An interpretive model of occupational safety performance for Small- and Medium-sized Enterprises

E. Cagno [a], G.J.L. Micheli [a,*], C. Jacinto [b], D. Masi [a]

[a] Department of Management, Economics & Industrial Engineering, Politecnico di Milano, 20156 Milan, Italy
[b] UNIDEMI – R&D Unit in Mechanical and Industrial Engineering, Faculty of Sciences and Technology, Universidade Nova de Lisboa, Caparica, Portugal

Article history:
Received 7 November 2012
Received in revised form
18 July 2013
Accepted 6 August 2013
Available online 18 November 2013

1. Introduction

Work-related accidents and diseases are common in all parts of the world and often have many direct and indirect negative consequences for workers and their families. This fact not only has a considerable human dimension but also has a major negative impact on the economy. The enormous economic costs associated with poor safety and health at work inhibit economic growth and affect the competitiveness of countries. Because of these reasons, an ongoing and sustainable reduction in accidents at work and occupational diseases is one of the objectives of the European Union (EU) (European Commission, 2009). The EU Commission has launched a five-year strategy for Safety and Health at work, which covers the period of 2007–2012 and aims to reduce by 25% the total incidence rate of accidents at work (European Commission, 2009). To achieve this goal it calls for action by players at all levels – European, national, local and workplace. In particular, key players to reach this goal are Small- and Medium-sized Enterprises (SMEs).

Following the daily news, it is easy to get under the impression that the European economy is dominated by large, multinational enterprises: what usually gets lost is that more than 99% of all European businesses are, in fact, SMEs. Moreover, between 2002 and 2008, the number of SMEs increased by 2.4 million (13%), whereas the number of Large Enterprises (LEs) increased by only 2000 (5%) (European Commission, 2009). The Occupational Safety and Health (OSH, sometimes “Occupational Health and Safety”, OHS) conditions in SMEs are very often poorer than in the larger enterprises: Micheli and Cagno (2010) and further publications reviewed by Cagno et al. (2011) show that there are higher accident rates and worse consequences.

This situation occurs for different reasons. It is firstly possible to consider the scarcity – with regard to LEs – of human, economic

* Corresponding author. Tel.: +39 0223994056.
E-mail addresses: guido.micheli@polimi.it (E. Cagno), enrico.cagno@polimi.it (G.J.L. Micheli), mcj@fct.unl.pt (C. Jacinto), donato.masi@mail.polimi.it (D. Masi).

and technological resources (Beaver, 2003; Micheli and Cagno, 2008). From another point of view, some papers (Hasle and Limborg, 2006; Champoux and Brun, 2003) focused on the lack of capacity of Small Enterprises to assess and control risks in an effective way. Last but not least, further studies (as reviewed by Cagno et al., 2011) have underlined that the low level of occurrence of accidents and injuries an SME can experience lowers risk perception, alters approach to risk control and changes the management priorities. Thus, only large severity accidents can have a long-term impact on OSH management system, but it can often be too late to intervene.

These observations underline the need of properly representing the safety performance of SMEs. Indeed, a clear and consistent representation of OSH-related factors at company level – and the interactions among them – would allow for improving risk perception and management practices, thus establishing better intervention priorities.

Based on the above, the aim of this paper is to propose a model of safety performance specifically designed for the SMEs. The model is specific for SMEs in the sense that the OSH-related factors and their cause-to-effect chain (i.e., the sequence of OSH-related factors, interconnected in a cause-to-effect way) proposed take into account the particular nature of an SME and the way in which this particular nature affects the safety performance. This paper is structured as follows: in the following section, the literature concerning safety performance models is reviewed; in the third section, the objectives of the research are presented; in the fourth section, the research methodology is described; in the fifth section, the results are presented; finally results are discussed and some concluding remarks are drawn.

2. Literature review

First of all, modelling and assessing "performance" can be observed to be more specific than the broader concept of Safety Management Systems, which encompasses several other functions. This work focuses on safety performance and on the factors that shape safety performance.

Researchers have proposed several conceptual models of occupational safety performance. These models propose relating some factors such as work environment characteristics or individual differences to some safety related outcomes such as accidents, injuries, or unsafe behaviours (Tucker, 2010). The key questions in this line of research have been summarized by Mohaghegh and Mosleh (Mohaghegh and Mosleh, 2009): (1) what are the organizational factors that affect risk, (2) how do these factors influence risk, and (3) how much do they contribute to risk? The existing models answer these questions in different ways. In this literature review, the models have been divided into two groups: the models considering a limited number of factors related to a safety outcome and the models considering a complex framework, which aims at investigating all the relevant factors related to a safety outcome.

According to Christian et al. (2009), the models considering a limited number of factors have analysed both person-related factors (i.e., associated with the individual) and situation-related factors (i.e., workplace conditions and organizational factors).

In the first group, person-related factors such as safety knowledge (Burke et al., 2002), safety motivation (Neal and Griffin, 2006), job satisfaction (Barling et al., 2003), caring (Burt et al., 2008), attitudes to safety (Mearns et al., 2001), job insecurity (Probst and Brubaker, 2001; Storseth, 2006), and personality (Clarke and Robertson, 2005; Forcier et al., 2001) have been related to outcomes such as safety performance (Burke et al., 2002), accidents (Neal and Griffin, 2006; Barling et al., 2003; Mearns et al., 2001; Probst and Brubaker, 2001; Clarke and Robertson, 2005; Forcier et al., 2001), personal support dimension of contextual performance (Burt et al., 2008), physical and mental health complaints (Storseth, 2006), and risk taking behaviour (Storseth, 2006).

In the second group, situation-related factors such as safety climate (Evans et al., 2005; Johnson, 2007; Pousette et al., 2008; Smith et al., 2006; Zohar and Luria, 2005; Probst, 2004; Probst et al., 2008; Wu et al., 2008; Zohar, 2000), safety leadership (Wu et al., 2008), safety management (Torp and Moen, 2006), work environment (Varonen and Mattila, 2002), safety activities (Varonen and Mattila, 2002), training (Lingard, 2002), work systems (Zacharatos et al., 2005), and work pressure (Lilley et al., 2002) have been related to outcomes such as accidents (Evans et al., 2005; Johnson, 2007; Smith et al., 2006; Varonen and Mattila, 2002; Zacharatos et al., 2005; Lilley et al., 2002), safe behaviour (Johnson, 2007; Pousette et al., 2008; Zohar and Luria, 2005; Torp and Moen, 2006; Lingard, 2002), work environment (Torp and Moen, 2006), musculoskeletal health (Torp and Moen, 2006), personal-safety orientation (Zacharatos et al., 2005), injury rate under-reporting (Probst et al., 2008), negative behaviours (Wu et al., 2008), micro-accidents (Zohar, 2000), and occupational stressors in general (Abbe et al., 2011).

These models have incorporated quantitative analyses into their research works and have thus provided statistical evidence of their assumptions. These models, though important for a better understanding of the companies' safety performance, are not fully exploitable by companies' managers and entrepreneurs because of two main reasons. The first is that they are not able to provide a comprehensive picture embracing all the factors related to the safety performance. Such a picture is essential, since establishing a proper intervention policy starts from a systematic identification of all the OSH-related factors and interactions describing the company's safety performance. The second is that it is possible to study the relationship between two factors independently from the context in which this relationship take place only in situations where the conditions of the context are assumed constant. If the conditions of the context are not constant – like in almost all the cases of the industrial practice – it is necessary to include in the model an adequate number of mediating factors representing the influence of the context on the relationship between the two main factors considered in the study.

In order to overcome these limitations, other researchers have proposed complex frameworks, which aim at investigating all the relevant factors related to a safety outcome. The development of a complex framework implies some modelling choices that are not necessary for a model considering a limited number of factors. The first modelling choice deals with the organization of factors according to different "levels of causality". The "level of causality" (Mohaghegh and Mosleh, 2009) describes the position of the factors in the cause-to-effect chain. The choice of the level of causality answers questions such as: should the safety climate be considered among the "bottom layer" factors, or should it move further up in the chain of causality? Another modelling choice is the "level of detail" (Mohaghegh and Mosleh, 2009) for constructs. For example, there are two possible approaches to make a cause-to-effect interaction between the "human resource system" and "safety climate". The modeller can consider these two factors as global factors. On the other hand, he/she can establish multiple relations between the "human resource system" and the different dimensions of the "safety climate" (e.g., "perception of the reporting system", "perception of training", etc.). The latter is modelled with a higher level of detail. The decision regarding the level of detail depends on the importance attached to the different dimensions of the constructs in terms of their impacts on the model output. Researchers have followed different paths with respect to these modelling alternatives.

Haight et al. (2001a, 2001b) published two papers that could be considered as the foundation for the proper use of the analytical approach for the quantification of safety intervention programs in the oil industry. The first phase of their study showed the relationship between the incident rates and the intervention factor levels for the safety and health program. In the second phase of the research work, efforts were made to quantify a loss prevention program and a mathematical expression was developed. Regression analysis was used to compare the recorded interventions and incident rates.

