

Insights from targeted prevention occupational safety and health interventions for effective sustainable development

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Abstract: In recent years, an increasing number of companies across various sectors have come to recognize the profound economic and social effects of inadequate health and safety measures in the workplace. Consequently, there has been a growing emphasis on putting in place robust and effective Occupational Safety and Health (OSH) management to enhance workers' well-being. Small and Medium-sized Enterprises (SMEs), which often lack the necessary resources and expertise to effectively manage OSH interventions independently, might need external help. In this direction, national health authorities in several countries, including Italy, have launched support interventions aimed at assisting companies in improving OSH conditions. This research revolves around OSH interventions and seeks to enhance their effectiveness. The primary objective is to investigate how various factors influence the development and effectiveness of these interventions, with particular attention to key levers for their long-term effectiveness and sustainability. The analysis delves into three Italian OSH interventions developed by the Italian National Institute for Insurance against Accidents at Work (INAIL) in different environments: the metalworking, fishing, and port maritime sectors. These interventions were investigated with the promoters – INAIL experts – through interviews and subsequent follow-ups to complement and discuss initial findings. The discussion with these experts focused on evaluating the effectiveness of these interventions and how they could have been improved to ensure long-term effects. The meticulous planning of all intervention phases, with particular emphasis on post-implementation monitoring, emerged as a critical factor in their success. Only continuous monitoring of the post-intervention phases can assess effectiveness accurately and people in charge can make timely adjustments and be aware of more effective and sustainable approaches to OSH intervention design and management.

Keywords: occupational safety; occupational health; evaluation; intervention; drivers

1. Background

Ensuring the health and safety of workers within companies is not only a matter of compliance with regulation but is paramount to maintaining a productive and sustainable work environment (Hasle & Zwetsloot, 2011). Uncertainties new and old at the workplace, such as technological advancements and changes in work practice, require continuous advances in actions taken for Occupational Safety and Health (OSH) management (Badri et al., 2018).

OSH has an impact on all aspects of work, and managers or specialists monitor it to ensure that companies have adequate health and safety requirements (Micheli et al., 2022). ‘Intervention’ is the prevailing term in the OSH domain, referring to measures taken to prevent injuries and diseases in the work environment by improving employees’ safety, health, and well-being (Vitrano & Micheli, 2024).

Among that, examples of frequently studied industry sectors include health services, public services, construction, transport, education, utilities (water, gas, electricity), chemical industries, textiles, agriculture, oil and gas production, and mechanical and electrical engineering.

In the past, OSH interventions were not prioritized within companies, often perceived as a burden rather than added value. The interventions implemented within the company were typically undertaken to improve productivity and cut costs, with OSH benefits viewed more as potential value-adds rather than drivers for action (De Merich et al., 2022).

Over the years, an increasing number of companies have devoted more attention to OSH interventions, recognizing it as a fundamental component of the company’s success (Vitrano et al., 2024). Investments in the OSH field can have multiple potential benefits, extending beyond worker well-being. In particular, financial benefits include both the tangible benefits from preventing work-related injuries and

diseases as well as intangible benefits related to increased employee retention and morale, improved production quality, and enhanced corporate reputation (Mustard & Yanar, 2023). Usually, commercially successful companies have effective health and safety management systems in place. The principles of great and effective management constitute a solid basis for improving the health and safety performance of the companies, also in areas beyond health and safety management (Masi et al., 2014).

As a result, a rising number of employers are focusing on their employees' health and safety concerns, going beyond simply implementing and adopting the standards required by law (Fox et al., 2018). However, it is not always so straightforward to implement the right targeted health and safety intervention and assess their short and long-term benefits (Vitrano et al., 2023). Several implications arise in practice that make their actual applicability and management complex. As highlighted by Cagno et al. (2014), managing OSH is often challenging due to limited resources, lack of expertise, and a complex regulatory environment, especially in Small and Medium Enterprises (SMEs).

The context in which OSH interventions operate is complex and ever-changing, at the organizational, economic, and technological levels (Micheli & Cagno, 2010). Consequently, there are several variables involved, making it challenging to understand how they influence the success or failure of interventions and predict their effectiveness (Fridrich et al., 2015).

