefore, to this end, the concept of circularity was considered. Aarikka-Stenroos et al. (2021, p.271) defined a circular ecosystem as a “multi-actor entity in which interdependent actors play complementary roles. [...] A circular economy ecosystem emerges or is created around a common, system-level goal related to resource circularity, circular economy knowledge, or circular economy business and business models.” Aminoff et al. (2017, p.530) defined circular ecosystems as “co-evolving, dynamic, and potentially self-organizing configurations, in which actors integrate resources and co-create circular value flows in interaction with each other.” Actors and their interdependence and complementary roles are critical, particularly in OSH (Nielsen et al., 2024).

Trevisan et al. (2022) explained circular ecosystems by identifying five elements and synthesizing their core values. The five elements identified are Value; Actors; Data, Materials, and Flows; Circular Activities and Strategies; and Governance. According to the authors, value is central to the ecosystem, involving collective value creation and capture with the presence of multiple value circles; actors work collaboratively in the development and commercialization of innovations, with an orchestrator as a key figure; data, materials, and flow management is essential, necessitating a rethinking of resource utilization, the integration of diverse data sources, and careful management of information and material flows; circular activities and strategies focus on sustainability, supporting collective economic and environmental benefits; governance promotes these efforts by facilitating coordination and value sharing.

From these premises, industrial ecosystems and, in particular, circular ecosystems have been considered relevant for the OSH field. An OSH ecosystem should refer to a system that persists over time, always seeking a stable balance, in which the figures involved are aware of their role and the managed activities. They act for themselves, the welfare of others, and that of the entire system. This ecosystem should include integrated management of various elements to create value for the entire system that manages OSH across nations, including corporate figures, territorial bodies, prevention activities, and governance. The development of an ecosystem intervention should entail careful attention to every stage of the process—design, implementation, evaluation, follow-up—while ensuring the effectiveness of interventions over time, that is,

their sustainability: the possibility that an intervention lasts over time, self-sustaining itself without the introduction of external resources or orchestration (Chambers et al., 2013).

Table 1 offers value to the affinity between circular economy principles and OSH when discussing ecosystems. This table stands as a significant contribution provided by the authors of this study by transposing the circular ecosystem elements identified by Trevisan et al. (2022) into the OSH domain and establishing a foundation for understanding how circular economy practices can be integrated into OSH.

The circular ecosystem's concept, as demonstrated, encloses values and key drivers that are close to those of OSH and can be pivotal for the effectiveness of an intervention. Based on some selected elements derived from circular ecosystems, this study aims to investigate how different aspects can affect the interventions' development and consequently detect which of them can enable more effective OSH interventions along the different phases of design, implementation, evaluation, and follow-up. This ensures their sustainability "to the extent to which these interventions can continue to be delivered, while institutionalized within settings, and having the necessary capacity built to support their delivery," as noted by Chamber et al. (2013, p.3). The resulting research question is: *How can an ecosystem perspective contribute to the effectiveness of OSH interventions?*

### 3. Methods

Aligned with the theoretical background on ecosystem perspective and the main objective, this is a qualitative explorative study examining the introduction of an ecosystem perspective into OSH and how it empowers the discussion of effectiveness in interventions by understanding the underlying aspects contributing to their success or failure and sustainability. The overall research design was built on expert interactions, which is highly recommended at this stage to streamline a complex problem. In line with standard practice, we obtained participant-informed consent and secured ethics approval before beginning data collection. The experts were introduced to the ecosystem perspective through a brief introductory meeting—either in person or remotely—and by sharing a document that explained its theoretical pillars as applied to OSH interventions, along with an overview of the study's empirical design.

#### 3.1. Research design

Based on this explorative approach, the study unfolded in two phases, later detailed:

1. Exploratory interviews or guided compilations of a questionnaire with a group (from 2 to 4) of experts based in three European countries to gather information on past interventions;
2. A single focus group with the same experts—grounded in the initial findings—to discuss strategies for enhancing intervention effectiveness.

##### 3.1.1. First phase

In the first phase, group interviews or guided compilations of a questionnaire (only in one case preferred by participants) were performed. We provided a sample of the interview questions so that participants could review them before agreeing to take part. Once each expert consented, we sent the full interview protocol. We asked the participants of each country to share their knowledge about different OSH interventions, at least three with the following characteristics. Interventions that were planned and created within a company and also involved other organizations or external actors (e.g., associations, universities, research centers, consultants, and others). Therefore, they needed to be developed within the company but also had an impact outside of it. This

**Table 1**

The five elements of circular ecosystems, from Trevisan et al. (2022), and the relevance for the OSH context.

Circular ecosystem elements		OSH relevance
<b>Value</b>	Circular value proposition	Communicates intervention objectives and intended value with participants actively defining goals and generating value.
	Value co-creation	Emphasizes interactions, shared resources, and collaboration to gain a competitive advantage.
	Collective capture of value	Is an essential component for keeping individuals committed and ensuring timely contributions.
	Multiple cycles of value	Allow individuals to share value through creative governance and collaboration, e.g., enabling the effective formation of temporary partnerships.
<b>Actors</b>	Heterogeneity and appropriate balance of actors	Facilitate resolving problems within the ecosystem owing to the presence of diverse complementary capabilities.
	Alignment of interests	Is agreeing on individual and collective interests to achieve objectives and fostering the adoption of standard practices and policies to improve the entire system.
	Defining roles and responsibilities	Is essential for avoiding misunderstandings and improving the coordination of activities by defined individuals.
	Trust among business actors	Is crucial in maintaining an effective coordination strategy, enabling resource sharing, knowledge, and ideas.
<b>Circular activities and strategies</b>	Development of common strategies and objectives	Is vital for providing guidance to the intervention and enabling individuals to align and identify with them, fostering greater cooperation.
	Environmental and financial return	With activities that should be entirely sustainable by considering the three dimensions: social, financial, and environmental. For an ecosystem to remain healthy, it must generate not only improvements in worker well-being but also contribute to environmental goals and financial return. This integration fosters broader participation among actors and encourages the development of innovative strategies that might otherwise be overlooked.
<b>Data, Materials, and Flows</b>	Multiple circular economy activities	Across sectors foster collaboration, resource sharing, and synergies among various actors, enhancing overall system effectiveness and sustainability, and creating learning and collaboration opportunities.
	Redefining and rethinking resource utilization	Is crucial for optimizing the existing resources.
	Integration of information and material flows	—Both top-down and bottom-up—ensures that information flows not only efficiently but meaningfully across all levels of the organization and beyond with a comprehensive view of the system. The integration of internal and external communication systems facilitates faster feedback loops and better alignment of interventions with workers' realities.
<b>Governance</b>	Data sharing	Enables improved access to information about how resources are used, their conditions, and their location. Key players must be actively involved, sometimes through economic incentives, and using platforms can facilitate communication and data sharing.
	Presence of rules and standards	Ensures coordination between the essential activities that contribute to the value proposition, promoting a commitment to a safe and healthy work environment for all employees and involving workers in consultation and participation.

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Table 1 (continued)

Circular ecosystem elements	OSH relevance
Presence of the orchestrator	Promotes cooperation and synergy among individuals, enhancing system effectiveness and contributing to its sustainable growth and development.
Non-hierarchical and collaborative relations	Ensure individual collaboration based on a non-hierarchical division of power.

strategy enabled the evaluation of interventions that fit the scope of this study, developed at the company level and beyond. Information from interviews and questionnaires was supplemented with secondary data, including reports and articles related to each intervention, provided by respondents.

The interviews were conducted via Microsoft Teams, typically lasting 60 min, and involved two researchers from our team. All sessions were recorded, transcribed, and integrated with the interviewers' notes for comprehensive analysis. A questionnaire and a semi-structured interview protocol (see Appendix A) guided the answers, focusing on key topics and supporting questions. The protocol was designed to explore all phases of intervention development—from design through implementation, evaluation, and follow-up—while embedding an analysis of the five elements of circular ecosystems (Value; Actors; Data, Materials, and Flows; Circular Activities and Strategies; and Governance) as adapted for the OSH domain in Table 1. Table 2 outlines the main characteristics of this first phase.

### 3.1.2. Second phase

Starting the second phase, a single focus group was organized, as it was deemed an appropriate research technique to engage a wide range of expert perspectives within one structured session (Cagno et al., 2014; Tong et al., 2007). The decision to conduct a single focus group rather than multiple sessions was justified by the strong and well-structured foundation of information obtained during the first phase of data collection. This allowed the Authors to identify and gather all the required expertise within a single event, thereby enabling the focus group to focus on in-depth discussion and validation of key insights, as well as to openly address pertinent issues in order to preserve the exploratory nature of the study.

To ensure effective participation, detailed instructions on the focus group's format and the required tools were distributed in advance, providing all participants with a common baseline understanding of the ecosystem perspective and the necessary resources before data collection began. During the focus group, participants discussed how adopting an ecosystem perspective could contribute to more effective inter-

Table 2

Research design: first phase.

<b>Number of participants</b>	Three countries, at least two experts per country, answered in groups.
<b>Interview/guided compilation duration</b>	One hour for interviews and interviewees in groups for each country.
<b>Topic</b>	Reports, articles, webpages, and so on complemented the information from the interviews/questionnaires.
<b>Structure of interview/guided compilation</b>	Discussion about three significant interventions, in terms of scope, highlighting successful dynamics and challenges encountered. For interviews, the protocol was shared with participants beforehand and is detailed in Appendix A.
	The questions were organized into four categories corresponding to the key phases of intervention development: design, implementation, evaluation, and follow-up. Each category considered the five elements of circular ecosystems (Value; Actors; Data, Materials, and flows; Circular activities and strategies; and Governance) to provide a comprehensive framework for analysis.

ventions for OSH management by investigating dynamics that can affect their outcomes.