Papazoglou et al. (2003) proposed an integrated quantitative risk assessment method for hazardous chemical installations, taking into account management as well as technical design and producing risk level measures. A key component of the method is the management model; in this model, major hazard safety management is seen as the systematic control and monitoring of the possible scenarios and initiating and basic events represented in the risk analysis of the plant. The management model consists of the tasks which must be carried out systematically in the primary business functions (such as operations, emergency operations, maintenance and modifications). For example, availability of hardware and its failure rate are controlled by the design and execution of the maintenance regime and function. Failure rates are also influenced by controlling operations, testing and maintenance functions.

Barlow and Iverson (2005) proposed a model of workplace safety focused on job stressors. The model relates into a cause-to-effect chain of interactions antecedents of safety performance, occupational stress, moderators, workplace safety, and consequences of workplace safety summarized in personal factors and organizational factors. The antecedents proposed are individual factors, substance abuse, organizational leadership, job and organizational factors, and safety factors. The moderators proposed (i.e., those that can interact with the previous and change them) are safety communication, stress tolerance and safety climate. Both the antecedents and the moderators lead to the (so-called) "outcome of workplace safety", which implies several "consequences of workplace safety" (consisting of both personal and organizational factors).

Neal and Griffin (2006) moved from an organizational behaviour perspective and presented a systematic model of safety climate in organizations; furthermore, they examined the antecedents and consequences of safety climate at the individual and organizational level. They suggested that work environment antecedents and individual antecedents directly influence safety knowledge and motivation; safety knowledge and motivation then lead to safety performance and ultimately result in safety outcomes. The work environmental antecedents consisted of safety climate as well as of organizational factors (e.g., supervision and work design); the individual antecedents of safety included attitudes such as organizational commitment or safety attitudes and individual differences (e.g., conscientiousness, neuroticism, and personality traits). This model of safety performance has been used by multiple researchers (Probst, 2004; Real, 2008) and was the base for the integrated model proposed by Christian et al. (2009).

Iyer et al. (2005, 2004) developed a mathematical relationship between the primary safety program intervention activity levels and the incident rates in the forestry operations of a power company. In these research studies, incident rates were compared to the recordable past incidents and the model developed was used to optimize the safety and health program. Statistical methods such as regression analysis and forecasting techniques were used to validate the optimization model. Results from the studies showed a statistically significant, exponentially decreasing mathematical relationship, indicating the relationship between the incident rate and the intervention application rate.

Christian et al. (2009) integrated past research findings with conceptual and methodological advances in behavioural safety research. They hypothesized that situational factors, individual differences, and attitudes are not directly related to safety performance and are even less directly related to safety outcomes. It was suggested that these factors affect more proximal states or self-regulatory processes that directly affect safety performance behaviours. The antecedents in their model referred to both person related factors and situation related factors. The person related factors were personality characteristics and job; the situation related factors were safety climate and leadership. The proximal antecedents consisted of both safety motivation and safety knowledge, in agreement with Neal and Griffin (2004). These proximal antecedents were hypothesised to lead to safety performance; the safety performance behaviours are safety compliance and safety participation. These safety performance behaviours in turn influence the safety outcomes of accidents and injuries. The authors stated that this framework informs not only the magnitude of the relationships between various antecedents of safety criteria, but also the processes through which workplace accidents and injuries occur.

Oyewole et al. (2010) provided an analytical background for the development of an effective safety intervention program with the aim of minimizing incident rates. They collected safety intervention data from the environmental safety and health department of an American-owned oil company in the Niger-Delta. The proposed safety model was developed to determine the safety intervention factors and interactions that minimize incident rates, with the aim of predicting a better resource allocation strategy. Several main safety intervention factors were highlighted, labelled leadership and accountability, qualification, selection and pre-job, employee engagement and planning, work in progress and evaluation, measurement and verification. These factors have been investigated to show their effects on incident rate performance. An analysis of variance test showed that four safety factors were significant. After this prior analysis, response surface design plots were used to determine the resource allocation method. In this way, the developed safety model recommended the allocation of the available resources to the significant safety intervention activities in order to achieve the desirable incident rate.

2.1. Gap analysis

The problem addressed in this paper is that even these complex frameworks are not fully exploitable by SMEs' managers and owners for the establishment of a proper intervention policy. Indeed, the development of an intervention policy requires a deep understanding of all the factors determining the safety performance of the company, and existing models are not able to match this need because of four main gaps.

First, existing frameworks are too specific to represent the safety performance of a generic SME. In fact, although they consider a higher number of factors with respect to the first group of models, they focus on a particular industry (Haight et al., 2001a, 2001b; Papazoglou et al., 2003; Iyer et al., 2005, 2004; Oyewole et al., 2010) or on a particular area of intervention (Christian et al., 2009; Neal and Griffin, 2006). However, the safety performance of a generic SME should be described independently from the particular industry and by means of all the relevant areas of intervention.

Second, the perceptions of practitioners are not considered in the definition of the cause-to-effect chain (rather, a few elements/mechanisms per time are empirically tested within a view of cause-to-effect chain, to facilitate prioritizing preventive strategies, as in Jacinto and Guedes Soares, 2008). In some cases (see e.g. Oyewole et al., 2010), the factors are organized in a unique layer and thus they do not represent a cause-to-effect chain, i.e., they do not make a distinction between the groups interactions. In other models (see e.g. Christian et al., 2009), the position of a factor within the cause-to-effect chain is defined based on the literature or based on a qualitative analysis. However, a decision maker could decide to intervene from the top or from the bottom of the cause-to-effect chain. For instance, a decision maker could intervene at corporate policy level, thus modifying a great number of factors dependent from the corporate policy, or at working environment level, thus modifying this factor while maintaining the same corporate policy. Consequently, decision makers should be able to define the relative position of the factors within the causal chain, (to assess both risks and their causes, as highlighted in Cagno et al., 2000) but the existing models do not capture this knowledge.

Third, the abovementioned safety performance models generally consider a single level of detail for the factors. Apart from the model of Christian et al. (2009), which considers three different levels of detail, other models (see e.g. Neal and Griffin, 2004) take into account a single level of detail. However, one intervention may well aim at improving performance within an overall area, e.g. improving the whole working environment, or instead within one specific factor, e.g. intervening on the equipment conditions, which represent a specific aspect of the working environment. The existing frameworks do not explicitly describe this set of alternatives.

Fourth, the existing models do not take into account the particular features of SMEs: the research tends to show that OSH problems in SMEs are related to lack of resources, lack of knowledge of the firm's risks, more hazardous work environments, and deficiencies in organizational processes. As for the resources, SMEs have considerably less financial stability than large firms do, which makes OSH investments less attractive because the financial benefits of prevention are not obvious in the short term (Champoux and Brun, 2003). As for the knowledge of the firm's risks, it has to be considered that whilst SMEs have significantly higher accidents and injury rates, given their small size and short life span any actual experience of serious accidents is likely to be quite limited. The low level of occurrence of accidents and injuries an SME can experience lowers risk perception, alters approach to risk control, and changes the management priorities (Hasle et al., 2009). As for work environments, SMEs tend to operate in more hazardous work environments than larger organizations, thus directly increasing the likelihood of accidents (Kelloway and Cooper, 2011). For example, Sørensen et al. (2007) found that several aspects of the work environment were related to firm size, with ergonomic, physical and chemical hazards significantly greater in SMEs compared to large firms. Last but not least, as for the organizational processes, SMEs tend to show several deficiencies in organizational processes relevant to OSH (Kelloway and Cooper, 2011), such as the provision of training, safety management systems, communication, and human resources practices (see e.g. Shannon et al., 1997; Vredenburgh, 2002; Zacharatos et al., 2005). Because of these reasons, all authors seem to agree that a specific, customized approach is required to promote awareness and management of OSH in SMEs.

Summing up, a model properly representing the safety performance of a generic SME is missing, since the existing frameworks are too specific, they are lacking of a cause-to-effect chain structure based on the perceptions of practitioners, they consider a single level of detail, and they do not take into account the particular features of SMEs.

The lack of a model properly representing the safety performance of a generic SME hinders the implementation of systematic safety management, which requires well-defined principles and procedures (Neonen, 2013). Such an approach has been suggested in theoretical frameworks giving normative statements about the way in which safety management systems should be structured and should operate (see e.g. Hale et al., 1997), and in several guidelines for managing safety, such as BS 8800 – Occupational Health and safety management systems – Guide (BS 8800, 2004); OHSAS 18001 – Occupational Health and safety management systems – Specification (OHSAS, 18001, 2007); and ILO-OSH – Guidelines to health and safety management systems (ILO-OSH, 2001) and in several operational models (see e.g. Neonen, 2013). These guidelines and these models follow largely similar frameworks for the identification of workplace hazards, assessment of the risks associated with these hazards, and then elimination or minimization of these hazards through the proper implementation of operational controls and improvements. However, regarding the (effective) implementation of operational controls and improvements, they need some method to help determine where actions should be taken and how determine and prioritize the expenditure of resources on risk reduction (Kausek, 2007; see also the impact of possible operational controls and improvements on the safety cost in Cagno et al., 2013). A safety performance model could represent such a method, aligned with the systematic approach of these guidelines.