Hence, the aim of this work is to gather evidence on effective interventions and get insights into potential strategies for their development and monitoring over time.

2. Methods

Three Italian OSH interventions in different sectors – metalworking, fishing, and port maritime – initiated by the Italian National Institute for Insurance against Accidents at Work (INAIL), in collaboration with the Prevention Services of the Local Health Authorities, were discussed with INAIL experts. Interviews and subsequent follow-ups were conducted to investigate these interventions, known as Targeted Prevention Plans (TPPs), and their operational dynamics (Campo et al., 2022).

2.1 Overview of targeted prevention plans (TPPs)

All three interventions followed the Italian National Prevention Plan (NPP), which is usually renovated every 5 years. The current 2020-2025 NPP represents the fundamental central planning tool for prevention and health promotion initiatives across Italy. Within the NPP's macro-objective ‘5.4 occupational injuries and diseases’, a territorial intervention model, known as TPP, is presented to support the process of risk assessment and organization of prevention and protection activities for the improvement of companies' OSH performance. TPPs are structured according to the concept of Plan-Do-Check-Act (PDCA). The PDCA is an iterative process used by

companies to achieve continual improvement and is often applied for intervention development. The revised PDCA framework proposed by ISO 45001:2018 (ISO, 2018) supports the development of the phases of TPPs.

- Plan: assess risks, develop intervention strategies, and allocate resources.
- Do: implement interventions, provide training, and monitor progress closely.
- Check: collect and analyze data on intervention effectiveness, evaluate compliance, and identify areas for improvement.
- Act: take corrective actions based on findings, and continuously refine strategies for ongoing improvement.

According to this structure, TPPs are characterized by three main elements: (1) assistance, (2) monitoring and supervision, and (3) verification of effectiveness. These elements are universally applicable across various production settings, with possible variations in specific actions and mechanisms according to the territorial context.

TPPs aim to combine assistance and supervision activities with good collaboration and transparency between institutions and companies. This collaborative approach enables employers to better address risks and be aware of regulatory non-compliance. TPPs are characterized by specific phases, summarized as follows:

- initial analysis and shared design with territorial bodies for planning risk assessment and monitoring processes, ensuring the full involvement of stakeholders in the field, including workers, their representatives, associations and other bodies;
- presentation of the TPP to companies;
- training on proposed activities and tools;
- monitoring of companies on a sample basis, detecting persistent issues and exploring potential solutions;
- dissemination of results within the network and monitoring of the consequences to evaluate intervention effectiveness.

2.2 Characteristics of the sample

In this work, the proposed TPPs refer to three peculiar sectors described below and summarized in Table 1.

1. The metalworking sector is a very complex sector with many different health chemicals and safety risks, as related to risks for the use of equipment and machinery, typically requiring long interventions with continuous monitoring. Associations and institutions usually collaborate to adopt a shared OSH management approach in intervention development.
2. Port maritime sector presents a complex and diverse environment located in various locations, characterized by different levels of interference risks with rapid and

unpredictable work rhythms. OSH management in such settings can be facilitated by centralized national and territorial agreements, which enable more coordinated support networks.

- The fishing sector represents a highly specialized environment, very much affected by economic, environmental, and regulatory factors at both local and EU levels. Interventions in this sector are often brief and influenced by the production cycle. Micro-companies within the fishing industry contend with European competition and a pronounced sectoral crisis.

Table 1: TPP’s characteristics included in the sample.

Sector	Timeframe and Place	Stakeholder
Metalworking sector	Since 2014. Lombardy (Province of Varese)	Associations of Artisans and Labour Unions of Varese, University of Insubria, INAIL
Port maritime sector	Since 2016 TPP: 2016-2019 Trieste, Venice, Ravenna, Ancona, Bari, Taranto, Civitavecchia, Livorno, Piombino	Local Health Authorities and Port System Authorities (Trieste, Venice, Ravenna, Ancona, Bari, Taranto, Civitavecchia, Livorno, Piombino), Sant’Anna School of Advanced Studies, INAIL
Fishing sector	Since 2016 TPP: 2016-2019 Bari, Molfetta, Mola di Bari, Monopoli, Trani, and Bisceglie	Local Health Authority Bari, Sant’Anna School of Advanced Studies, Maritime Authorities, associations, Trade Unions, INAIL

3. Evidence from Italian TPPs

This section will detail the three interventions, known as TPPs, mentioned previously, and discuss how they have been retained and how their effects are monitored over time.