The meeting was divided into two parts. In the first part, participants were invited to reflect on how their interventions, as presented during the interviews or questionnaires, could have been improved and made self-sustainable, whereas, in the second part, the results of the initial discussion were further discussed to discern generalizable findings for interventions.

The focus group consisted of a 2.5-hour session conducted via Microsoft Teams, involving participants from three countries, with at least two experts from each country, alongside the two researchers from our team. The session was recorded and transcribed, and one of the researchers acted as the moderator, taking written notes to guide participants during the discussion. Additionally, the Miro platform, an online collaborative whiteboard, was used to facilitate group work and enhance participant engagement throughout the session. Table 3 outlines the main focus group characteristics and presents a detailed meeting agenda.

### 3.2. Participants

The sample size was kept reasonably small to facilitate lively discussion and maintain participant engagement during the focus group. Experts were recruited from three countries (2–4 participants per country). Participant selection followed an established focus-group methodology, which recommends a small, purposively chosen group to ensure thematic saturation (Tong et al., 2007). Accordingly, role selection prioritized depth of expertise over raw numbers. As a result, each partici-

Table 3

Research design: second phase.

<b>Number of participants</b>	Three countries, at least two experts per country.
<b>Focus group Topic</b>	2.5 h session. Starting from the knowledge of the described interventions, participants discussed interventions by highlighting successful dynamics and challenges encountered and their impact within the ecosystem perspective and, in the end, identifying generalizable and non-generalizable elements.
<b>Structure of the focus group</b>	<b>First part</b> Participants were divided into three country-based groups for a 20-minute session to reflect and respond to the following three questions regarding the interventions discussed during the interview: They entered their answers into designated spaces on the Miro platform, ensuring that everyone in the focus group had access to this information. <ul style="list-style-type: none"> <li>• How could the described interventions have been improved if designed using an ecosystem perspective?</li> <li>• How could the interventions have been made self-sustainable after the project's end (especially when funded and funds ended)? What were the main challenges in the projects you had in mind?</li> <li>• How could you have established a continuous post-assessment process for interventions when initial promoters (you, in most cases) were no longer in charge of them?</li> </ul> Next, all participants were gathered in the same virtual room for 30 min. Each country-based group had 10 min to present a summary of each intervention and share the responses to the previous questions, briefly described on the Miro platform. 15-minute break. <b>Second part</b> <ul style="list-style-type: none"> <li>• 10 min for individual reflection on all the interventions presented and preparation for the second phase.</li> <li>• 30-minute cross-national group discussion to identify generalizable and non-generalizable elements of the ecosystem perspective across the phases of intervention development, using a preset format on the Miro platform.</li> <li>• 45-minute closing discussion on the results of the working group sessions.</li> </ul>

participant was required to possess comprehensive knowledge of OSH interventions implemented within a company and also involving other organizations or external territorial actors. The choice went for public entities that develop OSH activities with a nationwide perspective. Three countries were selected: Denmark, Cyprus, and Italy, and the sample was deemed sufficiently diverse. However, since the study is exploratory in nature, it does not comprehensively represent all nations or entities involved in the process. Table 4 provides details on the countries and related experts.

## 4. Results

The results are presented according to the structure defined to investigate how adopting an ecosystem perspective can contribute to more effective, long-lasting interventions for OSH management. The first section (Section 4.1) gathers the analysis results drawn from the interviews and questionnaires completed by participants from the three selected countries, setting the stage for the following analysis arising from the focus group. The second section (Section 4.2) includes the results of the second phase, referring to the focus group.

### 4.1. First phase: interview and questionnaire findings

In this section, the interview and questionnaire results are presented using four phases of intervention development—from design through implementation, evaluation, and follow-up—and the five elements of circular ecosystems previously mentioned (Value; Actors; Data, Materials, and Flows; Circular activities and strategies; and Governance), by also including the impact as a valuable element for the assessment of the interventions. Table 5 provides knowledge about interventions implemented across the three European countries through ecosystem-based values and offers an interesting perspective on successful practices, with a focus on their long-term sustainability. For more details,

**Table 4**  
Research participants and institutions.

<b>Denmark</b>	Two senior researchers of the National Research Centre for the Working Environment (NFA, in Danish Det Nationale Forskningscenter for Arbejdsmiljø) (NFA, 2023). NFA is a government research institute under the Danish Ministry of Employment, which conducts research at the highest international level to <ul style="list-style-type: none"> <li>• offer consultancy services and develop projects with a distinct social purpose;</li> <li>• disseminate research-derived knowledge to workplaces, government bodies, social partners, and occupational safety consultants;</li> <li>• engage in the training of researchers and educational initiatives at universities.</li> </ul>
<b>Cyprus</b>	A professor and a senior researcher from the European University of Cyprus, and members of CERIDES. CERIDES Excellence in Innovation and Technology is a Center of Excellence of the European University Cyprus and provides education/training, research, and consulting solutions to the academic and business world, supportive of governance, promoting industry-innovation-entrepreneurship, focused on civic, societal responsibility, and environmental consciousness (CERIDES, 2023). The focus areas revolve around two fundamental pillars: risk and decision science, with an application to several horizontal areas such as Security, Safety, Cybersecurity, Telecommunications, Critical Infrastructure Protection, and Industrial Processes.
<b>Italy</b>	Four senior researchers from the Italian National Institute for Insurance against Accidents at Work (INAIL, in Italian, Istituto Nazionale Assicurazione Infortuni sul Lavoro) (INAIL, 2023a). INAIL is a national insurance institution with a dedicated internal department that manages research activities by pursuing the objective of improving health and safety conditions, countering the occurrence of accidents and injuries, and preventing the onset of occupational diseases. It continuously subsidizes projects in different disciplines to improve workers' well-being at work, such as creating technological tools to reduce the risks to the musculoskeletal system and designing new ways of managing the different types of risk (INAIL, 2023b).

see Appendix B, which offers an in-depth analysis of each intervention and includes illustrative interview quotes.

### 4.2. Second phase: focus group findings

The focus group aimed to guide participants in gathering evidence on generalizable insights on how adopting an ecosystem perspective could contribute to more effective, long-lasting interventions for OSH management by investigating the underlying aspects that influence intervention outcomes, starting with the specific interventions participants described and then reflecting on the broader, generalizable insights (for further details, see Table 3). The following subsections present the key thoughts shared by participants.

#### 4.2.1. Enhancing interventions through an ecosystem perspective

The questions asked participants of the focus group to reflect on how the interventions they described during the interview could have been improved if they had designed them with an ecosystem perspective in mind. Three main elements emerged from the discussion among countries:

- Awareness of all the phases of intervention
- Active involvement of actors
- Supporting tools and participatory methodologies

For the first point, how to build awareness in all intervention phases, one researcher from Cyprus said, “Actually, during the planning phase, awareness of all the steps of a system, of an ecosystem, is important. So, designing a product, software, or a technology, or a tool, or equipment, you have to be aware of how you are going to monitor it and how you collect any feedback and so on.” Therefore, the design phase must also include a proper assessment of the evaluation phase, for example, correctly planned in the three interventions described by Italian researchers who said, “All the phases from the implementation to the monitoring of the results have been included in the design.”

The second element is the active involvement of people engaged in the intervention. This issue crosses all phases of the intervention development, from design to monitoring. For the third intervention in Cyprus (Table 5), they stated, “Participation of workers in decision making is of major importance.” Danish participants emphasized that both interventions could have been improved with stronger involvement of other actors, for example, unions, employer associations, and public institutions as builders (for the first intervention) and vocational schools (for the second intervention). In this direction, Italy, for the third intervention, involved “port authorities in the design and planning to make them more involved from the outset.” Regarding the implementation phase, a clear example of active involvement was activated through pilot tests in the environment, as included in Cyprus' second intervention. In the check phase, when it comes to the monitoring of the implementation, gathering user feedback, as stated for the third Cypriot intervention, is essential: “You need the feedback of the workers, and you need to be aware of any new, easier, safer technologies that can be used for this kind of task.”

Another crucial element was identified in supporting tools and participatory methodologies. If correctly used, these elements encourage companies to be more involved and actively participate in the intervention. For example, in the three Italian interventions, interviewees mentioned providing other companies with the means to analyze data on the causes and dynamics of accidents and experimental tools for investigating and managing accidents and near misses. The decision to do so represents progress and adaptability and enhances the effectiveness of interventions.

Table 5

Interventions classified according to the intervention development phases and ecosystem-based values.