3. Research objective

All in all: in every enterprise, especially within the SMEs context, the *identification and prioritization of interventions* aimed at improving OSH performance, should take into account the relevant factors. However, this should not be done on a one-to-one basis, but rather through a meaningful group of connected factors, which together impact on the OSH performance and on the overall performance. This is surely more effective (attaining the objective) and more efficient (using less resources).

This paper proposes a model of safety performance for SMEs that overcomes the four limitations of the existing models, thanks to three main features.

1) Systemic: this allows the treatment of all relevant factors determining safety performance in a company. Global treatment of these factors is, yet, absent from the literature, in the sense of a meaningful group of connected factors. In contrast, existing studies dig deeper into specific safety aspects; generally, they focus on a particular industry or on a particular area of intervention. Such an approach, while allowing a better understanding of some safety dynamics, does not enable a holistic view of the subject. From a practical point of view, a holistic view would enable each SME to understand firstly the framework in which a given intervention takes place and secondly the aspects that a given intervention emphasizes or neglects.
2) Intervention-oriented: this allows allocating resources for improving performance in both a rational and a well-structured way, by means of a proper prioritization of the interventions themselves (see also Cagno et al., 2013). The analysis of the interactions between factors allows understanding how a specific intervention may modify the company's safety performance (Cagno et al., 2011). An intervention oriented framework is, as yet, absent from the literature, since the existing models do not rank the factors, thus neglecting the different alternatives for the decision maker in terms of influencing capability on other factors and specificity of the intervention. The framework proposed here is aimed at ranking the relevant factors by means of a cause-to-effect chain and of an adequate number of "levels of detail" for the relevant factors. A hierarchical structure will represent the cause-to-effect chain matching the perceptions of

practitioners, while a three-level structuring of the factors will describe three levels of detail.

3) SMEs-specific: this takes into account the peculiarities of SMEs, which are currently hardly covered in the literature. The models that deal with factors related to safety performance are, in most of the cases, intended for large corporations, or have been developed following case studies in big companies. Even from a practical point of view, the operational tools allowing companies to analyse safety problems (and performance, and related costs, as in Cagno et al., 2013) are mostly intended for large companies and are not directly transferable to SMEs without losing effectiveness.

This approach also means that successful interventions should be based on the very "few" groups of factors that are more likely to "cause the largest effect" in improving the global safety performance. It is noteworthy mentioning, however, that such "few key factors" may vary from one context to another or even from one enterprise to another. The hierarchy and the structure proposed in this work provide a carefully interlinked framework for decision, but the choice of the key factors for intervention needs to be made at a micro-level, probably within each individual enterprise. Such a framework will really enable an effective implementation of a structured intervention policy, as suggested by guidelines like OHSAS 18001.

4. Research methodology

Two main steps have been taken within the definition of the model.

4.1. Step 1— factors, sub-factors and affinity areas definitions

In the first step, starting from a literature review on the specific subject (Cagno et al., 2011) all the OSH factors — relevant for SMEs — have been confirmed/identified/modified using a Focus group approach. In fact, results from literature are always (but the tentative of Cagno et al., 2011; who merged evidence from literature at a theoretical level) really specific on a few factors per time, lacking a complete view of the problem. Thus, results from literature have been used as a basis for the Focus Group, to refine all the factors definitions, contents and links in a proper and shared way for SMEs. Focus Group is a team approach in which a group of specialists discuss the subject-matter under the conduction of moderators. This approach allows recreating a situation similar to the ordinary opinion making process, allowing participants to express themselves in a free communication style, or "peer communication". In particular, a Focus Group approach was selected because of several reasons. First, it allows for complementing quantitative research by illuminating existing data or by generating ideas for new inquiry. Consequently, the technique is particularly suited for the present research, considering that the participants of the focus group could base their analysis on factors and sub factors already described in the literature. Second, it is uniquely suited to helping members of specific groups articulate their beliefs, values, desires, concerns, aspirations, and needs in ways that produce a finer, richer aggregate, with greater community representation than is often achieved via other common assessments of group perceptions, needs, and knowledge. It can also stimulate the exchange of ideas: participants can "feed" off the ideas of others, recalling things they might not otherwise recall. Group participation can help participants define and frame their individual viewpoint by comparing/contrasting it to other perspectives (Morgan, 1997). Last, (being qualitative research) it can be rich in detail and context; this is essential for the description of factors and detailed sub-factors. Qualitative research can be useful in describing processes and systems, integrating perspectives and viewpoints, and understanding how people interpret events. These features are vital for the development of a new framework of factors specifically referred to SMEs. Qualitative research can be considered as being representative in a theoretical sense, even when situational specifics and contexts appear to differ (Sim, 1998); this is valid also for the case of SMEs, characterized by a high variability among them.

At their most basic form, focus groups are structured or semi-structured meetings with a small group of individuals that allow for the exchange of information, opinions, and feedback related to a single topic. Focus groups consist of an experts' panel, which includes — at a minimum — a meeting facilitator (one of the co-authors of the research) and a few informed participants. Additional roles include recorders and/or observers (one of the co-authors of the research) either within or without the meeting room. In this research, a semi-structured meeting has been used, since the participants of the focus group could base on factors and sub factors already described in the literature. The Focus Group that was set-up in this work included five informed participants, with the necessary in-depth and wide knowledge on SME environments:

- two Senior OSH-researchers, also OSH Senior consultants with significant experience in dealing with SMEs;
- the Vice-President of an SME Association, owner of an SME and its Safety Responsible;
- one OSH-physician from an ASL (local health unit);
- the Director of an INAIL (Italian Workers' Compensation Authority) Provincial Head Quarters.

The rationale behind the choice of this set of participants, is that persons only from SMEs would have had a too narrow view of the problem, whilst a complete view of the OSH issue was needed, i.e. the merge of the one of the professionals who have experienced a number of SMEs along their careers (typically involved for a very long term within the same companies, so as they could also act as "internal" Safety Managers), the one of an SME owner (also Safety Manager for his company, as in many cases in SMEs), and the ones from the local health units and from the compensation authority, together with their actual view on the number of accidents and diseases that happened over last years. The number of participants was limited, in order to guarantee the convergence to a shared and stable result due to the iterative process eliciting each single contribution.

The discussions were split into twenty-four sessions of 3 h each, representing a total of 72 h of talks. The purpose of the discussions was threefold: 1) defining all the factors that determine safety performance within SMEs, 2) defining sub-factors, and 3) identifying the relationships among the factors themselves.

Once the participants had been sent the relevant pieces of information (list of OSH factors, their descriptions, and their mutual relationships stemming from the literature review), an iterative process was performed, consisting of the reading of the list of factors and their descriptions (from the literature at the first round, an updated list later), of the discussion about the completeness and appropriateness of that list (thus, giving as a result an enhanced list), of the discussion about the content of the factors (thus, giving as a result a — better — definition of the content of each factor, i.e. the sub-factors and their measures), and of the discussion about the relationships among the factors themselves (thus, giving as a result a clear map of direct cause-to-effect relationships). This iteration has been repeated until no relevant change has been proposed within a round.

Once factors and sub-factors had been identified, the Focus Group members were asked to express their judgment on the relationships (in terms of existence and direction of cause-to-effect relationships) among the factors themselves. The data obtained were summed-up by using the Ranking Order Clustering (ROC) algorithm (King, 1980). ROC algorithm was developed to gather pieces into families and families into machines, and it can also be used for registering the data holding *conceptual affinity* between factors, within a matrix with value 1 and 0. Through successive (i.e., iterative) ordering of columns and rows, it is possible to select independent factors that can be grouped in the same affinity area, which only have cause-to-effect relationships with factors belonging to other affinity areas. A meaningful title was given to each area obtained by this process; the title is able to embrace all the factors therein contained. Finally, the goodness of the identified affinity areas was validated by means of a confirmatory meeting of the Focus Group members.

4.2. Step 2 – hierarchy definition

Before defining the hierarchy, we have established which of the three levels of detail should be taken into consideration; as a result, we have decided to structure this hierarchy using the affinity areas. In such way, we have kept the hierarchy as generic as possible, in order to make the framework flexible with regard to the characteristics of the various companies.

Depending on the specific situation, each company can, in fact, choose an intervention based on different levels of detail. Within an interaction between two areas (top level), there are many interactions between factors. Therefore, enterprises are free to choose the interactions that best meet their needs.