3.1 First intervention: Metalworking sector

The first intervention focuses on the metalworking sector, specifically concerning the improvement of safety levels in foundries and hot metal processing facilities. Following serious accidents including two fatal ones in the northwest region of Italy in 2014, for which the authorities identified significant violations of OSH regulations, targeted assistance interventions were launched. These interventions aimed to:

- Provide and disseminate useful tools and operational methods for companies in the sector to manage risks more effectively;

- Revise, if necessary, the company's risk management system;
- Adopt appropriate solutions to ensure environments, equipment, and working methods that respect workers' health and safety.

3.1.1 Planning and implementation

The TPP involved 98 companies operating within the designated sector in the province of Varese. Of these, 49 actively participated in the TPP, with a total number of involved employees of 1,127.

Technical literature, regulations and some interesting company practices were collected and made available to the participating companies. Data from INAIL databases and previous supervisory activities were utilized. Additionally, a questionnaire was distributed to collect necessary data and served as a tool for self-assessment of OSH management in companies. Areas of analysis concerned the company's prevention systems, production processes, and major associated risks such as chemical hazards, noise and vibrations, microclimate conditions, and some transversal risks like manual handling, electrical systems, explosions, fires, and pressure equipment.

An initial public meeting was held, attended primarily by representatives, mainly Responsible for Prevention and Protection Services (RSPPs), from over 20 companies. The various parties involved in the TPP provided support to the participating companies. Non-responders and companies experiencing accidents during the study period were subject to inspections by local health authorities, and some participating companies were audited.

Collected data were organized, processed, and analyzed for statistical purposes in an anonymized format. After approval, the results were shared with participating companies and involved stakeholders. After that, the intervention continued in close collaboration with INAIL experts, who conducted two editions of a training course 'The multifactorial model for analyzing causes and reconstructing accident dynamics', attended by 40 participants from 19 companies. With the collaboration of workers’ representatives and RSPPs, a questionnaire, provided by INAIL, was administered to workers to assess their perception of risk. Collected data, obtained from 927 distributed questionnaires, with 558 returned, in an anonymized format, supported the sharing of knowledge with stakeholders involved in the survey.

3.1.2 Results

Following 2014, there were no further fatal accidents in the industry, and the frequency of accidents decreased appreciably. An analysis was conducted on accident data (i.e., the incidence index as a measure of frequency and the summary index as a measure of severity) from the 49 participating companies. It emerged that the implementation of procedures for recording near-misses contributed to the reduction of accident frequency but had less effect on the occurrence of serious accidents. Approximately 75% of the companies reviewed their risk assessment documents and strengthened the involvement

of all stakeholders in the monitoring and review process. Additionally, 48% of companies updated at least some work procedures with new technical or organizational solutions. While 76% of the companies had access to financial incentives, less than 10% participated in calls for funding, with only two companies receiving actual funds. A third of companies now monitor near-misses, but only a few utilize INAIL's software, through Infor.Mo and Condivido models. Nonetheless, 69% of them have organized training sessions based on the analysis of their near misses.

Another practice, known as "Training Breaks", has been included in the current metalworking contract as an innovative method for providing refresher training to workers on OSH matters. They offer specialized training where the instructor addresses homogeneous groups facing similar risks at the beginning of the work shift. Additional resources provided include checklists, a table of indicators for evaluating TPP, questionnaires to assess workers' risk perception, sheets to identify adopted solutions, tools for detecting near misses, and more.

3.1.3 Monitoring

The effects in the medium to long term are evaluated to determine whether the trends observed during the period from 2000 to 2015 tend to be confirmed. In any case, favoring the integration of different contributions and information, originating from various perspectives has emerged as a clear added value in these interventions.

The evolution of interventions has entailed the design and implementation of successive TPPs in the metalworking sector that have leveraged the tools and methods developed through collaborative efforts with social partners and the active involvement of associations in tool-sharing and development. This rich network has led to an important increase in the number of companies participating in these initiatives.