Cypriot interventions	Design	Implementation	Evaluation	Follow-up
<b>CYP—INT 1: In-house risk assessment for teleworkers</b>	<p><b>VALUE:</b> During early COVID-19, with no telework legislation in place, the University of Cyprus and the Department of Labour Inspection created a mobile/desktop app for teleworkers to self-assess six hazard categories and generate reports for employers.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Online meetings gathered teleworker feedback; internal presentation at the Department ensured effective promotion.</p> <p><b>ACTORS:</b> University of Cyprus research team; Department of Labour Inspection (Cyprus).</p> <p><b>GOVERNANCE:</b> A top-down Memorandum of Understanding between the university and the Department provided oversight and support.</p> <p><b>IMPACT:</b> A pilot questionnaire led to a project proposal and local funding to further develop the risk-assessment tool.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Early in COVID-19, widespread confusion about telework meant users actively sought guidance, so no additional actors were needed during implementation. The questionnaire was streamlined to focus on the two main telework risks (psychosocial and economic). A PDF handbook of the mobile app was also created for less tech-savvy workers.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Limited time and funding prevented adding partners or translating the tool into other languages, reducing its wider diffusion.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> During the evaluation, only user counts were recorded—no feedback was systematically collected or shared, which was acknowledged as a gap.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Employers gave positive feedback, and the tool remains Cyprus's sole telework-risk assessment resource, actively promoted by the Department of Labour Inspection. However, the project was planned around producing the tool, not around evaluating or sustaining it. A formal control plan would have addressed this.</p>	No information regarding this phase.
<b>CYP—INT 2: Safer rescuers</b>	<p><b>VALUE:</b> Integrated telecommunication technology with new practices to help first responders save lives while better protecting against toxic exposures and burns.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Nine parallel Work Packages (WPs)—covering training, integration, three pilot phases, and a final demonstration—ran continuously, using user feedback loops to refine the technology.</p> <p><b>ACTORS:</b> A balanced consortium of 34 experts from industry, research institutes, and academia ensured all relevant skills were represented.</p> <p><b>GOVERNANCE:</b> The 34 consortium members collaborated closely across all WPs under shared oversight.</p> <p><b>IMPACT:</b> Three pilots involving dozens of rescuers iteratively refined the technology, addressing both safety and ethical concerns.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Three activity types were executed—five training sessions, webinars, and pilot tests—each incorporating user feedback in a continuous back-and-forth refinement process.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Implementation faced COVID-19 challenges (two-thirds of the intervention occurred during the pandemic), delaying training by three months and complicating collaborative technology development.</p>	<p><b>IMPACT:</b> All WPs were completed on schedule, and the intervention was delivered without requesting extensions.</p>	No information regarding this phase.
<b>CYP—INT 3: Exoskeletons for airport staff</b>	<p><b>VALUE:</b> Tested a wearable exoskeleton during airport activities.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned.</p>	<p><b>IMPACT:</b> The exoskeletons reduced employees' musculoskeletal strain during luggage handling.</p>	No follow-up plan: exoskeletons were ultimately removed due to negative user experience and lack of initial worker involvement in design, cited as a root cause.

(continued on next page)

Table 5 (continued)

Cypriot interventions	Design	Implementation	Evaluation	Follow-up
	<p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Employees tested exoskeletons and provided feedback to the vendor and ramp handling department.</p> <p><b>ACTORS – GOVERNANCE:</b> Volunteers from ramp handling, health and safety manager, and company occupational physician.</p> <p><b>IMPACT:</b> Pilot tests collected employee feedback to refine the exoskeleton design.</p>	<p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Usability and flexibility issues led to negative experiences and removal of exoskeletons (e.g., removing them to use the restroom required assistance). Potential remedy: Lack of user involvement in planning.</p>		
<b>Danish interventions</b>	<b>Design</b>	<b>Implementation</b>	<b>Evaluation</b>	<b>Follow-up</b>
<b>DEN—INT 1: Safety culture at construction sites</b>	<p><b>VALUE:</b> Coaching managers to boost worker interaction and raise safety awareness.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Regular toolbox meetings brought together safety coordinators, supervisors, and workers to build a shared understanding of on-site procedures.</p> <p><b>ACTORS:</b> Safety coordinators (managers), company-appointed supervisors, and construction workers.</p> <p><b>GOVERNANCE:</b> Top-down: coordinators coached supervisors, who then engaged directly with workers.</p> <p><b>IMPACT:</b> Planned to measure among the workers whether there was an increase in safety awareness and communication between leaders and workers.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES:</b> Regular management meetings coached leaders on engaging workers effectively.</p> <p><b>DATA, MATERIALS, AND FLOWS – ACTORS – GOVERNANCE:</b> As planned.</p> <p><b>IMPACT:</b> Challenges: Safety coordinators had limited autonomy. The sector's fluid workforce created coordination issues. Potential remedy: Encourage collaboration by holding regular cross-group meetings among leadership and staff.</p>	<p><b>VALUE:</b> The team measured the safety climate and gave feedback to leaders.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Weekly on-site worker interviews gathered data on supervisor interactions, and supervisors received direct feedback.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Achieved initial goals: leaders and safety coordinators now interact more frequently with workers around safety.</p>	<p>No long-term follow-up was scheduled once funds ended; recognized the need for multi-year monitoring.</p>
<b>DEN—INT 2: Safety levels of apprentices in small construction companies</b>	<p><b>VALUE:</b> Introduce a structured, safe training program for construction apprentices.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Vocational school teachers distributed a safety checklist to companies; a baseline questionnaire was used in control sites.</p> <p><b>ACTORS:</b> Over 100 small construction companies, owner-managers (responsible for apprentices), apprentices, and vocational school teachers.</p> <p><b>GOVERNANCE:</b> Participatory, iterative design overseen by a panel of experts, local training boards, apprentices, and owner-managers to tailor content.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Additional activities encouraged company participation: expanded the checklist to meet compulsory OSH requirements, provided promotional materials, and offered free OSH specialist visits.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Low dropout rate; maintaining strong school-apprentice relationships was crucial. Challenges: Not all checklist items were adopted, though many were. Success varied by each party's approach. Potential remedy: Involving a school teacher proved effective, as they consistently worked with apprentices.</p>	<p>No evaluation was developed due to pilot funding ending, but promoters would evaluate it in the next related studies.</p>	<p>No formal follow-up in the first pilot (funding ceased), but due to its success, the intervention was planned to be scaled up.</p> <p>Plans to track whether companies/teachers continue using tools; subsequent pilots included checks at 3–4 years post-intervention.</p>

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Table 5 (continued)

Cypriot interventions	Design	Implementation	Evaluation	Follow-up
	<p><b>IMPACT:</b> Teachers would embed and sustain the intervention in new worksites—acting as central facilitators—and follow a schedule for ongoing evaluation of work practices and safety.</p> <p><b>DEN—INT 3: Certified Occupational Health and Safety Management Systems (COHSMs) across industries</b></p>			<p><i>This activity cannot be considered an intervention, as it was a comparative study that did not involve other entities, especially companies.</i></p>
Italian interventions	Design	Implementation	Evaluation	Follow-up
<b>ITA—INT 1: Safety improvement in foundry sector</b>	<p><b>VALUE:</b> Following serious accidents in foundries, a targeted intervention was developed to address major OSH violations in the foundry and hot metal sectors.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> A standard targeted model was used: companies completed a self-evaluation questionnaire, and data were shared through working group meetings and seminars.</p> <p><b>ACTORS:</b> Research institutes, industry associations, employers' associations, trade unions, local health units, and technicians from two sector companies.</p> <p><b>GOVERNANCE:</b> Explicitly managed by two national bodies.</p> <p><b>IMPACT:</b> Sustainability was ensured by self-financing from all participating actors.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned, other tools were developed for data analysis of the causes and dynamics of accidents and experimental tools for the management and analysis of accidents and near misses.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Challenges: Some actors were not fully engaged. Potential remedy: Ongoing data sharing and involvement improved engagement.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Evaluation was prepared during the design phase using a table of qualitative and quantitative indicators to track intervention phases and outputs at both the network and company levels.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> Quantitative objectives were met; there was room to improve qualitative outputs.</p>	<p><b>VALUE – GOVERNANCE – ACTORS:</b> Long-term sustainability was ensured through ongoing funded research involving the same actor-network, with a five-year follow-up plan in collaboration with companies.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Improvement measures (e.g., break training, risk assessment) were set up.</p> <p><b>ACTORS:</b> A follow-up network was identified.</p>
<b>ITA—INT 2: Risk assessment in fishing industry</b>	<p><b>VALUE:</b> The intervention addressed maritime sector challenges by promoting productivity, quality, environmental protection, and OSH in line with EU policies. All phases—from implementation to result monitoring—were integrated into the design.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The design followed a targeted intervention model with active involvement and information sharing. Data was exchanged through meetings, seminars, and risk perception surveys, tailored to operator needs.</p> <p><b>ACTORS:</b> Key territorial actors included employers' associations, trade unions, and local health units, selected for their OSH expertise and established local presence.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Seafarer participation exceeded expectations. Tools were developed to analyze accident causes and dynamics, including experimental tools for managing incidents and leveraging technology for emergency response at sea.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Evaluation was prepared during the design phase using a table of qualitative and quantitative indicators to track intervention phases and outputs at both the network and company levels.</p> <p><b>ACTORS:</b> No changes; all implementation actors took part in the evaluation.</p> <p><b>GOVERNANCE:</b> No changes.</p>	<p><b>VALUE – GOVERNANCE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS – ACTORS:</b> Post-intervention supervision was led by the authors in charge (in the governance, as the orchestrators), with sustainability ensured through ongoing funded research involving the same actor-network.</p> <p><b>IMPACT:</b> Only part of the improvement measures was implemented due to companies' administrative difficulties in accessing specific funding calls.</p>

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Table 5 (continued)