Once the detail level had been established, the Focus Group discussion was oriented towards the definition of the existing cause-to-effect interactions between the various affinity areas. The analytical tool applied in this last instance was the Interpretive Structural Model (ISM). In fact, ISM© is a computer-assisted learning process that allows individuals, or groups, to develop a map of the total existing relationships among the various elements present in a complex system. The basic idea of such a model is to capitalize on the knowledge and experience acquired by experts, in order to break the system down to multiple subsystems and then build a multi-level structural model (Anantatmula and Kanungo, 2005; Warfield, 1976, 2005; Singh and Kant, 2008). The model so formed portrays the structure of a complex issue, a system of a field of study, in a carefully designed pattern employing graphics as well as words (see for example Jharkharia and Shankar, 2004; Mandal and Deshmukh, 1994; Ravi and Shankar, 2005; Singh and Kant, 2008). For complex problems, like the one under consideration, a number of factors may be affecting the safety performance of companies. Summing up, an ISM approach was selected because the direct and indirect relationships between the enablers describe the situation far more accurately than the individual factors taken into isolation. Therefore, ISM develops insights into collective understandings of these relationships.

ISM methodology suggests the use of the expert opinions based on various management techniques such as brainstorming, nominal technique, etc. in developing the contextual relationship among the variables. Thus, in this research for identifying the contextual relationship among the factors related to the OSH performance of a company, two experts from academia with research interests in the area of occupational safety in SMEs were consulted.

The steps involved in the ISM methodology include the list of the variables affecting the system under consideration, the creation of matrixes summarizing the relationships among these variables, the creation of graphs, and the conversion of these graphs into an

Table 1
Factors, sub-factors and affinity areas.

Affinity area	Factors	Sub-factors
Company culture and economic links/ties	Company culture	Existence of an explicit corporate policy Will to obtain and keep a company safety certification
	Availability and use of resources	Budget allocation to safety Match budget-final balance
Levers	Reward system	Budget allocation to safety reward Match budget-final balance for safety reward Maximum reward percentage attributable to remuneration Percentage of staff remunerated with safety performance incentives
	Penalty system	Internal penalty system levels Maximum penalty remuneration percentage
	Supervision	External supervisory staff Internal supervisory Staff Percentage of premises covered by supervision
	Recruitment policy	Average number of specified certifications for a safety worker
	Training	Average training hours in a working-year Average training hours for the newly-hired Specificity of training Managing cultural sub-layers (cultural differences) Budget allocation to training Match budget-final balance for training
	Information	Average information time-lapse for the newly-hired Information capillarity Information communication speed following a change Budget allocation to information Match budget-final balance for information
	Auditing	Annual number of external audits Annual number of internal audits
	Communication & feedback system	Amount of non-compulsory information communicated Percentage of people to whom information is communicated Average information transmission time-lapse
	Program plan	Training plan Technical and maintenance updating plan Product substitution plan Auditing programming plan PPE standard and innovation substitution plan
Staff behaviour	Orientation towards active participation to safety	Accepted workers' suggestions
	Proper use of PPE (Personal Protection Equipment)	Percentage of staff systematically using PPE in a proper way Percentage of accidents and nonconformities not linked to improper use of PPE
	Compliance with of operating procedures	Percentage of nonconformities not linked to improper operating procedures
	Proper use of machinery and equipment	Percentage of nonconformities not linked to improper use of machinery and equipment
	Proper use of substances	Percentage of nonconformities not linked to improper use of substances
	PPE conditions	

(*continued on next page*)

Table 1 (*continued*)

Affinity area	Factors	Sub-factors
Working environment		Percentage of accidents and nonconformities not linked to worn out PPE
	Equipment conditions	Percentage of accidents and nonconformities not linked to machinery and equipment in bad conditions
	Workplace conditions	Percentage of production areas without layout variability
		Percentage of accidents and nonconformities not linked to messy and/or dirty workplace
Labour force characteristics	Age	Average age of workers
	Worker seniority	Number of working years in the company
		Number of years in specific activities
		Previous experience
	Gender	Work-force distribution by sex (M – F)
	Degree of integration non-local workers	Percentage of non-local workers
		Language understanding level
		Country of origin and length of stay (in the local country)
	Unemployment rate	Unemployment rate
	Working time	Number of work shifts
		Overtime work
	Remuneration and hierarchy	Average remuneration
		Flat hierarchy
	Contract type	Contract duration
Company and local characteristics	Location and mobility	Percentage of staff traveling less than one hour to get to work
		Closeness to provincial seat
		Geopolitical location
	Company size	Company size by turnover
		Company size by staff
	Company structure	Juridical nature
		Company ownership
	Sectorial risk	Sectorial insurance code of the company
	Labour Union presence	Role of Labour Union
Labour (variation and turnover) management	Personnel variation	Staff increase/decrease
	Personnel turnover	Personnel turnover (number of workers in and out annually)
Risk level	Frequency of accidents	Working accident frequency Index
	Severity of accidents	Working accident severity Index

ISM. These steps will be detailed in Section 6, where the method is applied.

5. Factors, subfactors and areas of affinity

The results of the focus group and of the application of ROC algorithm are reported in Table 1.

Most of the factors and sub-factors listed in Table 1 have a relatively self-explanatory name (or title). For this reason, and to keep the text as straightforward as possible, their formal definitions are presented at the end of the paper in Annex. Only the affinity areas are defined here.

The affinity area **Company culture and economic links/ties** describes the policy of the company in terms of safety at work. The term "policy" has not been used in the definition of the area because in an SME an explicit policy on safety at work is not always present; it is therefore more appropriate to speak of cultural context, which can manifest in SMEs in different ways. Orientation toward safety for an SME is often expressed by means of resources invested; it is therefore appropriate to define the area of investigation considering the two different elements. The factors included in this area of investigation are the Company culture and the Availability and use of resources.

The affinity area **Levers** describes the collection of tools in the hands of management for the improvement of the workplace safety conditions. The factors included in this area of investigation are Reward system, Penalty system, Supervision, Recruitment Policy, Training, Information, Auditing, Communication & feedback system, and Program plans.

The affinity area **Staff behaviour** aims at describing all behavioural factors that have impact on the safety performance of the enterprise. The factors included in this area of investigation are Orientation towards active participation to safety, Proper use of PPE (Personal Protection Equipment), Compliance with operating procedures, Proper use of machinery and equipment, and Proper use of substances.

The affinity area **Working environment** includes factors that describe both the condition of the workplace and the proper maintenance of all tools used in the production. The good state depends on the maintenance and replacement policies adopted by the management and proper behaviour and use of resources by the workers. The factors included in this area are PPE conditions, Equipment conditions, Workplace conditions.

The affinity area **Labour force characteristics** contains most of the factors that describe personal aspects of the worker and that, according to the literature, have the greatest impact on performance in safety. This area of inquiry has also been associated with some factors more properly characteristic of Labour management. The factors included in this area of investigation are Age, Worker seniority, Gender, Degree of integration of non-local workers, Unemployment rate, Working time, Remuneration and hierarchy, Contract type.

The affinity area **Company and local characteristics** considers the socio-economic and physical features of the company. This area includes the following factors: Location and mobility, Company size, Company structure, Sectorial risk, and Labour Union presence.

The affinity area **Labour (variation and turnover) management** analyses issues concerning apparently non-safety related Labour management in the company. This affinity area includes the following factors: Personnel variation and Personnel turnover.

The affinity area **Risk level** describes the safety performance of a company, in terms of severity and frequency of accidents, both at an assessment level (that is, before accidents happen) and at an accident analysis level (that is, after accidents have happened). For sake of ease, this affinity area can therefore include two main factors: Frequency of accidents and Severity of accidents.

6. Discussion and conclusion

6.1. ISM methodology and model development

The steps involved in the ISM methodology are as follows:

(1) Variables affecting the system under consideration are listed, which can be objectives, actions, and individuals, etc. In this particular study, the variables are the affinity areas identified in the previous step;
(2) From the variables identified in the first step, a **contextual relationship** is established among variables with respect to which pairs of variables would be examined;
(3) A **structural self-interaction matrix** (SSIM) is developed for variables, which indicates pairwise relationships among variables of the system under consideration;
(4) **Reachability matrix** is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It

Table 2
Structural self-interaction matrix (SSIM).

		8	7	6	5	4	3	2	1
1	Policy (company culture and economic links/ties)	V	V	O	O	O	V	V	
2	Staff behaviour	V	V	A	A	A	A		
3	Levers	V	V	A	A	O			
4	Labour force characteristics	V	V	O	O				
5	Company and local characteristics	V	V	O					
6	Labour management	V	V						
7	Working environment	V							
8	Risk level								

Table 3
Reachability matrix; driving power and dependence in bold.

		1	2	3	4	5	6	7	8	Driving power
1	Policy	1	1	1	0	0	0	1	1	**5**
2	Staff behaviour	0	1	0	0	0	0	1	1	**3**
3	Levers	0	1	1	0	0	0	1	1	**4**
4	Labour force characteristics	0	1	0	1	0	0	1	1	**4**
5	Company and local characteristics	0	1	1	0	1	0	1	1	**5**
6	Labour management	0	1	1	0	0	1	1	1	**5**
7	Working environment	0	0	0	0	0	0	1	1	**2**
8	Risk level	0	0	0	0	0	0	0	1	**1**
Dependence		**1**	**6**	**4**	**1**	**1**	**1**	**7**	**8**	

states that if a variable A is related to B and B is related to C, then A is necessarily related to C;

(5) The reachability matrix obtained in the fourth step is **partitioned** into different levels;
(6) Based on the relationships given above in the reachability matrix, a directed **graph** is drawn and the transitive links are removed;
(7) The resultant digraph is converted into an ISM, by replacing variable nodes with statements;
(8) The ISM model developed in the seventh step is reviewed to check for conceptual inconsistency and necessary modifications are made.