To evaluate the effectiveness of the TPP, data from surveillance conducted before and after the intervention were used. The approach to the verification of effectiveness was based on a comprehensive table that documented qualitative and quantitative data on TPP activities and the benefits gained by participating companies. Specifically, the following were some of the major improvements observed in OSH activities: enhanced management of risk assessment implementation and review processes (reported by 75% of companies), updates and implementation of procedures (reported by 48% of companies), access to financial incentives (implemented by 76% of companies), the monitoring of near misses (reported by 33% of companies), and the planning of intra-company training sessions (reported by 60% of companies).

3.1.4 Follow-up activities

Compared to the first TPP in 2014, there has been a notable improvement in the mechanisms for sharing objectives and active participation in the development of operational tools among institutions and social partners during the planning, assistance, and results monitoring phases. This instrumental support aims to enhance the ability for self-

assessment of risk factors by initiating the monitoring of events (follow-up) and subsequently identifying and applying OSH management measures based on a proactive and participatory safety culture.

The implementation of good practices such as "Training Breaks" and the experimentation of the sharing platform for managing near misses are currently underway in companies. Concerning the verification of outcome indicators (e.g., accident frequency and severity indices), local health authorities are following up on vigilance and audit activities, while employers' associations are actively promoting, supporting, and monitoring the effectiveness of the good practices introduced through this TPP.

3.2 Second intervention: Port maritime sector

The port maritime sector faces various critical challenges, including the lack of coordination between general and sector-specific health and safety regulations, and the complexity of activities carried out in ports with the simultaneous presence of several companies, particularly during ship-dock coordination, leading to intricate interference risk management. Additionally, the sector faces evolving trade dynamics, mainly determined by a new generation of larger vessels carrying over 24,000 twenty-foot equivalent units (TEUs), with the consequent forecast increase in traffic and work rhythms, high accident rates, and a complex institutional governance framework.

On this premise, an in-depth study was developed on health and safety management approaches in the port maritime sector with the aim of achieving closer integration between technological innovation and OSH, through integrated support actions provided to sector companies by the institutional network comprising INAIL, universities, associations, local health authorities, and port system authorities.

3.2.1 Planning and implementation

Nine TPPs were carried out in nine national ports (Trieste, Venice, Ravenna, Ancona, Bari, Taranto, Civitavecchia, Livorno, Piombino) in which the model for analyzing the dynamics and causes of sector-specific accidents was transferred to the various OSH figures of the company through training actions. This TPP engaged over 120 companies within the port maritime sector, involving more than 880 participants.

The survey on workers' risk perception was conducted with anonymous questionnaires distributed and collected through workers' representatives. Over 1,400 questionnaires were processed (1,385 for port activities and 82 for mooring service activities).

3.2.2 Results

Analyses of the data collected showed that workers feel well-integrated with their work colleagues and consider themselves well-informed and trained including training for the use of work equipment requiring special skills, while there is room for improvement regarding work procedures. More than one-third of the respondents consider the issues of interference, workspace organization, and emergency and safety management in the hold as areas requiring

improvement actions. In particular, the management of interference risk and the organization of work environments are correlated with the main types of serious and fatal injuries recorded in the sector, which include workers being struck on the ground or board the ship, falls from heights of moved goods, and falls from heights by the injured person.

3.2.3 Monitoring

Based on the identification of risk assessment and prevention management issues observed during the supervision phase across the network of participating ports, various tools – such as technical documentation, checklists, protocols, methodologies, and models – and existing technologies within the network or other ports were collected. Examples of such solutions already in use include simulators for training purposes, automation, remote-control systems for processes like container roll-on/roll-off (ro-ro), and sensor technology for detecting hazardous materials. Solutions adopted by other ports encompass integrated platforms for vehicle access management using sensor technology, and hydraulic mooring systems to prevent cable breakage, among others. Additionally, potential solutions not yet implemented in ports include the application of neural networks to camera surveillance systems, the use of exoskeletons to mitigate biomechanical loads, and wearable sensor networks for assessing risks. In particular, exoskeletons were tested in some port activities (e.g., <https://www.portialtotirreno.it/?s=esoscheletri>) to improve employee health and make certain work phases involving the back and upper limbs more agile, as seen in major manufacturing companies such as Boeing and Ford (i.e., EksoBionics).