Italian interventions	Design	Implementation	Evaluation	Follow-up
ITA—INT 3: Safety improvement in port areas	<b>GOVERNANCE:</b> Explicitly managed by two national bodies.	<b>IMPACT:</b> Difficulties arose in organizing and tailoring training activities to the target audience.	<b>IMPACT:</b> Both quantitative and qualitative objectives were met.	
	<b>IMPACT:</b> Sustainability was supported through targeted funding for research and territorial prevention services.			
	<b>VALUE:</b> The goal was to integrate technological innovation with workplace safety in Italian ports by providing managerial tools for risk assessment. All phases, from implementation to monitoring, were built into the design.	<b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned, other tools were developed for data analysis of the causes and dynamics of accidents and experimental tools for the management and analysis of accidents and near misses.	<b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Evaluation was prepared during the design phase using a table of qualitative and quantitative indicators to track intervention phases and outputs at both the network and company levels.	<b>VALUE – GOVERNANCE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS – ACTORS:</b> Improvement measures, technologies, and good practices were identified. Monitoring was conducted by local health units in the network.
	<b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The intervention followed a targeted model with data sharing through meetings and seminars, especially during the design phase.	<b>ACTORS:</b> No changes.	<b>ACTORS:</b> No changes.	<b>IMPACT:</b> Improvements were noted in the final phase. A post-project agreement with the association of Italian Ports supported the dissemination of near-miss analysis tools and improvement technologies.
	<b>ACTORS:</b> Involved actors included research institutes, employers' associations, trade unions, and local health units, selected for expertise and local engagement.	<b>GOVERNANCE:</b> No changes.	<b>GOVERNANCE:</b> No changes.	
<b>GOVERNANCE:</b> Explicitly managed by two national bodies.	<b>IMPACT:</b> Low participation from some actors. Possible remedy: Ongoing information sharing and targeted engagement improved their involvement.	<b>IMPACT:</b> Quantitative objectives were achieved.		
<b>IMPACT:</b> Sustainability was supported by dedicated funding for research and territorial governance.				

#### 4.2.2. Ensuring self-sustainability of interventions

Two main elements were identified as critical for the sustainability of interventions:

- Planning of all the phases of intervention
- Budget and resource allocation

For the first point, this approach facilitates the idea of a virtuous cycle where the continuous assessment of completed interventions enables better follow-up activities and plans for more effective ones that address previous challenges. This strategy is an additional step beyond the “awareness” highlighted in the previous section. At this stage, the design phase will require concrete actions for a comprehensive assessment of all phases; simply raising awareness among individuals is insufficient.

The second aspect can be integrated into proper planning, including the budget allocation for the post-intervention period. One participant from Cyprus said, “It would be of great benefit for everyone if part of the given budget was for the continuation of the product/service/idea and for future activities.” However, monitoring usually starts when the intervention is complete. If funds have not been allocated for that phase, securing resources for evaluating outcomes becomes challenging, as was common in Denmark and Cyprus’s interventions. Ideally, after implementing an intervention, a follow-up phase that does not require a continuous intake of funds is required.

#### 4.2.3. Establishing a sustainable post-assessment process for interventions

Taking the steps of the previous section, it becomes crucial to explore how a continuous post-assessment process for interventions can be established. Two key elements that emerged from the discussion were:

- Identifying appropriate actors
- Providing processes and tools (e.g., platforms and indicators)

Identifying the proper individuals who would take charge of the activities of the post-assessment phase is essential. Providing them with suitable tools to guide them in the monitoring process is also important. As mentioned during the focus group, “You need specific actors; you need to choose the people and their places because, yes, they are very important for the continuity and the sustainability” (Cyprus). Local knowledge is crucial, as stressed by Danish participants: “The integration of safety management into work practices is important across construction sites, but the practices of doing it might require local knowledge” (Denmark).

Regarding how the post-assessment phase should be conducted, Italian participants highlighted the importance of self-evaluation and the standardization of processes and indicators. They expressed, “What is important is self-evaluation of companies over time for the maintenance of ecosystems, self-evaluating companies over time, and also standardization of an evaluation process through indicators, leading and lagging indicators, and national guidelines.” Companies, particularly SMEs, should be provided with procedures and tools enabling maintenance of the intervention, even after the initial implementation, as confirmed by Cyprus and Denmark. A researcher from Cyprus, referring to SMEs, noted, “They do not have the budget, so they are using OIRA [Online Interactive Risk Assessment]. We have a very large number actually of companies using this.” Danish interventions provided companies with “measurement tools that were easy and straightforward to apply for practice people [who] were trained to use them.” Consequently, the identification of responsible individuals and the provision of appropriate tools are critical for ensuring the ongoing success of an intervention.

## 5. Discussion—how to pursue the sustainability of OSH interventions

The introduction of the ecosystem perspective in OSH offers scholars a fresh approach to designing, implementing, and evaluating interventions, paying greater explicit attention to the post-assessment phase and their sustainability.

With the involvement of experts from multiple countries, key elements of the ecosystem perspective were noted as essential to increase interventions' effectiveness and were discussed in relation to current intervention strategies. Traditional OSH interventions typically follow well-established methodologies—such as standardized protocols, linear phase models, and theory-of-change frameworks, as well as Plan-Do-Check-Act (PDCA) cycles, and participatory action research—focused on structured design and implementation phases, with relatively modest consideration of sustained evaluation, frequently concluding once initial funding is exhausted or preliminary data are collected.

In contrast, the ecosystem perspective builds on and extends the most useful aspects of these existing models—such as the iterative nature of PDCA cycles, participatory co-creation, and theory-grounded logic models—while also including multi-actor governance structures, systemic feedback mechanisms, and clear plans for follow-up and long-term sustainability. Additionally, this approach applies to interventions of varying scales and types, whether involving a few or many actors. It is therefore of particular value in resource-constrained settings like SMEs, as it can support the transformation of isolated interventions to dynamic ecosystems that spread the effort of developing OSH interventions amongst various internal and external actors and can adapt to stakeholder needs and changing regulations.

The ecosystem perspective considered multiple components, including the elements of circular ecosystems, introduced by Trevisan et al. (2022), such as value, actors, circular activities and strategies, data, materials and flows, and governance. To guide the following discussion, we have provided a reference framework (Fig. 1) that integrates the elements that emerged from our conversations with experts, gathered through interviews and a focus group, within an ecosystem perspective.

The framework offers, through mediators and moderators, a key to interpreting the diverse aspects influencing intervention development and its long-term sustainability. This is because they significantly affect the sustainability of interventions over time, unveiling the underlying aspects contributing to the success or failure of interventions, as similarly investigated by Micheli et al. (2018). By definition, a mediator variable helps to understand the underlying aspects of a relationship between two other variables, while a moderator variable influences the strength and direction of the relationship. The framework in detail is discussed below.

### 5.1. Mediators: planning intervention development phases

The mediator serves as the essential prerequisite for ensuring the sustainability of an intervention. All experts recognized the need to plan all intervention phases to ensure sustainability. Without progressing beyond the “Implementation” phase, how can we expect the other phases to follow naturally? This observation aligns with previous literature (Chambers et al., 2013; Nielsen et al., 2024; Vitrano et al., 2023), where researchers argued that effective intervention development requires considering the entire lifecycle, from design through to implementation, evaluation, and follow-up.

Proper planning includes awareness and appropriate resource allocation as part of the design of the intervention, as emphasized by Danish participants and discussed in the focus group (see Section 4.2.2 for detailed findings). Without it, the pursuit of sustainability becomes unattainable, while all the other dynamics, as explained below, influence the strength of the central relationship, thus acting as moderators.

The current issue in the literature related to the low effectiveness of the interventions can be summarized with a quote from a researcher interviewed during our study, who noted that interventions are “funded, basically to produce an output, not to operate the output.” Consequently, the assessment of the results is based on this idea, which prevents adequate ongoing monitoring. Hence, recognizing the significance of all intervention phases is the basis for changing the intervention development approach (Vitrano et al., 2024).

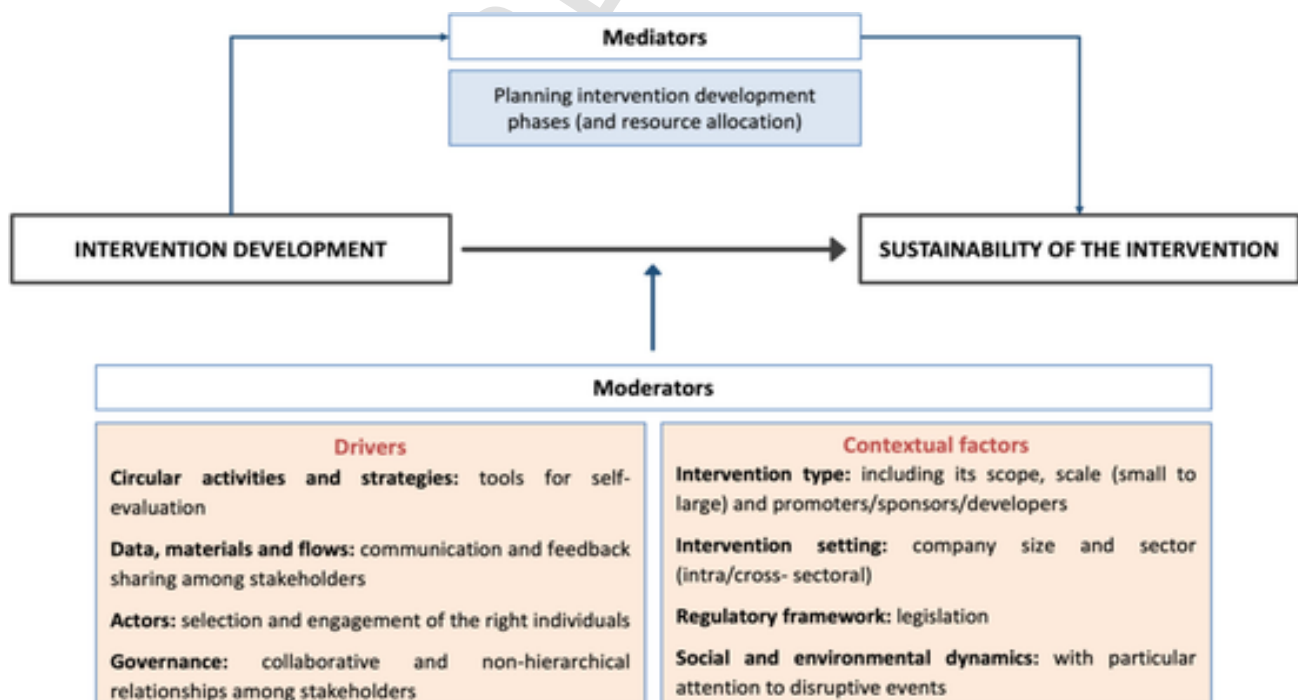


Fig. 1. Reference framework with aspects affecting the sustainability of the OSH interventions.