6.2. Structural self-interaction matrix (SSIM)

A cause-to-effect chain of interactions has been chosen as the simplest way to represent the model of interconnection of the elements of OSH in SMEs, in order to understand which way they finally affect the safety performance (risk level) of a company. Practically, the existence and direction of the cause-to-effect relationships among the affinity areas (each consisting of a number of Factors and sub-factors) was highlighted by the Focus Group (it was one of the outcomes from step 1, at a "Factors" level then grouped at an "Affinity area" level), and mapped in Table 2. Following consolidated literature on ISM, four symbols (V, A, X, and O) are used to denote the direction of relationship between the affinity areas (so-called "enabler" in ISM literature) "i" (row) and "j" (column):

V: enabler "i" positively impacts on enabler "j";
A: enabler "j" positively impacts on enabler "i";
X: enabler "i" and "j" positively impact on each other; and
O: enablers "i" and "j" are unrelated.

6.3. Reachability matrix

The SSIM is then transformed into a binary matrix, called the reachability matrix by substituting V, A, X, O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are the following:

- if the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;
- if the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;
- if the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1;
- if the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Following these rules, and after incorporating the transitivities (see section "Research Methodology") the final reachability matrix is shown in Table 3.

In Table 3, the driving power and the dependence of each enabler are also shown. The driving power for each enabler is the total number of enablers (including itself), which it may affect. Dependence is the total number of enablers (including itself), which may be affecting it. The ratio [Driving power]/[Dependence] gives us a picture of how much an affinity area is an independent variable of the problem (rather than dependent, in case of low value of the ratio). On the one hand, some affinity areas are shown to be extremely "independent", such as Policy (5/1), Labour Force Characteristics (4/1), Company and local Characteristics (5/1), and Labour Management (5/1): this means that these are the variables which lay at the beginning of the OSH-related cause-to-effect chain. In other words, they represent a sort of set of contextual constraints, which imply a set of consequences. On the other hand, the most "dependent" variables are shown to be Staff Behaviour (3/6), Working Environment (2/7), and most of all Risk Level (1/8). Of course, these are the variables that lay at the end of the OSH-related cause-to-effect chain, i.e. the ones that strongly depend on the previous variables. In other words, these are the "effects" of the previous variables. It is noteworthy that, whilst "Risk Level" was expected to be at the end of the cause-to-effect chain, both Staff Behaviour and Working Environment are shown to be more "effects" than "causes", so addressing likely interventions elsewhere. As for the interventions are concerned, of particular interest seems to be the affinity area so-called "Levers" (4/4), which is a true connection between "independent" and "dependent" variables. This area is not so much "independent" to be considered a contextual constraint (on which it is extremely difficult to intervene), and it still has an impact on the end of the cause-to-effect chain (most of all, on the Risk Level, i.e., the OSH performance of a company), showing itself to be a rather good area on which to focus the interventions to implement.

6.4. Level partitions

From the final reachability matrix, the reachability and antecedent set for each enabler are found. The reachability set consists of the element itself and the other elements that it may affect, whereas the antecedent set consists of the element itself and the other elements that may affect it. Thereafter, the intersection of these sets is derived for all the enablers. The enablers, for whom the reachability and the intersection sets are the same, occupy the top level in the ISM hierarchy. The top-level element in the hierarchy would not help achieve any other element above its own level. Once the top-level element is identified, it is separated out from the other elements (Table 3). Then, the same process is repeated to find out the elements in the next level. This iterative process is continued until the level of each element is found. Results for iteration 1–5 are summarized in Table 4. These levels help in building the digraph and the final model.

Table 4
Level partitions.

Variable		Reachability set	Antecedent set	Intersection set	Level
First iteration					
Policy	1	1,2,3,7,8	1	1	
Staff behaviour	2	2,7,8	1,2,3,4,5,6	2	
Levers	3	2,3,7,8	1,3,5,6	3	
Labour force characteristics	4	2,4,7,8	4	4	
Company and local characteristics	5	2,3,5,7,8	5	5	
Labour management	6	2,3,6,7,8	6	6	
Working environment	7	7,8	1,2,3,4,5,6,7	7	
Risk level	8	8	1,2,3,4,5,6,7,8	8	I
Second iteration					
Policy	1	1,2,3,7	1	1	
Staff behaviour	2	2,7	1,2,3,4,5,6	2	
Levers	3	2,3,7	1,3,5,6	3	
Labour force characteristics	4	2,4,7	4	4	
Company and local characteristics	5	2,3,5,7	5	5	
Labour management	6	2,3,6,7	6	6	
Working environment	7	7	1,2,3,4,5,6,7	7	II
Third iteration					
Policy	1	1,2,3	1	1	
Staff behaviour	2	2	1,2,3,4,5,6	2	III
Levers	3	2,3	1,3,5,6	3	
Labour force characteristics	4	2,4	4	4	
Company and local characteristics	5	2,3,5	5	5	
Labour management	6	2,3,6	6	6	
Fourth iteration					
Policy	1	1,3	1	1	
Levers	3	3	1,3,5,6	3	IV
Labour force characteristics	4	4	4	4	IV
Company and local characteristics	5	3,5	5	5	
Labour management	6	3,6	6	6	
Fifth iteration					
Policy	1	1	1	1	V
Company and local characteristics	5	5	5	5	V
Labour management	6	6	6	6	V

6.5. Building the ISM-based model

From the final reachability matrix, the structural model is generated by means of vertices or nodes and lines of edges. If there is a relationship between the enablers "j" and "i" this is shown by an arrow which points from "i" to "j". This graph is called a directed graph or digraph. After removing the transitivities as described in the section "Research Methodology", the digraph is finally converted into an ISM-based model as shown in Fig. 1.

The mapping of these logic interactions (Fig. 1) together with the contents of Table 1, constitute the OSH-Factor Framework proposed in this study, i.e., this is the skeleton of the hierarchical structure that SMEs can use as their "departing point" or guidance. From here, everyone should be able to make their own local diagnosis of the OSH situation and identify their own strengths and weaknesses in terms of OSH performance. This, in turn, allows them to use adequately the structural model proposed here to decide on which specific factors (only a few groups) they should intervene first. The main idea is to concentrate efforts and resources on those more likely to bring visible benefits, rather than applying blindly a generic and all-embracing system.

For the variables identified in this research, the ISM model developed (Fig. 1) depicts that each affinity area impacts at least indirectly (due to the pertinence to a cause-to-effect chain) on the riskiness situation in the company (i.e., Risk level), but also that

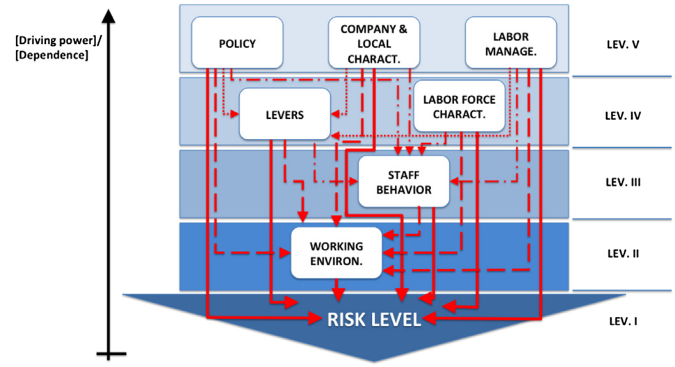

Fig. 1. Outcome: OSH Interpretive Structural Model (different line formatting reflecting the iterations of the "level partitions" phase of the ISM methodology).

each one does it in a very different way. What does immediately affect the Risk level, are, for instance, the Staff Behaviour and the Working Environment, which means that a company has an immediate impact and great control on interventions from such areas. The question is: how can companies change Staff Behaviour and Working Environment? As explained above ("dependent" vs. "independent" variables), of course they can intervene on them, e.g. by means of the reduction in the layout complexity and variability (see Table 1), but they can also decide to intervene on areas somehow easier to manage, like Levers (or Labour force characteristics), knowing that the cause-to-effect chain will imply a direct impact on the Risk level, but also an indirect one (via Staff Behaviour and Working Environment). Finally, areas such as Company Culture and Characteristics are not so easy to change, but they are shown to be of great importance because they spread their impact onto the remaining areas, to have a huge cumulative impact on the Risk level.

6.6. Concluding remarks

Caring for safety and health of workers is (at least, should be) a strategic priority. Companies attempt to improve their safety performance by various means or interventions; the latter are not, however, planned according to a specific and well-structured analysis. The common knowledge of individual safety practitioners – even of the experienced ones – could be not enough for the design of a proper intervention program. Indeed, practitioners do not really have a complete and systemic view of the relevant factors that characterize safety within their companies, but – of course – only a partial view related to their experience. This issue is even more significant within the SMEs, since there is a higher injury risk than larger enterprises and less human, economic and technological availability of resources if compared to larger enterprises.