3.2.4 Follow-up activities

The focus in the following years has shifted towards enhancing and coordinating territorial networks and operational business support tools within the TPPs of the port maritime sector. The assistance and control activities undertaken in the project have enabled the institutional network to analyze organizational contexts and deepen understanding of risk factors associated with activities across various work cycles in nine national ports. Methodologies for analyzing accident causes and sharing best practices have been transferred. Implementation agreements have been developed in some Italian ports between institutional partners, enabling continued assistance and control activities for companies within their respective port areas.

To raise awareness among port companies regarding reporting, analyzing, and addressing hazardous and near-miss situations, the Condivido model, a web-based tool for event management, has been made available to port companies at no cost and with the possibility to get economic incentives from INAIL based on accident trends and management improvements.

Furthermore, the current objective is to develop an archive of reports specific to port areas over time. This will enable companies to assess potential risk factors accurately and

promptly before accidents occur. Additionally, it will provide the port system authorities with valuable information for monitoring OSH levels in port areas over time, offering feedback for training activities, and facilitating comparisons between companies regarding available improvement solutions.

3.3 Third intervention: Fishing sector

The phenomenon of occupational accidents in the fishing sector is extremely heterogeneous. Among the risk factors detected, are the characteristics of the working environment (e.g., lighting, confined spaces, age of vessels), marine weather factors, organizational elements such as ergonomic factors, workloads and fatigue, contextual elements such as contractual characteristics and the presence of non-EU workforce with language difficulties, cultural, religious and dietary peculiarities. Another important aspect concerns the phenomenon of fatal accidents related to emergencies such as men overboard and sinkings. Also in this area, there is a lack of harmonization between general health and safety legislation and sector-specific legislation.

3.3.1 Planning and implementation

The TPP between 2016 and 2019 was implemented in the Bari area and concerned the marinas of Molfetta, Mola di Bari, Monopoli, Trani, and Bisceglie. The objective of the TPP was to deepen the knowledge of employers (ship owners), captains and workers, who often work together on ships, regarding the quality of their safety documents, the specific dynamics and causes of fatal and serious fishing accidents, the prevention criteria and technologies available for the management of emergencies (e.g., fire, sinking, man overboard recovery), good practices for controlling biomechanical risks related to manual handling of loads, and economic incentive systems for implementing actions to improve OSH.

The institutional planning network consisted of the local health authority (Bari), INAIL, maritime authorities, and various associations such as Federpesca, Assopesca, and trade unions that were fundamental in raising awareness and involving companies in the sector to participate in the TPP.

The training phase aimed to provide practical examples of the causes and dynamics of accidents in the fishing sector, offering examples of solutions used in other marinas and a moment to exchange experiences in similar contexts. Videos taken on board local fishing vessels related to most types of fishing practiced were also shown to stimulate discussions on risk perception and onboard procedures. Additionally, technological solutions developed for reducing and managing biomechanical risks were presented. The technological solutions presented are the three best practices validated by the Ministry of Labor for better management of biomechanical risk in the fishing sector, which can be viewed at the URL: <https://www.lavoro.gov.it/temi-e-priorita/salute-e-sicurezza/focus-on/buone-prassi/pagine/buone-prassi-validate-dalla-commissione-consultiva-permanente>. These involve technological modifications applicable to existing

boats and for different types of fishing. They include the installation of a raisable and tiltable platform in the stern area, allowing the initial sorting operations of the catch to be performed while standing upright; the introduction of a conveyor belt system that transports the catch, eliminating manual transportation and allowing work to be done while standing upright.

These activities, conducted during fishing downtime, involved over 50 companies (motor fishing boats) in the sector with more than 370 participants attending classroom sessions. Subsequent training sessions were held in swimming pools and at sea to demonstrate the use of life-saving equipment.

The risk perception survey of fishing operators was conducted employing anonymous questionnaires distributed and collected through the associations involved. More than 340 questionnaires were processed.