Another critical aspect relates to resource allocation, especially financial resources. Moreover, the importance of human resources should not be underestimated. As already noted by Baril-Gingras et al. (2006), Zwetsloot et al. (2020), and Masi and Cagno (2015), the lack of appropriate resource allocation is a barrier severely hindering the long-term success of interventions. Ideally, every intervention should have a continuously monitored and developed budget. However, during an interview, one individual pointed out that “you cannot give to all of the project’s budget to continue monitoring and developing”; a selection must be made. This observation opens up a challenging debate, which falls beyond the scope of this study but remains open for future discussions on the subject.

## 5.2. Moderators: drivers and contextual factors

The moderators enclose the drivers and the contextual factors affecting the outcome. While contextual factors are typically unchangeable and should be taken as they are, drivers, by contrast, represent the components that we can leverage to strengthen the relationship, thereby enhancing the sustainability of the intervention. Several drivers have been identified, and they have the potential to facilitate appropriate assessment and subsequent follow-up activities. This resonates with Hasle’s works (Hasle et al., 2014; Hasle and Limborg, 2006) that discuss the importance of studying the working environment to correctly operate interventions and drive their outcomes.

All these aspects are framed within the ecosystem perspective through the five components proposed by Trevisan et al. (2022), thus providing insights into activities, data flows, actors, and governance, with the value component integrated within the others.

- *Circular activities and strategies: tools for self-evaluation*

When aiming for the sustainability of the intervention, companies should be empowered to continue the activities initiated during the intervention. Therefore, the importance of self-evaluation procedures and lagging and leading indicators to equip companies for the post-intervention phases was acknowledged in particular by Italian experts in their interventions and during focus group discussions (as detailed in Section 4.2.3). Similarly, Fridrich et al. (2015) highlighted that self-assessment and continuous evaluation are key to ensuring long-term intervention effectiveness and adapting to evolving conditions, while Vitrano and Micheli (2024) identified the development of appropriate sets of key performance indicators (KPIs) for the evaluation of interventions as a valuable research direction for enhancing their effectiveness.

This recognition enables monitoring of the intervention and promoting its self-sustainability, as these activities would be administered by the key actors directly impacted by the intervention’s outcomes. Raising the awareness of individuals directly involved is a key strategy for increasing their commitment to the intervention’s progress, as already evidenced by Vitrano et al. (2023) and reinforced by the focus group discussion (see Section 4.2.1 for detailed findings). The underlying logic guiding the phases of intervention development changes, shifting from a project-based, linear approach to an iterative, continuous improvement model, further strengthening the choice of circular ecosystems for the analysis, where continuous feedback and adaptation are integral to maintaining sustainability, as emphasized by Aarikka-Stenroos et al. (2021). Consequently, the execution of activities should evolve accordingly.

- *Data, materials, and flows: Communication and feedback sharing among actors*

Participants in the focus group, particularly Italian experts reflecting on their interventions (Table 5), stressed the importance of data sharing and transparency between all actors, including promoters and

users, right from the early stages of intervention development. Cagno et al. (2016), indeed, asserted that data transparency and knowledge sharing are key drivers for the development of interventions, fostering alignment between stakeholders and monitoring of activities over time. Gathering the “voice of the workers” and setting up pilot tests are prerequisites for obtaining reliable data and establishing a network for sharing information across various action groups, thereby promoting data integration.

- *Actors: Selection and engagement of the right individuals*

Actors’ identification and involvement emerged as a central theme in the expert discussions (see Sections 4.2.1 and 4.2.3). There was general agreement that appointing the right individuals at each phase of the intervention is a key driver of its success. Similarly, Nielsen et al. (2024) suggested that selecting the right individuals and ensuring their active engagement throughout the intervention process is crucial for achieving lasting results. However, acknowledging that individuals may change as the intervention progresses, with a particular emphasis on the post-intervention phase, where the initial promoters have no more responsibilities, is essential. Hence, these people should step into the role of the initial promoters and continue to execute the intervention as planned. This dynamic aligns with the principles of ecosystems by Jacobides et al. (2018), where the roles and interactions of actors evolve over time to ensure that value is continuously created and maintained.

- *Governance: Collaborative and non-hierarchical relationships among actors*

Experts agreed that effective governance of interventions should be based on collaborative relationships among actors, avoiding hierarchical structures, as reflected in most of the interventions presented in Table 5 (e.g., DEN—INT 2 and CYP—INT 2). From the literature review of Vitrano and Micheli (2024), and as previously stated by Hasle and Sørensen (2011), it emerged that a collaborative governance structure introduces greater flexibility, enabling interventions to adapt. This structure brings indeed flexibility, enabling changes during development and the selection or alteration of individuals in response to evolving needs and conditions.

Contextual factors appeared relevant already during the first interviews with experts. They are summarized below:

- *Intervention type: Scope, scale (small to large), and promoters/sponsors/developers*

All the attributes of an intervention play a defining role in shaping its development and the pursuit of its sustainability. The contingency of some interventions may prevent them from lasting over time, as they might have been conceived to accomplish short-term objectives. During the focus group, differences among small and large interventions were debated. Substantial differences emerged when considering the inclusion of individuals, the dynamics of their interactions, and the supporting tools proposed during the intervention, as frequently emphasized by Cypriot participants (see Section 4.2.1). In large interventions, typically characterized by extensive working teams, high levels of collaboration among participants, and comprehensive data integration are required, posing substantial challenges. By contrast, small-scale interventions are managed by a compact team of a few individuals, where each member has significant influence. However, this scenario may lead to a higher risk of incurring errors, as these groups usually have limited expertise and proper training, a challenge already noted by Micheli and Cagno (2010).

- *Intervention setting: Company size and sector (intra/cross-sectoral)*

The setting of the intervention, including factors like the size of the company and its sector, shapes both the intervention itself and the design of its various phases. For instance, when introducing interventions in SMEs, the limited human and financial resources should be accounted for. As a result, organizations often cannot rely solely on internal capabilities to sustain interventions, necessitating external support in terms of competencies and funding. This was evident in the Italian interventions (Table 5), where employers' associations, trade unions, and local health units played a key role in supporting intervention development; a challenge extensively documented in previous studies on SME interventions (Cagno et al., 2016; Masi and Cagno, 2015; Micheli et al., 2018; Micheli and Cagno, 2010). This is particularly relevant from an ecosystem perspective, where the roles of various actors may need to adapt depending on the available resources and sector-specific requirements (Aarikka-Stenroos et al., 2021).

- *Regulatory framework: Legislation*

The regulatory framework, as established by national OSH systems, sets the context for developing interventions and frames regulatory gaps (lack of reference legislation) and areas needing improvement (e.g., as reported by CYP—INT 1, Table 5). In the same way, Rocha (2010) highlighted the critical influence of the regulatory environment in shaping the OSH network of stakeholders and intervention development.

- *Social and environmental dynamics: with particular attention to disruptive events*

External events can significantly affect all phases of interventions, and the unforeseen nature of certain events may prevent interventions from continuing as initially planned if flexible, adaptive strategies are not implemented. COVID-19 was frequently cited by participants as a factor that hindered intervention outcomes (e.g., explicitly mentioned in CYP—INT 2, Table 5). For example, in the literature, Badri et al. (2018) focused on the recent rapid technological advancements, such as real-time communication, big data, and human-machine cooperation, which may bring unforeseen challenges for OSH management.

In conclusion, this discussion has examined the dynamics influencing intervention development through a reference framework based on the ecosystem perspective. By categorizing these dynamics as mediator and moderator variables, the framework helps clarify their relationships to both the effectiveness and sustainability of intervention and the advantages of using such a perspective to identify and implement strategies that enhance intervention outcomes.

## 6. Conclusions

Advancing OSH research toward more theoretical and strategic perspectives has the potential to significantly enhance interventions at an operational level. Guided by this belief, this study explores how the effectiveness of OSH interventions can be enhanced by leveraging various aspects influencing their development. It identifies key elements that contribute to more effective OSH interventions, ensuring their sustainability when designed and managed appropriately. In this regard, an ecosystem perspective has been deemed appropriate for consideration.