The safety performance models try to overcome this limitation describing the relationship between factors influencing the safety performance of companies and safety related outcomes; the use of these models should suggest interventions of proven effectiveness and allow for the development of specific and well-structured intervention programs (the idea of a model enabling the development of a specific and well-structured intervention program is an underdeveloped issue: few examples can be found in literature, as an example in Cagno et al., 2001).

However, the existing safety performance models show some limitations with respect to this purpose. Almost always, they are too specific, they lack a cause-to-effect chain structured on the basis of the perceptions of practitioners, they consider a single level of detail, and they do not take into account the particular features of

SMEs (as for the last issue, more insight is provided in Cagno et al., 2013). The proposed safety performance model tries to overcome the four limitations of the existing models, since it is systemic, intervention-oriented and specifically intended to meet SMEs needs.

Being systemic, it overcomes the specificity of existing models and it enables a holistic view of the factors influencing the safety performance of SMEs. From a practical point of view, this means that practitioners are enabled to understand firstly the framework in which a given intervention takes place and secondly the aspects that a given intervention emphasizes or neglects.

Being intervention-oriented, it overcomes the lack of a cause-to-effect chain structured based on the perceptions of practitioners and the lack of an adequate number of levels of detail. Indeed, the model provides a hierarchy, which enables to clearly understand direct and indirect cause-to-effect relationships among factors, and it describes each factor based on three different levels of detail. From a practical point of view, this means that practitioners are enabled to consider a structured set of alternatives for their intervention programs. A structured set of alternatives clarifies the possibility of intervening from the top or from the bottom of the cause-to-effect chain and within an overall area or on a specific aspect of safety performance. In such a way, decision makers are enabled to identify the best choices among several possible interventions, to properly prioritize them. Linking back to existing literature, we refer on the one hand (as an example) to the contribution of Abbe et al. (2011), which is concerned with links among occupational stressors, symptoms, and injuries, in order to identify a specific (to this purpose!) cause-to-effect chain; on the other hand, our contribution has to do with an overall understanding of a wider issue (that is, all the factors affecting OSH performance, also a larger set of managerial items). Thus, the two papers are not at all in contrast or overlapping: rather, our contribution is the one to use when first approaching the overall OSH issue trying to identify main patterns of intervention; therefore, when it comes to (as an example) facing psychological and physical outcomes, of course the contribution of Abbe et al. (2011) may be tremendously beneficial.

Being intended to meet the needs of SMEs, it overcomes the limitation of existing very customised models that have been generally developed for large enterprises. Instead, we strongly believe that the choice of the key interventions needs to be made at a micro-level; to this purpose a framework built on SME-specific knowledge (through the Focus Group) will really enable the identification and understanding of the main likely interventions patterns, also thanks to such a structured view and such level of detail and operationalization (as in Table 1), and such simple representation of the overall view (Fig. 1), that can be immediately understood and used by SMEs' managers.

It has also to be underlined how the model helps implementing a proper safety management system according to guidelines such as OHSAS 18001 or ILO-OSH – Guidelines, since it matches their suggestions respect to the structured and systematic identification of interventions.

As for the impact on scientific research, the model provides a tool for the representation of the context in which the OSH interventions take place. Context can be defined as "formal and informal structures, which are not directly related to safety, but are expected to influence outcome substantially" (Pedersen et al., 2012). Too often, OSH intervention studies do not provide adequate information about the context that may be influential in determining immediate, as well as long-term, effects (Lipscomb et al., 2009; Pedersen et al., 2012). However, since OSH interventions are complex social activities, set in complex, dynamic social systems (Goldenhar et al., 2001) the success of an intervention is crucially dependent on how the context affects the implementation of the intervention (Olsen et al., 2008; Pawson, 2002). Thanks to the proposed model, a single intervention could be described not only as a link between a limited number of factors, but also taking into account the levels of all the remaining factors included in the model, which can represent the context in which the intervention takes place.

Finally, the model may also support syntheses of evidence. There is a need for syntheses of evidence, such as systematic reviews, to provide a better basis for rational decision making (Verbeek et al., 2004). However, a synthesis of evidence requires a shared definition of the interventions and of the context in which these interventions take place: the proposed model could represent a step forward.

6.7. Limitations and further research

Because of its nature, Focus Group methodology does not require a control group (unlike for example in surveys) because it is assumed to "converge" to a shared and stable result due to the iterative process eliciting each single contribution. In addition, the number of participants is limited, in order to guarantee the convergence. Of course, this methodology was required due to the complexity and width of the subject. Thus, further research is welcome to refine the results of this paper, e.g. in terms of different geographical location, cultural background, etc. of the participants. Again, because of its nature, ISM does not consider the strength of a relationship in a quantitative way: rather it is aimed at identifying which are dependent/independent variables of a complex problem (which was – overall – the goal of this paper). Thus, there is room for further research, mainly quantitative, to assess the strength of the relationships in place.

Last but not least, the whole interpretive model has been proposed based on SME-specific knowledge. Thus, it is valid for an SME context. As it stands, we may also assume that additional research could show that this model is almost valid also for large enterprises…or maybe not?

Annex

Affinity area Company culture and economic links/ties

Company culture describes the commitment of management to consider occupational safety as an integral part of business management. This factor can be operationally defined using two sub-factors: the existence of an explicit corporate policy and the will to obtain and keep a company safety certification. **Existence of an explicit corporate policy** describes the presence or absence of an explicit internal policy and formalized plans to give the problem of safety an important role in business management or irrelevant. **Will to obtain and keep a company safety certification** measures a company's interest in having a certification that qualifies the high level of safety. That factor describes the adoption of modus operandi and technologies in line with the principles and actions that allow improving the level of safety within the company.

Availability and use of resources describes the use of economic resources for the development and improvement of safety conditions according to its corporate policy. This factor can be operationally defined using two sub-factors: Budget allocation to safety and Match budget-final balance. **Budget allocation to safety** provides a measure of the amount of resources that potentially are allocated to safety interventions in order to improve the safety performance and decrease accident rates. **Match budget-final balance** measures the actual degree of economic support for safety from the corporate direction with respect to the budget.

Affinity area Levers

Reward system describes the system of incentives aimed at workers in order to increase the company's safety performance. The design of a bonus system is based on attitudes as feedback on accidents, reporting of near-misses, lack of injury for a given period. This factor can be operationally defined by the following sub-factors: Budget allocation to safety reward, Match budget-final balance for safety reward, Maximum reward percentage attributable to remuneration, Percentage of staff remunerated with safety performance incentives. **Budget allocation to safety reward** quantifies the economic resources that the company plans to use as bonus and then provides an indication of how much the company invests in incentive mechanism. **Match budget-final balance for safety reward** quantifies economic resources actually allocated as bonus. The comparison between budget and accounts is an indicator of the difference between what the company would do for improving safety and what actually gets done. **Maximum remuneration percentage attributable as reward** measures reward in percentage with respect to the base remuneration. This allows for observing the link between the percentage of the reward and the margin of performance improvements in safety, assuming that greater amount of the reward implies a greater incentive to behave properly. **Percentage of staff remunerated with safety performance incentives** measures the percentage of workers who can receive a reward for safety reasons.

Penalty system describes the system of fines for infringement of working operating procedures and improper use of: PPE, safety devices, dangerous substances, machinery and equipment. This factor can be operationally defined by the following sub-factors: Internal Penalty System Levels and Maximum penalty remuneration percentage. **Internal penalty system levels** describes the way it is structured a system of internal penalties. **Maximum penalty remuneration percentage** measures the magnitude of penalty with respect to remuneration. This allows for observing the link between the percentage of penalties and the margin of improvement of performance in safety, assuming that more sanctions represent an incentive to behave properly.

Supervision describes the system of supervision on compliance with obligations and safety provisions. The action of supervision is entrusted to the safety supervisors, which can be both internal and external personnel. This factor can be operationally defined by the following sub-factors: external supervisory staff, Internal Supervisory Staff, and Percentage of Premises covered by Supervision. **External supervisory staff** supervision measures capillarity of supervision conducted by external experts. This factor explains how deploying surveillance assignments to external staff may affect the achievement of the objectives in safety. **Internal supervisory Staff** measures capillarity of supervision conducted by internal staff. **Percentage of premises covered by supervision** measures the coverage of supervision over all business areas. The data serves to complete the description of the factor since the only information on the number of officers, internal and external, is not exhaustive. It can happen that there are departments where more people are needed to cover adequately the space and this would be to the detriment of other corporate sites to supervise. The Organization's goal is to be able to control effectively the entire business area.

Recruitment policy describes the importance given to a safety-oriented attitude and to safety knowledge at the time of hiring. This factor can be operationally defined by the Average number of specified certifications for a safety worker. **Average number of specified certifications for a safety worker** is an objective measure of the skill of workers in safety. This choice is based on the assumption that if a company hires people with a greater number of certificates, it will be more safety-conscious than another one neglecting these certificates. Respondents pointed out that the measure of this factor is difficult, because often the worker denies possessing certificates to avoid receiving assignments in safety, not believing to have the necessary experience.