3.3.2 Results

The analysis of collected data returned a context in which the workers, who showed a high level of seniority, felt valued, integrated, and had good working relationships with colleagues. Health issues reported in the questionnaires, though not solely related to work activity, indicated potential exposures, such as back, shoulder, or elbow pain. In relation to perception, there is still a high level of attention to exposure to noise, ergonomic factors, load handling, work intensity, and physical exertion, highlighting the need for targeted improvement and prevention actions. Slips rank highest among reported non-injury events, a fact that correlates with the high consideration of the usefulness of specific personal protective equipment (PPE), such as non-slip boots. The relative perception of risk exposure is high also for contact with moving work machinery or equipment such as cables and nets. Conversely, accidents involving crushing by suspended or moving loads/equipment, such as sacks, and falls from height or into the sea, although reported as experienced events, are not perceived as significant exposure risks.

For a deeper understanding of the injuries characterizing the fishing sector, you can refer to the publication “Second Report on Maritime Workers. Activities and Risk Factors of Sea Workers” (URL: <https://www.inail.it/cs/internet/comunicazione/pubblicazioni/catalogo-generale/pubbl-rapporto-lavori-marittimi.html>).

3.3.3 Monitoring

All the activities generated considerable interest from stakeholders in the sector, including shipowners and workers, who actively supported the ongoing monitoring of the implemented activities. This interest translated into the submission of safety improvement plans, which included structural modifications on board, procurement of new and updated PPE, and acquisition of rescue equipment. The video material made on board was used to create a DVD as a dissemination tool on risks and possible solutions. Moreover, the training model developed allows for cascading transfer actions to additional marinas as it was prepared with short interventions that can be delivered

during crew members' periods ashore. The results of the TPP were communicated and presented at local events.

3.3.4 Follow-up activities

The fishing sector has experienced an economic downturn lasting over a decade because of some external factors such as the globalization of markets and international policies, as well as internal factors including strong traditionalism, low technological innovation, and over-exploitation of national fish stocks. Despite interventions by institutions and social partners in the form of information dissemination, training, availability of good practices, and economic incentives, the crisis in the sector has persisted.

At present, the activities of the institutional network and associations focus on a few marinas where greater awareness of OSH issues has developed over the years. Also in this sector, assistance and control activities focus on strengthening the management approach to OSH, also through the promotion of tools for the management of near misses and dangerous situations, e.g., the Condivido model mentioned previously. In addition, through participation in INAIL's economic incentives, motivated companies, with the support of associations have the opportunity to modernize equipment and protection systems.

4. Conclusions

The experiences implemented have contributed to a deeper understanding of the factors influencing the effectiveness of OSH interventions (referring to TPPs in this work) towards SMEs. This is a primary objective in prevention not only guiding the activities of institutional support networks but also identifying key elements that can determine long-term improvements in company health and safety levels. The experiences and results described in this work provide valuable insights for guiding future directions of applied research.

- The motivation of companies to participate in TPPs is favored by the strengthening of the collaboration between institutions and social partners. In fact, the increasing active involvement of associations in planning and implementing interventions has led to a rise in company participation rates across various TPPs.
- The methodological framework provided by the standard TPP model and associated good practices applicable by companies at zero cost, such as the Condivido model and ‘Training Breaks’, have strengthened employers' self-assessment capabilities regarding risk management levels and have fostered the participation of workers in the process of reporting near misses and hazardous situations.
- The social dialogue and organizational capacities of the institutions-social partners network have been strengthened by active participation in territorial

committees, which are pivotal platforms for sharing prevention activities.

- The approach to monitoring the effectiveness of the TPPs is supported by the use of qualitative-quantitative indicators that measure actions and describe mechanisms implemented in the three macro-activities of the TPPs – (1) assistance, (2) monitoring and supervision, and (3) verification. The analysis of these indicators and subsequent improvement actions in companies direct the maintenance of the support activities over time.
- The implementation of good practices by companies is linked to economic incentive systems promoted by INAIL through public calls. These systems can help to support the motivation for continuous improvement necessary to maintain effective levels of prevention of occupational injuries and diseases over time. The continuous monitoring of the post-intervention phases can assess effectiveness accurately and people in charge can make timely adjustments and be aware of more effective and sustainable approaches to OSH intervention design and management.

By building on these insights and maintaining cooperation among various stakeholders, we can make significant advancements in promoting workplace health and safety. The described interventions could serve as models and facilitate the export of these methods to other countries while considering the regulatory and technical peculiarities of each nation.

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