The research builds on a qualitative, exploratory design, structured around expert engagement in two phases: exploratory interviews aimed at gathering insights on past OSH interventions and a focus group, starting from previous findings, to collectively discuss and refine strategies for improving intervention effectiveness. Three main questions led the

focus group discussion. Based on the questions, experts started discussing generalizable insights on the effectiveness and sustainability of OSH interventions and the post-intervention phase by investigating underlying dynamics contributing to intervention outcomes. A reference framework has been created, enclosing all the elements derived from experts' conversations and identifying a set of mediators and moderators that play pivotal roles in sustaining interventions.

Most limitations of this study stem from the methods employed and their exploratory nature, which might hinder the generalizability of the results. The organization of a single focus group, although grounded on a strong and well-structured foundation of information obtained during the first phase of data collection, may not have ensured that all possible perspectives were fully explored, particularly given time constraints and the limited number of participants (three European countries). Furthermore, the use of two different data collection techniques—group interviews and guided questionnaires—may have introduced variations in the type and depth of information gathered, as their nature differs in terms of interaction and response dynamics. Therefore, future research should further validate and expand upon the findings of this study by conducting additional qualitative studies and engaging experts, possibly including OSH practitioners, from various countries.

Additionally, practitioners would benefit from the findings of this study, as it offers evidence on how to orchestrate and maintain interventions effectively over time. Information about the interventions implemented across three European countries also offers practitioners an interesting perspective on interventions developed across countries, thus providing a clear understanding of the successful practices, with a focus on their long-term sustainability.

In conclusion, the authors hope that the evidence obtained here will inspire scholars and practitioners to work toward effectiveness and sustainability in OSH interventions instead of pursuing opportunistic behaviors yielding short-term benefits but failing to create long-term effects.

## CRediT authorship contribution statement

**Gaia Vitrano:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Guido J.L. Micheli:** Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization, Data curation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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We would like to express our sincere gratitude to all the experts who generously contributed their time and insights to our focus group discussions. Their valuable input and perspectives have been crucial in shaping the findings and conclusions of this research.

## Data availability

Data will be made available on request.

## Appendix A. Interview protocol

### Introductory questions

1. What type of interventions are being discussed? In which fields (safety or health) and at what organizational levels (company, territorial, national) are they implemented? A brief description of the intervention and key facts.
2. Considering the intervention just introduced, did you feel the need to build the intervention considering all the phases—design, implementation, evaluation, and follow-up? Did you care about the long-term sustainability of the intervention (once the implementation ended)?
3. Do you believe—generally speaking—that the nature of the intervention can influence its design throughout all the phases?

### Design

1. (VALUE) What actual or perceived need/condition/situation gave rise to the development of this intervention, and what were its primary (explicit/implicit/planned/blurred...) objectives?
2. (GOVERNANCE) Was there any form of governance, whether explicit or implicit, during the design phase? Was it tailored specifically for the intervention or based on ordinary governance practices?
3. (GOVERNANCE—ACTORS) Were there (explicit/implicit/planned/blurred) collaborations with other organizations? How were collaboration and governance managed—through top-down or bottom-up approaches?
4. (VALUE—ACTORS) How did you bring actors into the intervention? Have you got the need to plan the actors to be involved? Did you plan any (explicit/implicit) criteria for their selection (e.g., project relevance, pre-existing relationships, demonstrated R&D capabilities, unique technologies, cultural alignment, shared values)? Did you follow the plan? Did their roles evolve during the intervention's development?
5. (VALUE—CIRCULAR ACTIVITIES AND STRATEGIES—DATA, FLOWS AND MATERIALS) Did you set procedures/strategies/activities to manage the cooperation among actors and the sharing of data and information during the intervention development?
6. (IMPACT) Before implementation, did you feel the need to assess the actual feasibility and sustainability of the planned intervention? Were there any pilot tests in the design phase?

### Implementation

1. (VALUE—ACTORS—CIRCULAR ACTIVITIES AND STRATEGIES—GOVERNANCE) Did you perceive the need to actively involve actors during the intervention's implementation? Did you implement any activities/strategies to promote and coordinate them?
2. (VALUE—DATA, FLOWS AND MATERIALS) Were any tools, software, or procedures introduced as part of the intervention, especially to facilitate material and information sharing?
3. (DATA, FLOWS AND MATERIALS) Did you perceive/observe any deviations from the planned (human and material) resources during the implementation?
4. (IMPACT) Did you perceive/observe challenges during the implementation? How were they addressed?

### Evaluation

1. (VALUE—DATA, FLOWS AND MATERIALS—CIRCULAR ACTIVITIES AND STRATEGIES) Once implemented, did you feel the need to collect feedback on the intervention's success? (If Yes) What measures, tools, or procedures were employed? Was the intervention's efficiency assessed based on the health and safety of workers?
2. (ACTORS—GOVERNANCE) Were actors (physically implementing the intervention) involved in the evaluation phase, and were new actors engaged during this stage? How did collaboration take place in this phase?
3. (IMPACT) Were the initial (explicit/implicit/planned/blurred) objectives of the intervention met? Did you accomplish any other results not planned or explicitly identified in the design phase?

### Follow-up

1. (VALUE—DATA, FLOWS AND MATERIALS—CIRCULAR ACTIVITIES AND STRATEGIES—ACTORS) After the end of the intervention, did you put in place—based on feedback and results—any improvement actions (for the long-term sustainability of the intervention)? Did you perceive actors had a primary role in this phase? Did they facilitate the process?
2. (GOVERNANCE) Did you establish any (explicit/implicit) governance for the follow-up of the intervention?

## Appendix B. Results first phase

Table 6

Interventions emerged from the interviews: descriptions with quotes classified according to the intervention development phases and ecosystem-based values.

Intervention	Design	Implementation	Evaluation	Follow-up
<p>CYP—INT 1: In-house risk assessment for teleworkers</p> <p>This intervention was related to the health of teleworkers and was developed in Cyprus with the support of the Department of Labour Inspection during the initial months of the COVID-19 pandemic. Given the absence of specific legislation on teleworking at the time, the objective was to develop a tool to assist teleworkers in conducting their own risk assessment, generating reports, and engaging in discussions with their employers to find appropriate measures and solutions to address various workplace hazards effectively.</p>	<p>VALUE: Since there was no specific legislation on teleworking, the research team, composed of the University of Cyprus supported by the Department of Labour Inspection, decided to create, during the initial months of the COVID-19 pandemic, a mobile and desktop application to help teleworkers conduct an in-house risk assessment, generate reports, and discuss findings with employers. The tool covered six categories of hazards that teleworkers must identify and then discuss with their employers to find appropriate measures and solutions.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> 1. Online meetings helped to gather feedback on teleworking issues; 2. Internal presentation at the Department of Labour Inspection helped to fully explain the tool so that they could promote it effectively.</p> <p><b>ACTORS:</b> The actors involved were the university research group and the Department of Labour of Cyprus.</p> <p><b>GOVERNANCE:</b> Collaboration and governance were mainly managed through a top-down approach. A Memorandum of Understanding (MoU) was concluded with the Department of Labour Inspection, which supported the activities proposed by the university research group.</p> <p><b>IMPACT:</b> The university research group created a pilot questionnaire. Based on this, they wrote a project proposal and obtained local funding to continue the development of the tool for risk assessment.</p>	<p>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS: At that time, during the first months of the COVID-19 pandemic, people were confused about telework. They sought information and guidance. This situation led to participation from everyone. Thus, the promoters did not need to involve actors during the intervention's implementation. The deviation observed concerned the content of the questionnaire to be created. It was decided to focus on only the two major risk categories of teleworking (i.e., psychosocial and economic risks). Besides the mobile application, it was developed and shared as a PDF handbook, also considering old workers, explaining the procedures to use the tool, and assessing risk.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Challenges:</b> Lack of time and economic resources prevented the inclusion of additional partners and the translation of the tool into other languages, thus increasing its diffusion in other countries.</p>	<p>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS: This was the answer about the evaluation phase: "I think we just checked the users, the number of the users, and we did not have or share any feedback from/to the users. I mean, this is what we are missing."</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Goal achievement:</b> They received positive feedback from some employers on its effectiveness. It was currently the only tool available in Cyprus for assessing the risk of teleworking. The Department of Labour Inspection supports and promotes it on its website as the primary resource for teleworkers.</p> <p>The main problem was that there was only planning for doing, not planning for evaluation and follow-up. However, a control plan could have been useful.</p> <p>It was also added that: "the problem today is that whenever the actions are funded, basically to produce an output, not to operate the output, the intervention measures tend to produce the output and measure the results based on the fact that the output is produced because they don't have to operate relatively for a sufficiently long time. That is one of the clauses in these initiatives."</p>	<p>No information regarding this phase.</p>
<b>Intervention</b>	<b>Design</b>	<b>Implementation</b>	<b>Evaluation</b>	<b>Follow-up</b>