Training describes training activities for workers concerning knowledge and skills needed to adopt the procedures and working behaviours conforming to safety and prevention. An efficient training system must provide a continuous update and, in particular, must be provided extensively to newly hired, making these initially work together with an operator already expert. This factor can be operationally defined by the following sub-factors: Average training hours in a working-year, Average training hours for the newly-hired, Specificity of training, Managing cultural sub-layers (cultural differences), Budget allocation to training, Match budget-final balance for training. **Average training hours in a working-year** measure the time annually prepared for the training of workers. **Average training hours for the newly hired** is a measure of time provided for the training of newly hired workers. The information is useful to assess the adequacy of the training conducted for workers newly hired, which should be more intense than the average. **Specificity of training** evaluates the degree of differentiation of education in diversified profiles. A greater degree of diversification should imply a better safety performance, given that some specific profiles require a more intensive training. **Managing cultural sub-layers** factor describes mainly the language barriers management. This problem arises in the case of presence of personnel of non-European origin. The presence of hours of training is not in itself a valid safety indicator, and it should always be considered how and how much training content has been learned. The main barrier to learning is the language; this barrier is generally exceeded by adding to non EU workers an experienced worker, able to transmit the content by simplifying and progressively reporting it. **Budget allocation to training** defines the percentage of budget in safety training. **Match budget-final balance for training** defines what percentage of the final balance has been actually allocated to safety training. A final value significantly lower than the budget could reveal a decrease in the company's attention to the improvement of safety conditions, or insufficient allocation of resources to critical issues.

Information describes communication to workers on issues of safety at work. This factor can be operationally defined by the following sub-factors: Average information time-lapse for the newly-hired, Information capillarity, Information communication speed following a change, Budget allocation to information, Match budget-final balance for information. **Average information time-lapse for the newly hired** measures of the time passing – from start of the work – before the newly-hired workers are given the proper information on safety issues. Effective information must be given before the employee starts its activity. However, according to the experience, it often happens that the information is organized in moments that do not go hand in hand with recruitment. **Information capillarity** measures the degree of dissemination of informational content. The employer has the obligation to inform every worker, especially at the time of recruitment, about tasks and risks that could affect them. **Information communication speed following a change** measures the speed with which information is disseminated after a change. The greater the time between the change and information is, the greater is the potential exposure to the risk of the worker. **Budget allocation to information** defines the percentage of budget in safety information of workers. **Match budget-final balance for information** defines what percentage of the final balance has been actually allocated to safety information.

A final value significantly lower than the budget could be symptomatic of a loss of attention by the company towards the improvement of safety conditions.

Auditing describes the inspection activity performed to verify conformance to standards through review of objective evidence, in order to improve the performance of an organization. The auditing work can be carried out by both internal and external personnel. This factor can be operationally defined by the Annual number of external audits, and the Annual number of internal audits. **Annual number of external audits** measures the use of external auditing tool. The **Annual number of internal audits** measures the use of internal auditing tool.

Communication & feedback system describes the system of circulation of information related to safety on the company. Communication system and feedback is the means of transmission of information related to safety between workers and management. This system assumes an important role in the pursuit of performance goals. The efficiency of the communications system is a function of the number, extent and timeliness of the content that it treats. The principle that must inspire the information flow is the cooperation among all stakeholders, internal and/or external to the enterprise. This factor can be operationally defined by the Amount of non-compulsory information communicated, Percentage of people to whom information is communicated, Average information transmission time-lapse. **Amount of non-compulsory information communicated** measures the amount of non-compulsory (by law) information communicated to workers. The sub-factor is an indicator of the existence and of the degree of detail of voluntary information communicated to workers, which could be useful for improving performance in safety. **Percentage of people to whom information is communicated** measures the number of persons who are involved in the system of communication and feedback. The sub-factor is an indicator of the degree of dissemination of content that is processed by the system of communication. The system will be much more effective if the number of people involved is higher. **Average information transmission time-lapse** measures the average time elapsed between collecting the information and its communication/dissemination to the parties involved. The sub-factor is an indicator of the degree of rapidity with which the contents are disseminated by the communication system. The higher the speed with which information is transmitted to improving performance in safety is, the greater the efficiency of the system will be.

Program plan describes the existence of a formulation of paths to meet planned objectives regarding training, technological upgrading, maintenance and replacement of products, substances, PPE, and auditing. This factor investigates the existence of specific programming plans and has the task of highlighting the planning of actions which have a significant influence on safety in the areas mentioned above. The Organization of operations and the presence of an updated schedule are elements that impact positively in the management of safety and facilitate control. This factor can be operationally defined by the following sub-factors: Training plan, Technical and maintenance updating plan, Product substitution plan, Auditing programming plan, PPE standard and innovation substitution plan. **Training plan** highlights the existence of a task scheduler for the training of workers in safety. **Technical and maintenance updating plan** highlights the existence of a task scheduler for the innovation of the technologies employed and for their maintenance. A proper scheduled maintenance activity significantly reduces the risks related to a wear out of the machines and to poor maintenance. **Product substitution plan** describes the use of programming for the substitution of products and substances currently used with more innovative – and safer – ones. **Auditing programming plan** highlights the existence of a task scheduler for auditing. Programming increases the degree of detail and promotes the organization of auditing activities, thus improving safety performance. **PPE standard and innovation substitution plan** highlights the existence of a clear policy for PPE replacement. Research developments in new materials allow companies to benefit from a wider range of devices that protect their workers more effectively.

Affinity area staff behaviour

Orientation towards active participation to safety describes the proneness of workers to support initiatives for improving the safety conditions, through personal proposals and timely communication of critical problems. This factor is measured through Accepted workers' suggestions. **Accepted workers' suggestions** measure workers' proneness to sustain the improvement of safety by means of new ideas. It only considers "accepted" ideas, since accounting for the total number of proposals could not be a valid measure of commitment because not all suggestions actually improve the safety conditions.

Proper use of PPE describes the use and care of PPE by workers in order to maximize the protective function over time. This factor can be operationally defined by the Percentage of the workers systematically using PPE in a proper way, and (by difference) by the Percentage of accidents and nonconformities not linked to improper use of PPE. **Percentage of staff systematically using PPE in a proper way** measures the spread of a systematic and proper use of PPE within the company. By difference, it can be measured from datasets stemming from audits, accidents reports. The non-utilization of PPE can reveal, on the one hand, the lack of perception of risk or overconfidence of the worker; on the other hand, the lack of control by management. The improper use of PPE can be measured (by difference) as **Percentage of accidents and nonconformities not linked to improper use of PPE**. A low degree of compliance with the use of individual protection devices can be traced back to a lack of training/information.

Compliance with operating procedures describes the compliance with safety operating procedures established by the employer. The procedures must be defined for each operational activity: processes, stores, stocks, external and internal transport. They must also be simple and concise, to promote understanding. Therefore, this factor can be measured (by difference) as **Percentage of nonconformities not linked to improper operating procedures**. A high degree of non-compliance can be due to many different aspects, such as a bad definition of procedures attributable to management, a negative behavioural habit of workers, an insufficient level of education and information. In any case, the compliance level may serve as alarm signal.

Proper use of machinery and equipment describes the proper use of machines and equipment; the goodness of use depends on compliance with operating rules listed in the manual, from the use of instrumentation for the intended function to the adoption of the protection needed for its use. Therefore, this factor can be measured (by difference) as **Percentage of nonconformities not linked to improper use of machinery and equipment**. A high Percentage of nonconformities linked to improper use of machinery and tools can be due to many different aspects, like a bad definition of procedures attributable to management, a negative behavioural habit of workers, and an insufficient level of education and information.

Proper use of substances describes the use and handling of substances according to their labelling rules, the functions to which they were designed for, and the necessary protection. The proper use of substances is somehow connected to the proper use of PPE and compliance with operating procedures; nonetheless, being considered separately in terms of risk assessment, it deserves specific consideration. This factor can be measured (by difference) as **Percentage of nonconformities not linked to improper use of substances**. A high degree of nonconformity of use can stem from a bad definition of procedures attributable to management, from a negative behavioural habit of workers, and most of all from an insufficient level information and training.

Affinity area Working environment

PPE conditions describe the condition of suitability of PPE used during work. The goodness of conditions depends on the timely replacement of unfit PPE and on the care that the staff puts to prevent its premature wear-out. This factor can be measured (by difference) as **Percentage of accidents and nonconformities not linked to worn out PPE.** It highlights the proportion of accidents not caused or aggravated by the use of PPE worn out and then not suitable. An index below may be due to a schedule or improper replacement of devices, or to an improper use of the tools of protection of workers.