Intervention	Design	Implementation	Evaluation	Follow-up
<p><b>CYP—INT 2: Safer rescuers</b></p> <p>The intervention was related to the safety of rescuers during their operations. In this intervention, innovative technology was developed to improve their safety by protecting them from exposure to toxic materials and burns. A consortium of 34 partners, including rescue institutions, technology providers, and support organizations, created a wearable device with sensors, including those for chemical analysis, to collect crucial data on the safety of rescuers.</p>	<p><b>VALUE:</b> The intervention introduced a unique structure for best associating modern telecommunications technology with novel practices for First Responders to save lives while safeguarding themselves more effectively, such as from exposure to toxic substances and burns.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The intervention has been organized into nine Work Packages (WPs) running in parallel throughout the entire duration of the intervention, continuously interacting with the technical, training, and demonstration WPs. Special attention has been paid to ensuring the attainment of intervention objectives and effective implementation in structuring the overall work plan. These WPs included training activities, the integration phase and realization of the three pilots, and the final large-scale demonstration.</p> <p><b>ACTORS:</b> The intervention was run by a consortium of 34 carefully selected participants, forming a complete group with many areas of expertise. Its most essential quality was its balance; this ensured that all important sectors of the industry, research institutes, and academia were represented.</p> <p><b>GOVERNANCE:</b> A consortium of 34 participants mutually interacting and collaborating was considered.</p> <p><b>IMPACT:</b> The intervention was tested in three different pilot tests. In these pilot studies, several dozen rescuers participated. The aim was to progressively refine the technology to make it more suitable and acceptable to them. This process involved not only technological aspects but also safety and ethical considerations.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned in the WPs. Three types of activities were developed: five training sessions, webinars, and pilot tests. The partners also introduced a system of user feedback. They said, “Because the technology started, and then we had the training. We were getting feedback, and then we were redeveloping based on feedback, and it was a back-and-forth process.”</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Challenges:</b> They encountered challenges during implementation because about two-thirds of the intervention took place during the COVID-19 pandemic, and the development of technologies, particularly collaborative ones, was complicated, but they finally made it. They added, “The intervention was not only about developing this, but we also had to train the first responders on how to use this technology. So, training was delayed for three months.”</p>	<p><b>IMPACT: Goal achievement:</b> The intervention was delivered on time by satisfying all the WPs. The interviewees said, “It worked, and we submitted and finished on time. We did not request any sort of delays from the commission.”</p>	<p>No information regarding this phase.</p>
<p><b>Intervention</b></p> <p><b>CYP—INT 3: Exoskeletons for airport staff</b></p> <p>This intervention tested wearable exoskeletons during airport tasks. The exoskeleton was designed to support lifting movements during luggage handling to reduce workload, exhaustion, and fatigue, ultimately ensuring employees' long-term well-being.</p>	<p><b>Design</b></p> <p><b>VALUE:</b> The aim of the intervention was the test of a wearable exoskeleton during airport activities.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> Employee involvement was important; they tested the exoskeletons and then reported feedback to the company providing those exoskeletons and to the ramp handling department of the airport.</p> <p><b>ACTORS – GOVERNANCE:</b> Volunteers from the ramp handling department were selected, and the health and safety manager and the company occupational physician were consulted.</p> <p><b>IMPACT:</b> Pilot tests were carried out by collecting feedback and proposals from the employees involved in the tests to create a more advanced version of exoskeletons.</p>	<p><b>Implementation</b></p> <p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Challenges:</b> However, owing to problems with flexibility and difficulty in use, the experience was negative and led to the removal of exoskeletons from the working environment. The interviewees made an example: “Even if you want to go to a toilet, you need to remove the exoskeleton, and someone else must help you just wear it again.”</p> <p><b>Potential remedies:</b> An initial plan and involvement of the correct bodies and players were lacking. The interviewees said, “The point is that they did not ask them, they did not involve them in planning, and they just forced them to use it.”</p>	<p><b>Evaluation</b></p> <p><b>IMPACT: Goal achievement:</b> The exoskeletons eased the physical strain when loading/unloading luggage onto the aircraft. Employees experienced reduced strain on the musculoskeletal system.</p>	<p><b>Follow-up</b></p> <p>No follow-up plan: exoskeletons were ultimately removed due to negative user experience and lack of initial worker involvement in design, cited as a root cause.</p>
<b>Intervention</b>	<b>Design</b>	<b>Implementation</b>	<b>Evaluation</b>	<b>Follow-up</b>

Intervention	Design	Implementation	Evaluation	Follow-up
<p><b>DEN—INT 1:</b> Safety culture at construction sites</p> <p>This intervention was related to safety in the construction sector and was implemented at a local construction site. This intervention's primary goal was to improve workplace safety by clearly increasing the importance of safety in interactions with workers. This goal was achieved by coaching managers to increase their worker interactions and raise safety awareness. Therefore, the aim was for workers to recognize that management paid attention to safety, leading them to prioritize safety.</p> <p>The sample included three intervention and three control companies, randomly selected.</p>	<p><b>VALUE:</b> Coaching the managers to increase their interactions with workers and raise safety awareness was crucial in this intervention.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES - DATA, MATERIALS, AND FLOWS:</b> Toolbox meetings were used across all professional groups and between leaders and managers. "It is also a social setting in the sense that you bring people together to have a common understanding of how you should proceed with a building construction site."</p> <p><b>ACTORS:</b> Safety coordinators (managers), supervisors (appointed by the company or workers), and construction workers were included.</p> <p><b>GOVERNANCE:</b> A top-down approach was used: safety coordinators talked with supervisors, and then they talked with construction workers.</p> <p><b>IMPACT:</b> Planned to measure among the workers whether there was an increase in safety awareness and communication between leaders and workers, asking questions like: "How often do you discuss safety with your manager? How often do you meet managers?"</p>	<p><b>VALUE - CIRCULAR ACTIVITIES AND STRATEGIES:</b> Many meetings with the management side ensured effective coaching, instructing them on how to interact with workers.</p> <p><b>DATA, MATERIALS, AND FLOWS – ACTORS – GOVERNANCE:</b> As planned.</p> <p><b>IMPACT:</b> Challenges: 1. Safety coordinators could not always act freely. 2. The construction sector was dynamic (frequently changing relationships and external workers), so a coordination problem arose.</p> <p><b>Potential remedies:</b> Promoting collaboration and organizing meetings among professional groups and between leaders and executives were common practices to foster collaboration.</p>	<p><b>VALUE:</b> The research team assessed the safety climate in various dimensions and provided feedback to leaders. The leader said, "It is the first time in my long career that my leadership has been measured."</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES - DATA, MATERIALS, AND FLOWS:</b> The motor was the feedback system. "The research team carried out weekly on-site interviews with workers about the most recent exchanges with their supervisors, and supervisors received feedback."</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Goal achievement:</b> The intervention has achieved its initial goals. Changes in interaction dynamics between leaders/safety coordinators and workers have occurred regarding interaction frequency and safety.</p>	<p>No, after the completion of the intervention and the depletion of funds, long-term follow-up activities were not scheduled.</p> <p>They added, "Long-term follow-up is interesting, but not always feasible, but very important. And I think there is a lack of long-term follow-up interventions to know what happened in the long term. I think if you do something, after two years, or maybe after five years, the effect of the intervention will have reduced."</p>
Intervention	Design	Implementation	Evaluation	Follow-up

Intervention	Design	Implementation	Evaluation	Follow-up
<p><b>DEN—INT 2:</b> Safety levels of apprentices in small construction companies</p> <p>This intervention was related to the safety of apprentices in small construction companies specializing in plumbing and similar trades. The main objective was to address the low levels of knowledge and communication regarding safety among apprentices when they usually join the companies. This intervention included an approach based on checklists, specific tools to improve the working environment, and incentives to fulfill health and safety obligations. This program was tested in a pilot phase to evaluate recruitment, implementation, and effects.</p>	<p><b>VALUE:</b> Creating safe training for companies to introduce apprentices in the construction sector.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES - DATA, MATERIALS, AND FLOWS:</b> The promoters used a checklist presented to the company by the school teacher to facilitate material and information sharing. A baseline questionnaire was issued to a control group where the intervention was not developed.</p> <p><b>ACTORS:</b> There was a pilot study involving over 100 companies. The actors involved in this intervention were of three types: the person responsible for apprentices (typically the owner-manager), apprentices, and professional teachers from the vocational schools. The training companies were selected through the construction program of a medium-sized Danish vocational school.</p> <p><b>GOVERNANCE:</b> The specific structure and content of the interventions were tailored to the target group through a participatory, iterative process involving a panel of experts and interviews with the local training boards, apprentices, and owner-managers of training companies.</p> <p>The research team said, "We have a number of people around this who could contribute information to the intervention, but also could retrieve information from the intervention. But, they were like an umbrella over the intervention."</p> <p><b>IMPACT:</b> "We implemented this intervention in various locations and asked apprenticeship school teachers to introduce it because we always try when we do an intervention, not always to be there ourselves, because you will leave it as a research artifact." Therefore, when conducting an intervention study, we try to identify who should continue the intervention after we have left the site. We thought that teachers could be the ones to carry on the intervention and introduce it to new workplaces, along with a schedule for ongoing evaluation of work and safety.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned, other activities were developed to encourage companies to participate ("So we tried various things to interest companies"); support in fulfilling compulsory OSH obligations, including expanding the checklist to cover the mandatory workplace risk assessment; provision of promotional materials to highlight the companies' commitment; offering the possibility of receiving a free visit from an OSH specialist.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT: Challenges:</b> The promoters stated that not all instructions on the checklist were followed, but some were incorporated. The success depends on the approach used by the different parties involved. The dropout rate was low, and they underlined the importance of maintaining good relations with schools, as apprentices come from there. <b>Potential remedies:</b> They mention the involvement of a school teacher in the intervention, which was seen as a successful solution because the teacher was consistently present for apprentices.</p>	<p>It was not planned because the study was developed as a pilot test, and funding ceased. However, the promoters plan to assess the intervention in subsequent related ones.</p>	<p>Since this intervention was successful, it will be implemented on a larger scale. Some methods for long-term intervention control have been introduced after the end of the first pilot. They aimed to "observe two things: whether the companies that have already implemented the tool will continue to use it, and whether teachers will continue to use it after three or four years."</p>
<p><b>Intervention</b></p> <p><b>DEN—INT 3:</b> Certified Occupational Health and Safety Management Systems (COHSMSs) across industries</p> <p>This intervention compared OSH efforts between workplaces with and without COHSMSs. A questionnaire, "Work Environment Activities in Danish Workplaces" (WEADW), was distributed to adopters and non-adopters of COHSMSs to evaluate OSH efforts at the workplace level. The result was that organizations with COHSMS presented significantly higher process and content efforts related to OSH.</p>	<p><b>Design</b></p> <p><i>This activity cannot be considered an intervention, as it was a comparative study that did not involve other entities, especially companies.</i></p>	<p><b>Implementation</b></p>	<p><b>Evaluation</b></p>	<p><b>Follow-up</b></p>
Intervention	Design	Implementation	Evaluation	Follow-up

Intervention	Design	Implementation	Evaluation	Follow-up
<p>ITA—INT 1: Safety level improvement in the foundry sector</p> <p>The intervention, a prevention plan, in Italian “Piano Mirato di Prevenzione” (PMP), concerned health and safety in the foundry and hot metal processing sectors. Following serious accidents in Italy in 2014, including two fatalities, authorities identified significant violations of OSH regulations. The objectives identified were to provide and disseminate useful tools and operational methods for companies in the sector to manage risks more comprehensively; to revise, if necessary, the company’s system for managing these risks; and to adopt appropriate solutions to ensure environmental equipment and work procedures that respect workers’ health and safety.</p>	<p><b>VALUE:</b> Following serious accidents, including two fatalities, authorities identified significant violations of OSH regulations, and it was decided to develop a focused intervention for the foundry and hot metal processing sectors.</p> <p>All the phases, from the implementation to the monitoring of the results, have been included in the design.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The design was based on the standard model of targeted intervention involving/informing the parties. A questionnaire was produced as a tool for self-evaluation of OSH management in companies. Data exchange and sharing took place through working group meetings or seminars.</p> <p><b>ACTORS:</b> The actors involved were research institutes with expertise in the field, associations, and proactive structures on the territory (e.g., employers’ associations, trade unions, local health units, technicians of two companies in the sector), also based on pre-existing relationships on the territory.</p> <p><b>GOVERNANCE:</b> The governance was defined explicitly and managed by two national parties.</p> <p><b>IMPACT:</b> Sustainability was guaranteed by self-financing by all actors.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> As planned, other tools were developed for data analysis of the causes and dynamics of accidents and experimental tools for the management and analysis of accidents and near misses.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <b>Challenges:</b> The difficulties encountered referred to the active participation of particular actors. <b>Potential remedies:</b> Continuous information sharing and involvement of the less active actors concerning the data produced and the planned initiatives improved their involvement. However, only some of the difficulties have been solved.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The evaluation took place through the preparation in the design phase of a table of qualitative and quantitative indicators to record how the various phases of the intervention were carried out, and the outputs produced by the activities at the level of the network of the actors and the level of the participating companies.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <b>Goal achievement:</b> The quantitative objectives have been achieved. The possibility of improving qualitative outputs exists.</p>	<p><b>VALUE – GOVERNANCE:</b> The post-intervention supervision was carried out by the authors in charge (in the governance, as the orchestrators), and sustainability actions over time have been programmed through other funded research activities currently in place that involve the network of identified actors in similar ways. It was an ongoing follow-up plan over five years through collaboration with companies.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The improvement measures (break training, risk assessment procedures, etc.) have been set up.</p> <p><b>ACTORS:</b> A network of actors responsible for the follow-up phase has been identified.</p>
Intervention	Design	Implementation	Evaluation	Follow-up

Intervention	Design	Implementation	Evaluation	Follow-up
<p>ITA—INT 2: Risk assessment procedures in the fishing industry</p> <p>The intervention was related to the professional fishing challenges faced by Small and Medium-sized Enterprises (SMEs). These challenges included maintaining high productivity, quality, environmental respect, and OSH in line with EU policies. The plan had the objective of deepening the knowledge of operators in the relevant fishing industry on the quality of risk assessment, transferring methodological and operational tools to support risk assessment and its monitoring, assigning good practices for the control of biomechanical risk related to the manual handling of loads and technological solutions for emergency management, informing on economic incentive systems for the control of specific risk factors, and activating a survey on workers' perception of risk.</p>	<p><b>VALUE:</b> The intervention aimed to keep up with the challenges of the maritime sectors by simultaneously trying to promote high productivity, quality, environmental respect, and occupational health and safety in line with EU policies.</p> <p>All the phases, from the implementation to the monitoring of the results, have been included in the design.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The design was based on the standard model of targeted intervention involving/informing the parties.</p> <p>Data exchange and sharing between the involved actors took place through meetings, seminars, and the dissemination of survey questionnaires on risk perception during the development of the action, and to complete the path. The sharing strategies have considered the specific needs of operators.</p> <p><b>ACTORS:</b> The actors involved were associations present and active on the territory with expertise in assistance and advice on health and safety, including employers' associations, trade unions, and local health units. They were also chosen based on pre-existing relationships in the territory.</p> <p><b>GOVERNANCE:</b> The governance was explicitly defined and managed by two national parties.</p> <p><b>IMPACT:</b> Sustainability has been covered by the funds provided in specific interventions to support research and governance in the territory of the prevention service in charge.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> In this phase, the adherence of the seafarers was higher than initially anticipated. As planned, other tools were developed to analyze data on the causes and dynamics of accidents and experimental tools for managing and analyzing accidents and near misses. The opportunities technology offers for correctly managing emergencies at sea were also presented.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <u>Challenges:</u> The difficulties encountered concerned the implementation of all training activities both from the organization's perspective and adequate methodologies for the target.</p>	<p><b>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The evaluation took place through the preparation in the design phase of a table of qualitative and quantitative indicators to record how the various phases of the intervention were carried out.</p> <p><b>ACTORS:</b> No changes; all those involved in implementing the intervention participated in the evaluation phase.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <u>Goal achievement:</u> The quantitative and qualitative objectives have been achieved.</p>	<p><b>VALUE – GOVERNANCE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS – ACTORS:</b> The post-intervention supervision was carried out by the authors in charge (in the governance, as the orchestrators), and sustainability actions over time have been programmed through other funded research activities currently in place that involve the network of identified actors in similar ways.</p> <p><b>IMPACT:</b> The improvement measures requiring economic commitments were only partly implemented because of the administrative difficulty of participating for companies in the specific calls for funding.</p>
Intervention	Design	Implementation	Evaluation	Follow-up

Intervention	Design	Implementation	Evaluation	Follow-up
<p>ITA—INT 3: Safety level improvement in port areas</p> <p>The intervention focused on analyzing the challenges in the maritime port sector in nine Italian ports. The main objective was to promote greater integration between technological innovation and workplace safety in these ports. Several actors were involved. These actors developed nine specific prevention plans (PMP) to transfer methodological tools to support the risk assessment process from a management perspective, to carry out a multicenter study on the risk perception of port workers, fine-tune the standard model of intervention, retrieve and evaluate technologies applicable to OSH in the sector, test new technologies for the assessment of vehicle and people flows in port areas, and reduce the risk of interference.</p>	<p>VALUE: The main objective was to promote greater integration between technological innovation and workplace safety in various Italian ports by providing methodological tools to support the risk assessment process from a management perspective.</p> <p>All the phases, from the implementation to the monitoring of the results, have been included in the design.</p> <p><b>CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS:</b> The design was based on the standard model of targeted intervention involving/informing the parties. Data exchange and sharing, especially in the design phase, took place through working group meetings or seminars.</p> <p><b>ACTORS:</b> The actors involved were research institutes with expertise in the field, associations, and proactive structures on the territory (e.g., employers' associations, trade unions, and local health units), also based on pre-existing relationships on the territory.</p> <p><b>GOVERNANCE:</b> The governance was explicitly defined and managed by two national parties.</p> <p><b>IMPACT:</b> Sustainability has been covered by the funds provided in specific interventions to support research and governance in the territory of the prevention service in charge.</p>	<p>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS: As planned, other tools were developed for data analysis of the causes and dynamics of accidents and experimental tools for the management and analysis of accidents and near misses.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <u>Challenges:</u> The difficulties encountered referred to the active participation of particular actors. <u>Potential remedies:</u> Continuous information sharing and involvement of the low participating actors concerning the data produced and the planned initiatives improved their involvement.</p>	<p>VALUE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS: The evaluation took place through the preparation in the design phase of a table of qualitative and quantitative indicators to record how the various phases of the intervention were carried out, and the outputs produced by the activities at the level of the network of the actors and the level of the participating companies.</p> <p><b>ACTORS:</b> No changes.</p> <p><b>GOVERNANCE:</b> No changes.</p> <p><b>IMPACT:</b> <u>Goal achievement:</u> The quantitative objectives have been achieved.</p>	<p>VALUE – GOVERNANCE – CIRCULAR ACTIVITIES AND STRATEGIES – DATA, MATERIALS, AND FLOWS – ACTORS: The improvement measures, technological solutions, and good practices in the participating network were identified. The monitoring was carried out by the network of local health units participating in the intervention.</p> <p><b>IMPACT:</b> The improvement was recorded in the final phase, and a specific agreement, after the end of the activities, was obtained from the intervention's promoters and the association of Italian ports for the diffusion of instruments for the analysis of near misses and technologies of improvement.</p>

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