Equipment conditions describe the condition of equipment used in the workplace. Similarly to the goodness of conditions of PPE, even the conditions of equipment depend on the use by workers and on the adequacy of the scheduled maintenance tasks from management. This factor can be measured (by difference) as **Percentage of accidents and nonconformities not linked to machinery and equipment in bad conditions**. A low value of the indicator is an alarm bell that indicates a general state of inadequacy of the equipment. The worker using equipment that does not respect the safety rules exponentially increases the probability of occurrence of serious incidents and this is reflected negatively on the goal of improving performance in safety.

Workplace conditions describe the condition of the workplace from the perspective of the variability of the layout, of order and cleanliness. In this concern, there are three major types of risk: architectural risk due to structural features of the environment in which the employee works, environmental hygiene risk, and technology risk of service plants. This factor can be operationally defined by the Percentage of production areas without layout variability, and (by difference) the Percentage of accidents and nonconformities not linked to messy and/or dirty workplace. **Percentage of production areas without layout variability** measures the presence of production areas not characterized by variability of layout. A large number of areas where displacements happen frequently denote a condition likely to increase risk because workers are asked a continuous mental effort to remember the new provisions. **Percentage of accidents and nonconformities not linked to messy and/or dirty workplace** measures (by difference) the diffusion of nonconformities and accidents related to conditions of order and cleanliness not complying with the hygiene and safety rules. A low value of this sub-factor represents an alarm bell that indicates a general state of inadequacy of the workplace.

Affinity area Labour force characteristics

Age describes the average age of workers. The age of workers is oft analysed with respect to workplace safety, as it frequently has a significant impact on the probability of occurrence of an accident and its severity. This factor can be operationally defined by the **Average age of workers**, which is a uniquely identifiable parameter using the identity cards.

Worker seniority describes the knowledge, accumulated over time, with respect to a job or a specific set of tasks. This factor can be operationally defined through Number of working years in the company, Number of years in specific activities, Previous experience.

Number of working years in the company indicates the number of working years within the same company. The assumption underpinning this factor is that the performance in safety is influenced by the number of years of total experience earned in the same workplace. **Number of years in specific activities** indicates the number of years spent by the worker in a specific task in well-defined processes and operations. The assumption underpinning this factor is that the safety performance is related to the experience in specific activities (job). **Previous experience** measures the years of work that the operator has matured in his life before the last hiring. The previous experience provides an indication of the degree of accumulated work culture. The importance of this information is linked to the fact that, contrary to expectations, quite often experience leads people to underestimate the problems of safety.

Gender describes the mean sex of the worker. This factor can be operationally defined by the **Work-force distribution by sex**.

Degree of integration of non-local workers describes the degree of integration of workers coming from a foreign country. The presence of foreign workers is important from a safety point of view, because people may come from countries where the attention paid to safety issues is relatively low, because a cultural distance may exist, and also because they may have a poor knowledge of the local language which manifests in the difficulty of receiving training and understanding the signs of danger. This factor can be operationally defined by Percentage of non-local workers, Language understanding level, and Country of origin and length of stay. **Percentage of non-local workers** measures the degree of presence of non-local workers within the organization. The number of non-local workers in a company is indicative of a potential increase in the probability of occurrence of an injury. A high value of this sub-factor represents an alarm bell for management to act on the levers available to direct employees to work safely. **Language understanding level** measures the degree of linguistic understanding by non-local workers. The sub-factor provides a measure of the degree of understanding of the local language among non-local workers. Experts highlight that the major problem during training is represented by the language barrier: the workers may have a hard time in understanding and this might result in missed learning safe working procedures with consequent increased risk. **Country of origin and length of stay (in the local country)** measures non-local workers cultural distance. The sub-factor provides a measure of cultural distance through the identification of the geopolitical area that represents the origin of workers and the years spent in Italy. Employees may come from countries where attention is focused on other issues rather than safety. The duration of stay is proportionally associated with the degree of knowledge of local culture. Integration with the local culture takes time and it is expected that a greater presence in years is related to a greater likelihood of setting, with a positive impact on the safety learning.

Unemployment rate describes the percentage of the jobless population in the geo-political area of the production site, which can impact on the frequency of accidents during periods of economic improvement, namely in those intervals where there is an increase in the number of employed. This factor can be operationally defined by **Unemployment rate**.

Working time describes the company's choices regarding type of shifts and overtime worked by employees, which can impact on the frequency of accidents. This factor can be operationally defined by Number of work shifts and Overtime work. **Number of work shifts** describes the work pattern, while **Overtime work** describes the use of overtime, which can be measured as the percentage of overtime work over the whole amount of worked hours.

Remuneration and hierarchy describe the average economic treatment of workers with reference to the distribution of staff between the various hierarchical levels present. This factor can be operationally defined by **Average remuneration**, which describes the average wage of staff present in the company, and **Flat hierarchy** which provides a measure of the number of hierarchical levels, depending on the number of employees. The organization's hierarchical stratification reveals the possible upgrade that a worker can climb in his career; the possibility of improving the working position is an element that stimulates the working virtues as to achieve a better status.

Contract type defines the main profiles of employment with respect to the time horizon and the objectives of each position. The worker's contract is a matter of interest for the analysis of the phenomenon of injuries because of the new non-traditional forms of employment. Worst safety and health conditions and higher accident rates for atypical workers with respect to non-flexible ones can be observed. This is generally due to lack of an effective training and of resources for workers having an expectation of permanence in the company limited in time. The result is that these workers get integrated quickly but also operate with a deficit of knowledge about the dangers of their work. Moreover, atypical employees easily accept the worst working conditions, suffer greater stress and assume an attitude of closure towards the adoption of behaviours and tools that can improve the work from a safety point of view. All this cannot but have a negative impact on safety conditions. This factor can be operationally defined by the Contract duration. **Contract duration** classifies the type of contract on the basis of its duration ("permanent", long term", short-tem", etc.). If a company has a distribution of contracts that tends toward short-term time horizons then it will have a greater probability of occurrence of accidents.

Affinity area Company and local characteristics

Location and mobility describes the geographical location of the production site and the ease of attainment. Therefore, this factor can be operationally defined using the Percentage of staff traveling less than one hour to get to work, the Closeness to provincial seat, and the Geopolitical location. **Percentage of staff traveling less than one hour to get to work** provides a measure of the number of workers who may incur tiredness and stress due to time spent to reach the workplace. The choice for time spent, rather than for the distance in kilometres, is due to the following reason: time has a strict proportional relationship with psychophysical status differently from distance, since there are factors like the traffic that would not be considered. A high value of this sub-factor indicates a potential increase in tiredness and stress among workers, which may affect the safety performance. **Closeness to provincial seat** measures the proximity to major infrastructures. The company's location in comparison to the capital of the province is roughly indicative of the area of residence of the majority of workers, which may affect their cultural background, therefore their safety behaviour. **Geopolitical location** indicates the country of location of the production site, which again may impact on workers' cultural background, therefore on their safety.

Company size describes the size of the enterprise in terms of number of employees and turnover: Microenterprise (less than 10 employees and annual turnover not exceeding EUR 2 million), Small enterprise (less than 50 employees and annual sales or total assets of the balance sheet not exceeding 10 million), Medium enterprise (less than 250 employees and annual turnover not exceeding EUR 50 million), following the European Commission Recommendation 2003/361/EC of 6 May 2003. The (smaller) size of a company influences many factors, such as financial fragility, a smaller provision of economic resources and time, less organic and organized approach to safety, a great versatility of operators which exposes them to a wide variety of risks, a minor technological innovation and the adoption of less standardized working procedures. All these factors have a negative impact on the achievement of high levels of safety performance. This factor can be operationally defined by **Company size by turnover** and **Company size by staff**.

Company structure describes the type of business property (public, private or fractional ownership) and the legal form. This factor can be operationally defined by Juridical nature and Company ownership. **Juridical nature** provides details on the legal form of company, which can be: general partnership, proprietorship, limited, incorporated, or other forms. **Company ownership** indicates the type of corporate property, which can generally be public or private. This information enables to understand, for instance, what is the influence on the dynamics of safety management, the availability of resources to be allocated to safety, and the adoption of a safety-oriented policy.

Sectorial risk describes the risk that characterizes every activity sector. The risk profile is established on the basis of historical data of recorded accidents. In fact, the kind of core activities influences the technologies used and the organization of business processes, and therefore has a certain importance on safety performance. This factor can be operationally defined by the **Sectorial insurance code of the company**.

Labour Union presence describes the role of Labour Unions in the company dynamics, in terms of collaboration (or limitation, if the case). This factor can be operationally defined by the **Role of Labour Union** that could be collaborative or neutral, with a great impact on the workers' behaviour and on the possibility itself of successfully implementing the planned interventions.

Affinity area Labour (variation and turnover) management

Personnel variation describes the increase or decrease of percentage personnel in one year.

Personnel turnover indicates the cycle of renewal or replacement of staff. A low rate of turnover constitutes a stability factor for employees, with positive impact on the average degree of safety training among the workers (at least, thanks to the avoided loss of knowledge because of turnover).

Affinity area risk level

Frequency of accidents represents the number of accidents occurred within the company given an amount of man-hours worked.

Severity of accidents represents the severity of accidents occurred within the company, in terms of day-loss for accidents.

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